Drainage Management, Swan-Canning Catchment

Section 16(e) report and recommendations of the Environmental Protection Authority

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Summary and recommendations

This report provides the Environmental Protection Authority's (EPA's) advice and recommendations to the Minister for the Environment in response to a request from the Minister to provide advice under Section 16(e) of the *Environmental Protection Act 1986*. Advice was requested on statutory mechanisms to control quality and quantity of drainage into the Swan and Canning Rivers. The management of urban drainage has been identified as a high priority in reducing nutrients entering the rivers and the Minister requests strategic advice on the means to improve co-ordination and statutory responsibility for the control and management of the impact of urban drainage on these rivers.

There have been a number of studies undertaken related to drainage management in Western Australia and a number of key initiatives are currently underway. The most recent of these, the Drainage Management Forum, Swan-Canning Catchment was convened to explore the issues and possible solutions related to drainage management in the Swan-Canning Catchment and derive recommendations for a way forward. The need for improved institutional arrangements for drainage management was identified as a key issue by participants in the Forum, as was the need to manage the drainage system as part of the whole ecosystem, greater transparency and accountability in decision making, greater community involvement, education and support, expanding the current drainage rating base and using a mix of sources to fund drainage management, and putting in place adequate monitoring and reporting systems.

The present governance framework does not provide clarity or accountability for improving river health. A simpler more accountable framework would involve a: 'Policy and Approval Authority' to regulate, develop policy, review and approve catchment plans, and evaluate and report progress; a Catchment Manager to develop catchment based plans including water quality targets, and monitor and report progress; and, Service Providers to plan, construct, operate and maintain drainage infrastructure. The new governance framework needs to accommodate the following principles: nutrient management as part of total water cycle management; community ownership of the problem and the solution; standards set for receiving environments; polluter pays/beneficiary pays; accountability for outcomes including monitoring and reporting; and, administrative efficiency.

Recommendations

On the basis of researching the key initiatives undertaken in relation to drainage management, and information presented to the Drainage Management Forum by various experts in drainage management and the recommendations derived from the Forum the EPA recommends:

1. **Drainage in the Swan-Canning Catchment be managed as a water resource as part of the total water cycle with the dual objectives of optimising stormwater runoff/groundwater levels and reducing nutrient and other contaminant flows into rivers and streams.**

2. **A three-tiered governance model be implemented based on a Policy and Approval authority, Catchment Manager and Service Provider[1]. The Policy and Approval Authority role to be undertaken by the Department of Environment (Water and Rivers Commission). The Catchment Manager role to be undertaken by the Swan River Trust, with the necessary legislative backing, in partnership with the Swan Catchment Council. The Service Providers, the Water Corporation and Local Government, to plan and deliver drainage services at a regional or local level.**

3. **A study be conducted into the resourcing of drainage across the catchment including the application of a whole of catchment drainage rate. The rate should cover at least stormwater, groundwater and nutrient management including the retrofitting of existing drains and operation of new drains. Consolidated funding be provided for the role of the Catchment Manager and any Community Service Obligations implemented by other agencies.**

4. **The Catchment Manager in cooperation with key stakeholders, develop a business plan including resourcing for the application of best management practices to the priority sources of contaminant input as a basis for possible implementation and continue to explore innovative best management practices.**

5. **The Catchment Manager establish a monitoring and reporting framework and targets including nutrient, contaminant, ecosystem health and management targets for the Swan-Canning system and specific sub-catchments and drains.**

6. **The WA Planning Commission provide the leadership for and incorporate water sensitive urban design principles, criteria and outcomes in its strategic land use planning, policies, structure plans and subdivision approval conditions.**

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[1] The role of the Policy and Approval Authority could be to regulate, develop policy, review and approve catchment including drainage plans, and evaluate and report progress.
The Catchment Manager would develop catchment based plans including water quality targets, and monitor and report progress.
Service Providers to develop drainage plans, and construct, operate and maintain drainage infrastructure.

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1 Introduction and background

This report provides the Environmental Protection Authority's (EPA's) advice and recommendations to the Minister for the Environment in response to a request from the Minister to provide advice under Section 16(e) of the *Environmental Protection Act 1986*. Section 16(e) of the Act requires the EPA to advise the Minister on any environmental matters which the Minister may refer to the EPA for advice. Advice was requested on statutory mechanisms to control quality and quantity of drainage into the Swan and Canning Rivers. The management of urban drainage has been identified as a high priority in reducing nutrients entering the rivers and the Minister requests advice on the means to improve co-ordination and statutory responsibility for the control and management of the impact of urban drainage on the rivers.

The Swan and Canning river system is of fundamental importance to the city of Perth. The river is highly valued by the community, however the community lacks detailed understanding of the state of the river or the factors leading to its decline. Despite the heavily altered, urban setting, it remains a significant environmental asset. However, the recent algal blooms and resultant fish kill events between April and June 2003 highlighted that much more is to be achieved and sustained to maintain a healthy and resilient river for Perth's future.

Effective drainage management has been identified as a gap in the management of our rivers. Traditionally, drainage systems were designed to convey stormwater run-off for flood control or lower the groundwater table to facilitate land development. Drainage water is disposed of in rivers and wetlands and is a major source of nutrients and contaminants. There is a trend across Australia towards emphasising management of drainage water quality in addition to the management of drainage water quantity. In this time of increasing water scarcity there is need for total water cycle management through improving water use efficiency by increasing the capture, storage and reuse of water close to source.

There have been a number studies undertaken related to drainage management in Western Australia and a number of recent initiatives; principally the Drainage Management Forum Swan-Canning Catchment, the Drainage Reform Group, the Australian National University research project on regulatory design for water quality management and the updating of the Department of Environment's technical guidelines for stormwater management.

The Drainage Management Forum, Swan-Canning Catchment was held at the Western Australian Cricket Association facilities in Perth on 24-25 November 2003 and reconvened for a third day on 29 March 2004 to examine drainage management in the catchment. The Forum was convened to explore the issues and possible solutions related to drainage management in the Swan-Canning Catchment and derive recommendations for a way forward. The Forum had a strong community focus and brought together a range of representatives from local communities, catchment management groups, State Government agencies, Local Government, researchers and consultants. During the Forum experts in the field presented information related to drainage management and

eight consultancies were engaged to examine the issues in detail with these findings being presented to the Forum.

Through their deliberations during the Forum, participants identified the need to manage the drainage system as part of the whole ecosystem, for improved institutional arrangements for drainage management, greater transparency and accountability in decision making, greater community involvement, education and support, expanding the current drainage rating base and using a mix of sources to fund drainage management, and putting in place adequate monitoring and reporting systems. These key themes were reflected in their recommendations for improving drainage management within the catchment.

The Drainage Reform Group initiative involves State agencies, Local Government and industry working cooperatively to reform drainage management throughout WA. This overall process is being facilitated by CSIRO Land and Water. A discussion paper on drainage reform in WA has now been released. The regulatory design for water quality management project is a partnership between the Australian Research Council, the Department of Environment and Water Corporation with the research being conducted by the Australian National University. The ANU have prepared a paper on institutional and governance issues and two papers related to the use of economic instruments for water quality management.

The Department of Environment is revising the 1998 stormwater quality manual under the guidance of the Stormwater Working Group comprising of key government and non-government stakeholders. The new "Stormwater Management Manual for Western Australia" includes source controls, planning issues, education and awareness, system performance monitoring, as well as the structural best management practice elements that were the focus of the 1998 manual. As part of this process the Stormwater Working Group prepared an interim position statement on the principles and objectives of urban stormwater management in WA.

Another recent initiative is the $750,000 Nutrient Intervention Program under the Swan-Canning Cleanup Program (SCCP). The program is intended to provide immediate remediation by nutrient stripping using various technologies in key drains entering the Swan and Canning Rivers.

Appendix 2 summarises a number of initiatives in drainage management recently completed or currently underway.

2 The issue

Large modifications to surface water hydrology have occurred in the Swan and Canning River catchments as a direct result of urban development. Extensive drainage networks now criss-cross the Perth metropolitan area where seasonal wetlands once stood and these networks rapidly deliver stormwater directly to the Swan and Canning Rivers. Both water quantity and quality are key issues in drainage management.

2.1 Flood control

With respect to water quantity, traditional drainage systems can increase the volume and rate of water flowing into and through natural waterways causing erosion of stream banks and vegetation. There has also been a change in many urban waterways from ephemeral to perennial systems because flood control led to deep drains that intercept shallow groundwater. Constant perennial flow impacts on aquatic ecology and channel form. In some cases, the efficiency of the drainage systems result in less surface and groundwater flow being received by waterways and wetlands impacting on their natural hydrology. Flooding is a natural part of the waterways environment with periodic changes in water level being crucial to maintain healthy ecological communities (Department of Environment, 2004a).

Importantly, stormwater is seen as a resource with Perth's sandy soils enabling the maximisation of infiltration and retaining stormwater on site. Stormwater, if managed appropriately can be utilised to supplement water supply needs and maintain both groundwater and surface water systems (Department of Environment, 2004a). It is estimated that in Perth over 200 Gigalitres is conveyed to the river and ocean through our existing drainage system. In addition, given that 105 Gigalitres is currently being extracted by private bores, it is of benefit to increase recharge and reduce drain flow.

2.2 Nutrient enrichment

Eutrophication is arguably the most important water quality issue facing the Swan-Canning river and estuarine system. Excess application of fertilisers in agricultural and urban areas and point and non-point source discharges from commercial and industrial areas all contribute towards the problem. Historical reliance on septic systems has also enriched groundwater that is captured by the existing deep drainage network in the metropolitan area. Nuisance algal blooms in the Swan River and regular blue-green algae blooms in the Canning River are a consequence of nutrient enriched rivers. Figures 1 and 2 in Appendix 3 highlight that total phosphorus and nitrogen tend to be higher in the urbanised coastal plain compared to many rural tributaries except for Ellen Brook where there is a high proportion of agricultural land including current and historical intensive landuses (Department of Environment, 2004b).

Under the Swan-Canning Cleanup Program catchment targets have been developed that specify the median concentration of total nitrogen and total phosphorus allowable in 15 tributaries of the Swan-Canning catchment (Appendix 3, Table 2). Tables 3 and 4 in Appendix 3 highlight that Ellen Brook, Mills Street Main Drain, Bannister Creek and Southern River tributaries are currently failing both short and long term targets (Department of Environment, 2004c). Table 5 and 6 in Appendix 3 highlight that total nitrogen and phosphorus loadings entering the rivers from natural tributaries such as the Avon River and Ellen Brook are significant. However, drains are the most significant contributors of contaminants in the rivers (Department of Environmental Protection, 2002).

2.3 Other contaminants

Recent studies by the Department of Environment have shown elevated levels of contaminants in the rivers and drains. A Swan-Canning Cleanup Program study into the nutrient and contaminant levels in the Mills Street Main Drain catchment showed not only elevated levels of total nitrogen and total phosphorus but a large proportion of samples having lead, zinc and copper concentrations above ANZECC and ARMCANZ trigger values for fresh water ecosystems in south-west Australia. Other toxicant results such as hydrocarbons, surfactants, pesticides and volatile organics were variable over the catchment indicating acute levels of contamination at some sites and below detection concentrations at others (Swan River Trust, 2003). A one-off investigation of water quality in the Bayswater area of the Swan River in April 2003 highlighted that some physical and chemical parameters were above recreational or aquatic ecosystem trigger values. Concentrations of copper, zinc, cobalt and nutrients exceeded guidelines at many drain and river sites. Dissolved oxygen and pH values were also below recommended guidelines (Department of Environment, 2003).

Analysis of current and historical land use undertaken by the Department of Environment for the Drainage Management Forum indicates that the Mills Street Main Drain, South Belmont Main Drain and Bannister Creek sub-catchments have the highest number, density and types of potentially polluting industries. The Central Business District and Yule Brook also have a high density and risk of potentially polluting industries (Department of Environment, 2004d).

Acidic drainage has been identified as an issue in the draft Proposed Framework for Managing Acid Sulfate Soils. Given the current low level of awareness about acid sulfate soil issues in Western Australia, it is likely that in some areas these soils have already been disturbed and are causing environmental problems that have yet to be recognised. There is the possibility that periodic fish kills in some rivers and estuaries may be incorrectly attributed on deoxygenation or algal blooms as the symptoms of fish deaths are similar, and detailed pathology is often required to clearly identify the cause of the kills. A number of acid sulfate soil related problems have been clearly identified that are likely to cause environmental and infrastructure damage unless rehabilitated. These issues include a number of acidic drains (such as the Bayswater Main Drain) that are discharging high concentrations of iron, aluminium and possibly other metals into the Swan-Canning Estuary (Department of Environment, 2004e).

2.4 Current development pressures

The issue of drainage in the metropolitan area is becoming increasingly urgent given that much of the land left to develop is difficult to drain and has the greatest potential to impact on the water quality of the Swan and Canning Rivers. The potential costs for development of this land in the traditional manner, without adverse environmental impacts, are high (Water and Rivers Commission, 2001a). There is a need for land and water management to be aligned at all levels so that drainage planning is integrated as part of general land-use planning. In the urban environment it is essential that drainage management strategies and plans be developed and that these inform structure plans before proceeding to the modification of Town Planning Schemes (Water and Rivers

Commission, 2001b). The proposed Southern River /Forrestdale/Brookdale/Wungong development area provides an example of this.

2.5 Institutional arrangements

A number of issues and difficulties associated with the current drainage management arrangements have been identified in numerous studies in recent years. These concerns have been summarised as:

- land use planning is not occurring in a holistic way. The current system is ad hoc and is occurring in the absence of prior consideration of environmental outcomes;
- responsibility for drainage management in the Perth metropolitan area is fragmented. 29 Local Governments manage approximately 80% of the drainage network (the local drains) and the Water Corporation manages the remaining 20% (the main drains);
- there is no clear institutional arrangements for the setting of overall statutory policy for drainage management, responsibility for statutory compliance and regulatory enforcement, and operational planning and service delivery;
- the lack of clear institutional arrangements and roles and responsibilities are a source of confusion and frustration for the land development industry, landowners and catchment managers;
- the current revenue collection arrangement provides no funding for overall planning by the Department of Environment (Water and Rivers Commission);
- only part of Perth (around 40 per cent) pays a 'drainage rate' to the Water Corporation;
- there is little or no integration of catchment and stream management initiatives and actions being taken by the community, Local Governments and the NRM agencies; and,
- the relationship between groundwater, drainage and water quality is not well understood.

3 Drainage governance

3.1 Current responsibilities

There are various responsibilities for aspects of drainage management. The Department of Environment (Water and Rivers Commission) provides the environmental strategic guidance for drainage and flood management, which is encapsulated in the planning process of the Department for Planning and Infrastructure.

Local Governments are responsible for ensuring that land development has adequate protection from major flooding and they promote flood awareness within the local community. In urban areas, Local Governments manage the majority of the drainage reticulation systems. Management and operational costs are recouped through the general Local Government rating systems.

The ownership and responsibility for flood mitigation works throughout the State is fragmentary and the State Floodplain Management Council has found it difficult to get consensus on institutional arrangements for managing excess flood waters. Floodwaters need to be considered in the broader context of stormwater and groundwater management for an integrated solution to be included in the draft Floodplain Management Strategy.

The Water Corporation collects drainage water (in urban areas usually only road runoff) from the Local Governments' drainage systems in 75 catchments in the metropolitan area and 6 rural catchments. The Corporation receives drainage revenue from customers in the metropolitan declared drainage catchments and a Community Service Obligation payment from Treasury for drainage services provided in rural areas.

Perth's drainage system grows marginally each year to service new subdivisions and urban renewal. Generally, the developers of new subdivisions pay for the cost of improving or extending the drainage reticulation system and pass the ownership of the improvements or extensions to the Local Government when completed. In contrast, where improvement or extension of main or large drains is required, the Water Corporation and the developer share the capital cost, which is then recouped through sale of lots and then ongoing rate revenue to the Water Corporation.

The Office of Water Regulation's (now Economic Regulation Authority and Office of Water Policy)"Operating Licence" issued to the Water Corporation specifies the flood protection (quantity) level of service to be delivered. There are no water quality or environmental requirements specified in the current operating Licence issued to the Water Corporation (Drainage Reform Group, 2003).

3.2 Legislative arrangements

Drainage in the Swan-Canning River system is defined and regulated under the *Metropolitan Water Authority Act 1982*. The Act through clauses 98 and 99 assigns responsibility for the preparation, review, amendment and over-all administration of the Arterial Drainage Scheme for Perth to the Water and Rivers Commission (now Department of Environment). The Water Corporation, through clause 100 of the *Metropolitan Water Authority Act 1982* has control and management of main drains to be operated and managed in accordance with the Arterial Drainage Scheme.

The Water Corporation provides main drainage services in 75 catchments covering around 40% of the Perth metropolitan area. In the remaining catchments drainage servicing are the sole responsibility of the Local Government. Within the area serviced by the Water Corporation, responsibility for transporting minor flows is shared between the Water Corporation and Local Government. The Water Corporation is commonly responsible for the larger assets at the bottom of the catchment with Local Government drainage networks within the catchment connecting to the Water Corporation main drains. The Water Corporation currently manages approximately 20% of the drainage infrastructure in the metropolitan area (Water Corporation, 2001).

The Water Corporation operates under the *Water Corporation Act 1995* which enables the Corporation to "collect, store, treat, market and dispose of wastewater and surplus water". The operating license issued by the Office of Water Regulation (now Economic Regulation Authority and Office of Water Policy) under the *Water Services Coordination Act 1995* requires the Corporation to operate, manage, maintain, plan and construct it's drains and drainage schemes within defined operating areas. As mentioned previously,

the conditions on the license reflect the traditional role of the urban drainage system, that is the removal of water from the landscape without causing flood damage to property. The license does not impose drain water quality or environmental requirements on the Water Corporation (Water Corporation, 2001). There is a perception in the community that there is a lack of commitment from Local Governments and the Water Corporation to address water quality issues once the water is in the drainage system (URS, 2003).

How the powers given to the Water and Rivers Commission (Department of Environment) in the *Metropolitan Water Authority Act 1982* relate to and interact with the operating license issued to Water Corporation by the Office of Water Regulation under the *Water Services Coordination Act 1995* has never been fully explored. Although the Water and Rivers Commission was given responsibility for preparation of the Arterial Drainage Scheme, this strategic drainage planning function has not been undertaken due to inadequate financial and staff provisions.

Under the Swan-Canning Cleanup Program a review of licensing and alternative statutory and non-statutory options for management of drainage was undertaken by ATA Environmental on behalf of the Department of Environmental Protection. The ATA Environmental report suggested that a potential regulatory model for drain management could be amendment of the *Metropolitan Water Authority Act 1982* to make the requirement mandatory for Local Governments and the Water Corporation to comply with the Arterial Drainage Scheme. The Scheme would hold the service provider(s) accountable and the key components would be:

- Specified targets for discharge of nutrients and other contaminants from the drain into the river;
- Conditions relating to the constructions of new main drains;
- Conditions relating to the monitoring of water quality within drains;
- Conditions relating to the installation of contaminant reduction mechanisms; and
- Conditions relating to the reporting of information about point source inputs (Department of Environmental Protection, 2002).

Importantly, specified targets if exceeded would initiate management responses rather than enforcement action. The Department of Environmental Protection in their report on the ATA Environmental investigation concluded that imposing legal liability on the Corporation as drain manager if the limit is exceeded was not feasible given the issues of natural justice. The Water Corporation has insufficient control over the existing pollutant concentrations to enable a legally enforceable limit to be placed on a drain.

The suggested approach by ATA Environmental would ensure any drain entering the Water Corporation drain must meet water quality requirements to the satisfaction of the Department of Environment and the Water Corporation. Compliance with the Scheme would allow the Water Corporation to prevent connection by drains that would not meet water quality requirements at the point of connection, where connection would put the Water Corporation's ability to meet it's obligations under threat. This system would be similar to the provision of sewerage systems. Where deep sewerage is being provided it

must to connect to existing wastewater treatment plants and be installed to the satisfaction of the Water Corporation. The Water Corporation specifies quality criteria for discharges to sewer and these are set at levels that will not breach requirements at the plants or at end-of-pipe disposal points (Strategic Environmental Solutions, 2002).

3.3 Proposed governance structure

The consultancy undertaken by Murdoch University for the Drainage Management Forum on institutional arrangements recommended that the Policy and Approval Authority plus Catchment manager model is the most effective option for institutional governance of drainage. Many of the participants at the Forum agreed the way forward involves separate regulator, catchment manager and service provider functions, however, there was no clear identification of which bodies should fill these roles.

Policy and Approval Authority

The broad role of the Policy and Approval Authority could be to regulate, develop policy, review and approve catchment including drainage plans, and evaluate and report progress. It is proposed that the Department of Environment (Water and Rivers Commission) would be the most appropriate Policy and Approval Authority within the context of current legislative arrangements. The Department of Environment has the ability and expertise to set standards and guidelines for water quality and quantity in the receiving environment, and review and approve catchment plans prepared by the Catchment Manager and drainage plans prepared by the Service Provider(s).

Catchment Manager

The Catchment Manager would develop catchment based plans including water quality targets, and monitor and report progress. It has been identified generally that the Swan River Trust could fill this role. The Drainage Management Forum recommended the Swan River Trust as the Catchment Manager in partnership with the Swan Catchment Council (Department of Environment, 2004f). The new legislation currently being drafted for the Swan River Trust will amend or replace the *Swan River Trust Act 1988*. The legislation will establish the Swan River Trust as the agency responsible for the integration and management of activities necessary to protect and restore the health of the rivers. It is proposed the new legislation will broaden the basis of drainage management and establish the governance arrangements necessary to achieve this (Swan River Trust, 2004).

Service Provider

The general role of the Service Providers is to plan, construct, operate and maintain drainage infrastructure. In terms of a practical way forward, the Water Corporation not only has the resources and expertise to operate and maintain the drainage infrastructure but also has the capability to undertake strategic drainage planning. As highlighted in advice to the EPA Chairman on Drainage in a consultancy undertaken by Strategic Environmental Solutions, the Water Corporation already has the expertise and experience in drainage planning, therefore this function should be reallocated to the Water Corporation. (Strategic Environmental Solutions, 2001). These drainage management plans would then be reviewed and approved by the Department of Environment as the

Policy and Approval Authority. This is consistent with Council of Australian Government (COAG) principles of separation between entities responsible for setting objectives for water related outcomes at catchment scale, those responsibilities for regulation, and those organisations that receive payment for providing management services.

The current and proposed stakeholder roles for each key element of drainage management are outlined in Table 1.

Land Use Planning

The need for interaction between drainage management and land use planning was a key finding of the Drainage Management Forum (Department of Environment, 2004f). To ensure integration of water sensitive urban design and land use planning instruments the WA Planning Commission has an important role in providing the leadership for and incorporating water sensitive urban design best management practice principles, criteria and outcomes it its strategic land use planning, policies, structure plans and subdivision approval conditions.

4 Structural and non-structural management measures

There are a number measures that can be put in place to address drainage water quality and quantity. Structural stormwater quality best management practices are permanent, engineered devices implemented to control, treat, or prevent stormwater runoff pollution. Non-structural stormwater quality best management practices are institutional and pollution-prevention practices including regulation, education and economic instruments designed to prevent or minimise pollutants from entering stormwater runoff and/or reduce the volume of stormwater requiring management (Ecological Engineering, 2003). The release of the interim position statement on the principles and objectives of urban stormwater management in WA highlights the shift in emphasis from 'end of pipe' treatment to 'at source' pollution prevention and stormwater management measures (Water and Rivers Commission, 2003). Recent studies have concluded that source control measures are more efficient in protecting water quality and are more cost effective than in-transit/end of pipe treatment by many orders of magnitude.

An assessment of the application of structural and non-structural best management practices for the catchment was undertaken for the Drainage Management Forum by Parsons Brinckerhoff. The Mills Street Main Drain Catchment was used as a representative catchment for the potential application of best management practices as it is highly urbanised and exports high levels of nutrients. Assessment of the effectiveness in terms of outcomes and cost effectiveness for non-structural best management practices for stormwater and groundwater flow included; point source regulation, education and enforcement, illegal discharge elimination programs, town planning controls, Master Gardener' style education/participation programs, water management strategies and financial incentives to lower the water table. The most effective structural best management practices for stormwater and groundwater flow proved to be groundwater reuse, bioretention systems, constructed wetlands and urban forestry (Parsons Brinckerhoff, 2004). As a basis for possible implementation, the Drainage Management

Forum recommended the development of a business plan including resourcing for the application of best management practices to the priority sources of contaminant input – Mills Street and Belmont Main Drains, Bannister Creek, Central Business District, Yule Brook, Ellen Brook and Southern River (Department of Environment, 2004f).

Water sensitive urban design is seen as a key component in improving drainage management. Water sensitive urban design seeks to incorporate stormwater treatment into the landscape in order to protect the natural systems, water quality, reduce run-off and peak flows and minimize drainage infrastructure costs (Water and Rivers Commission, 2003). Water sensitive urban design principles have been adapted across Australia, however, the application of water sensitive urban design in Perth has been limited (URS, 2003). An assessment undertaken by Essential Environmental Services for the Drainage Management Forum identified the issues and potential solutions for improved implementation of water sensitive urban design. It was found issues surrounding on-ground implementation include lack of detailed design and implementation of specific water sensitive urban design treatments and on-going maintenance, the perceived cost of installation and maintenance, and the lack of data on performance of treatments (Essential Environmental Services, 2004).

Both studies undertaken for the Forum, structural and non-structural best management practices and water sensitive urban design, recommended the critical need for water quality and quantity targets, standards and criteria to enable conceptual design and modelling for appropriate and effective treatments. Two studies carried out by the Department of Environment for the Forum examined the context, existing targets and future directions for target setting for the Swan - Canning system and monitoring and reporting frameworks. It was recommended that a target compliance system be established based on a sound monitoring and reporting framework (Department of Environment, 2004c; Department of Environment, 2004g). These findings are reflected in the outcomes of the Forum with participants recommending the development of long and short-term targets for a range of indicators for the rivers, specific sub-catchments and drains, and a monitoring framework including sampling and analysis protocols and a reporting system (Department of Environment, 2004f).

5 Resourcing management

With the shift towards total water cycle management, resourcing drainage management is a significant issue as the cost of retrofitting or redesigning the existing drainage network to conform to these principles will involve a substantial level of financial investment (ANU, 2003). As identified by the Drainage Management Forum there is a need for ongoing substantial and dedicated additional resources to apply structural and non-structural best management practices (Department of Environment, 2004f).

The consultancy undertaken by Acil Tasman for the Drainage Management Forum on options for resourcing improvements to drainage water quality favoured market-based approaches as they are seen as efficient, effective, incentive-based mechanisms for raising revenue and achieving complex environmental objectives. As the non-point

Table 1 Current and proposed drainage management arrangements

	Organisation	Strategic Planning	Policy	Regulation	Land Use Planning	Developer Approvals	Regional Planning	Setting Water Quality Standards	Monitoring	Target Setting	Waterways Management	Operation & Maintenance Asset infrastructure Major	Operation & Maintenance Asset infrastructure Minor	Drainage Management	Hydrology	Flood Plain Management	Stormwater Reuse	Education
Current	Environmental Protection Authority		✓	✓														
	Department of Environment	✓		✓					✓	✓						✓		✓
	Swan River Trust		✓	✓														
	Western Australian Planning Commission/ Department for Planning and Infrastructure			✓	✓													
	Office of Water Policy		✓	✓														
	Economic Regulation Authority		✓	✓														
	Water Corporation	✓			✓	✓	✓	✓	✓			✓		✓	✓	✓	✓	✓
	Local Government		✓		✓	✓							✓	✓	✓	✓		
	Swan Catchment Council	✓	✓				✓			✓								✓
Proposed	Department of Environment	✓ C	✓ C	✓ D	✓ C		✓ C	✓ D		✓ C					✓	✓	✓	✓
	Swan River Trust	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C	✓ D	✓ D	✓ D							✓
	Western Australian Planning Commission/ Department for Planning and Infrastructure	✓ C	✓ C	✓ C	✓ D	✓ D	✓ D											
	Office of Water Policy		✓ D	✓ C														
	Economic Regulation Authority		✓ D	✓ D														
	Water Corporation	✓ D	✓ C		✓ C	✓ C	✓ C	✓ C	✓ C			✓ D		✓	✓	✓	✓	✓
	Local Government	✓ C	✓ C		✓ C	✓ C	✓ C	✓ C	✓ C				✓ D	✓	✓	✓	✓	
	Swan Catchment Council	✓ C	✓ C		✓ C		✓ C		✓ C	✓ C								✓

C = Contributor
D = Decision-maker

source nature of drainage water pollution limits the range of market-based instruments that can be used, three resourcing models were identified; Consolidated funding, drainage rates and an environmental tax/charge/levy. Analysis indicated an environmental levy is the preferred option with the base for this levy being households or firms, including agricultural and horticultural enterprises, in the Swan-Canning Catchment. The tax base could also be structured to reflect the nature of land use and likelihood of an activity polluting (Acil Tasman, 2004).

The research undertaken by Market Equity on the community perspective on drainage for the Drainage Management Forum suggests the community will not accept a pure 'beneficiary pays' funding model in the form of a dedicated tax or levy, however, there is support for a combined 'polluter pays' and 'beneficiary pays' model (Market Equity, 2004). While there was majority support for a dedicated environmental levy to address drainage issues during the Drainage Management Forum, there were alternate views on the workability and appropriateness of such a levy. The Forum also favoured a combination of the polluter pays and beneficiaries pays for funding drainage management through the use of Consolidated funding and drainage rates with the quantums to be determined following detailed costing. The Forum recommended that drainage rates be applied across the catchment with the rate to cover stormwater, groundwater and nutrient management including the retrofitting of existing drains and operation of new drains. It was also recommended that Consolidated funding be provided for the role of the Catchment Manager and any Community Service Obligations implemented by other agencies (Department of Environment, 2004f).

With respect to drainage rates, the Water Corporation is currently empowered to charge rates on all properties located within declared drainage catchments. Only 67% of the land area within declared drainage catchments is rateable, the rest being public areas. In addition, approximately 57% of the metropolitan area is outside the declared drainage catchments (Water Corporation, 2001). This revenue is applied by the Water Corporation to operation of the system, depreciation of booked asset values, return on financial investment in assets plus a dividend to Government.

According to the ATA Environmental drain licensing study, the Water Corporation could recover costs by means of a drainage rate charged on a differential basis within the catchment. In line with the 'polluter pays' principle the differential rate would be determined according to the nature of the land-use and the level of management control over nutrient and pollutant discharge. Rates could be set on the basis of performance relative to targets and in line with the level of expenditure required to provide the necessary resources to implement catchment management and drainage management practices that would eventually result in the water quality targets being met (ATA Environmental, 2001).

Local Governments charge residents rates for the drainage services they provide. Local Governments do not differentiate their drainage rates based on the extent of service provided, thus residents who receive main drainage services from the Water Corporation are charged the same rate as residents who receive only subsidiary drainage services from

the Local Governments. Many Local Governments do not distinguish expenditure on the drainage system from the general engineering services works budgets. It is therefore difficult to ascertain the costs to Local Governments of managing drainage (Water Corporation, 2001).

6 Guiding principles

Broadly, the desired state for the management of drainage to the Swan and Canning Rivers includes:

- defined environmental outcomes for drainage relating to water quality and quantity;
- prescribed targets for drainage relating to water quantity and quality, the ecosystem and land use;
- responsibilities assigned for achieving these targets and outcomes ensuring the responsible bodies have the ability to achieve their obligations;
- a mix of regulatory, research and development, economic and voluntary mechanisms to achieve these outcomes;
- an established revenue base to achieve these outcomes; and,
- a system to ensure funds are optimally distributed within the drainage basin to achieve the outcomes.

To achieve this desired state a number of principles to guide the development of the most appropriate solution to drainage management were derived. These principles include:

- nutrient management as part of total water cycle management;
- community ownership of the problem and the solution;
- separate planning/regulator and operator function;
- standards set for receiving environments;
- polluter pays/beneficiary pays;
- accountability for outcomes including monitoring and reporting; and,
- administrative efficiency.

7 Conclusions

The Swan-Canning Rivers are of high value to the community for their environmental value, lifestyle benefits and as an icon for Perth. The community, however, lacks detailed understanding of the current state of the rivers or the contributing factors leading to decline. The health of the Swan-Canning River system is under threat from the ongoing inflow of nutrients and other contaminants particularly nitrogen and phosphorus. Constructed drains flowing into the Swan-Canning have traditionally been constructed and managed to control stormwater runoff and regulate water tables and consequently are now a major conveyor of nutrients and other pollutants from the landscape.

The present governance framework does not provide clarity or accountability for improving river health. A simpler more accountable framework would involve a Policy and Approval Authority to regulate, develop policy, review and approve catchment including drainage plans, and evaluate and report progress, a Catchment Manager to develop catchment based plans including water quality targets, and monitor and report

progress and the Service Providers to prepare plans, and construct, operate and maintain drainage infrastructure.

The new governance framework needs to accommodate the following functions; environmental objectives and targets for the river system and sub-catchments and best management practice performance objectives for water sensitive urban design in new and redeveloped areas, a reliable and consistent sampling, monitoring and reporting framework, strategic drainage planning in conjunction with land use planning and adequate resourcing to implement structural and non-structural best management practices and operate the existing and new drainage systems. Community participation including education is also important to such a framework.

8 Recommendations

On the basis of researching the key initiatives undertaken in relation to drainage management, and information presented to the Drainage Management Forum by various experts in drainage management and the recommendations derived from the Forum the EPA recommends:

1. **Drainage in the Swan-Canning Catchment be managed as a water resource as part of the total water cycle with the dual objectives of optimising stormwater runoff/groundwater levels and reducing nutrient and other contaminant flows into rivers and streams.**

2. **A three-tiered governance model be implemented based on a Policy and Approval authority, Catchment Manager and Service Provider[2]. The Policy and Approval Authority role to be undertaken by the Department of Environment (Water and Rivers Commission). The Catchment Manager role to be undertaken by the Swan River Trust, with the necessary legislative backing, in partnership with the Swan Catchment Council. The Service Providers, the Water Corporation and Local Government, to plan and deliver drainage services at a regional or local level.**

3. **A study be conducted into the resourcing of drainage across the catchment including the application of a whole of catchment drainage rate. The rate should cover at least stormwater, groundwater and nutrient management including the retrofitting of existing drains and operation of new drains. Consolidated funding be provided for the role of the Catchment Manager and any Community Service Obligations implemented by other agencies.**

[2] The role of the Policy and Approval Authority could be to regulate, develop policy, review and approve catchment including drainage plans, and evaluate and report progress.
The Catchment Manager would develop catchment based plans including water quality targets, and monitor and report progress.
Service Providers to develop drainage plans, and construct, operate and maintain drainage infrastructure.

4. **The Catchment Manager in cooperation with key stakeholders, develop a business plan including resourcing for the application of best management practices to the priority sources of contaminant input as a basis for possible implementation and continue to explore innovative best management practices.**

5. **The Catchment Manager establish a monitoring and reporting framework and targets including nutrient, contaminant, ecosystem health and management targets for the Swan-Canning system and specific sub-catchments and drains.**

6. **The WA Planning Commission provide the leadership for and incorporate water sensitive urban design principles, criteria and outcomes in its strategic land use planning, policies, structure plans and subdivision approval conditions.**

Appendix 1

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Appendix 2

Summary of initiatives in drainage management

Institutional

- Drainage Management Forum Swan-Canning Catchment
- Discussion paper on Drainage Reform in WA - Drainage Reform Group
- Regulatory Design for Water Quality Management in Perth WA - Australian National University
- State Water Strategy for Western Australia - Government of Western Australia

Technical

- Interim Position Statement: Urban Stormwater Management in WA: Principles and Objectives - Department of Environment
- Stormwater Management Manual for WA – Department of Environment
- Constructed wetlands and Drain retrofitting projects: Swan-Canning Cleanup Program – Swan River Trust and Department of Environment
- Australian Runoff Quality Manual (draft) - Engineers Australia

Planning

- Draft Planning Bulletin: Urban Stormwater Management - Western Australian Planning Commission
- Draft Statement of Planning Policy: Water Resources - Western Australian Planning Commission
- Review of Liveable Neighbourhoods Guidelines -Western Australian Planning Commission
- Water Resources Management Strategies/Plans - Department of Environment
- Southern River/Forrestdale/Brookdale/Wungong Structure Plan Area
- Review of North East Corridor Drainage Management Strategy
- Canning Plains (Mills St Drain) Catchment Management Plan

Appendix 3

Nutrient levels in the Swan-Canning Catchment

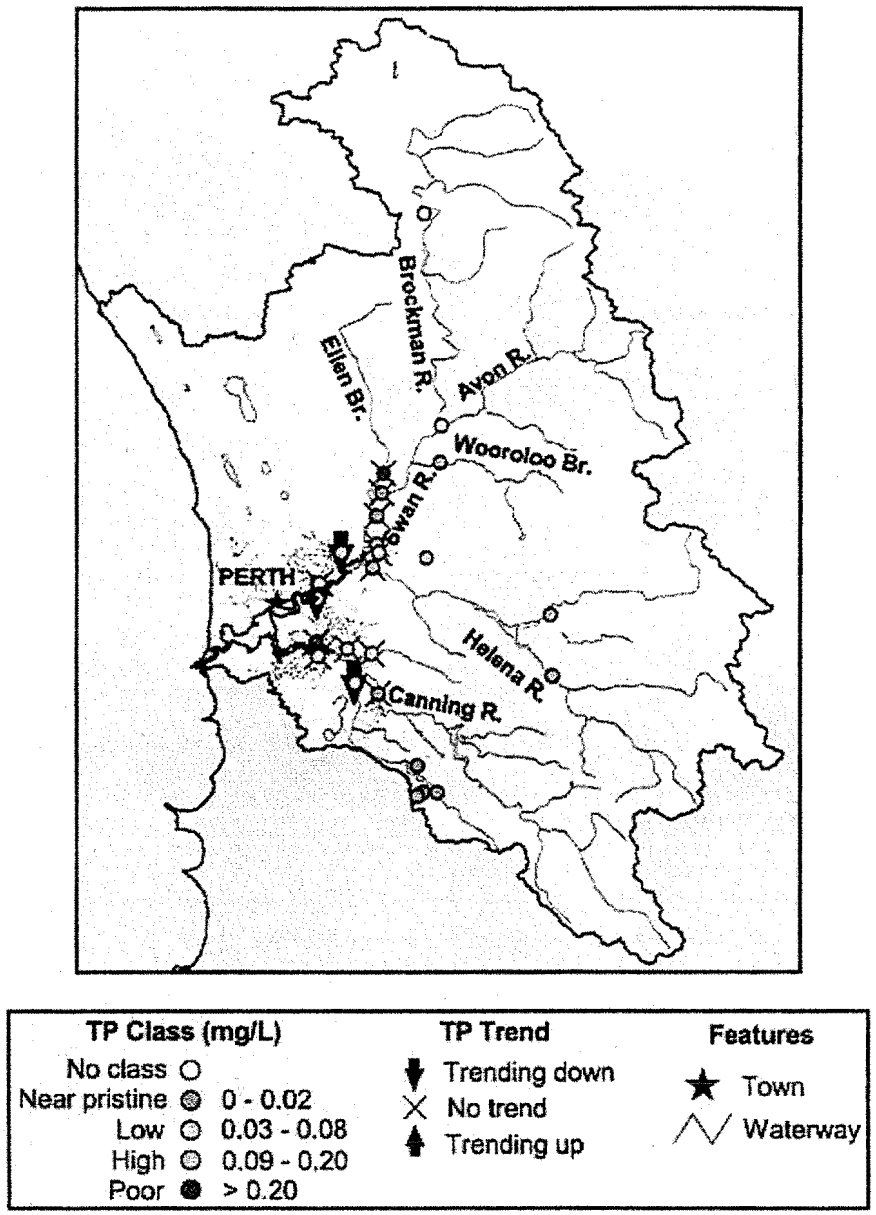


Figure 1 Total phosphorus levels in the Swan-Canning catchments
(Department of Environment, 2004a)

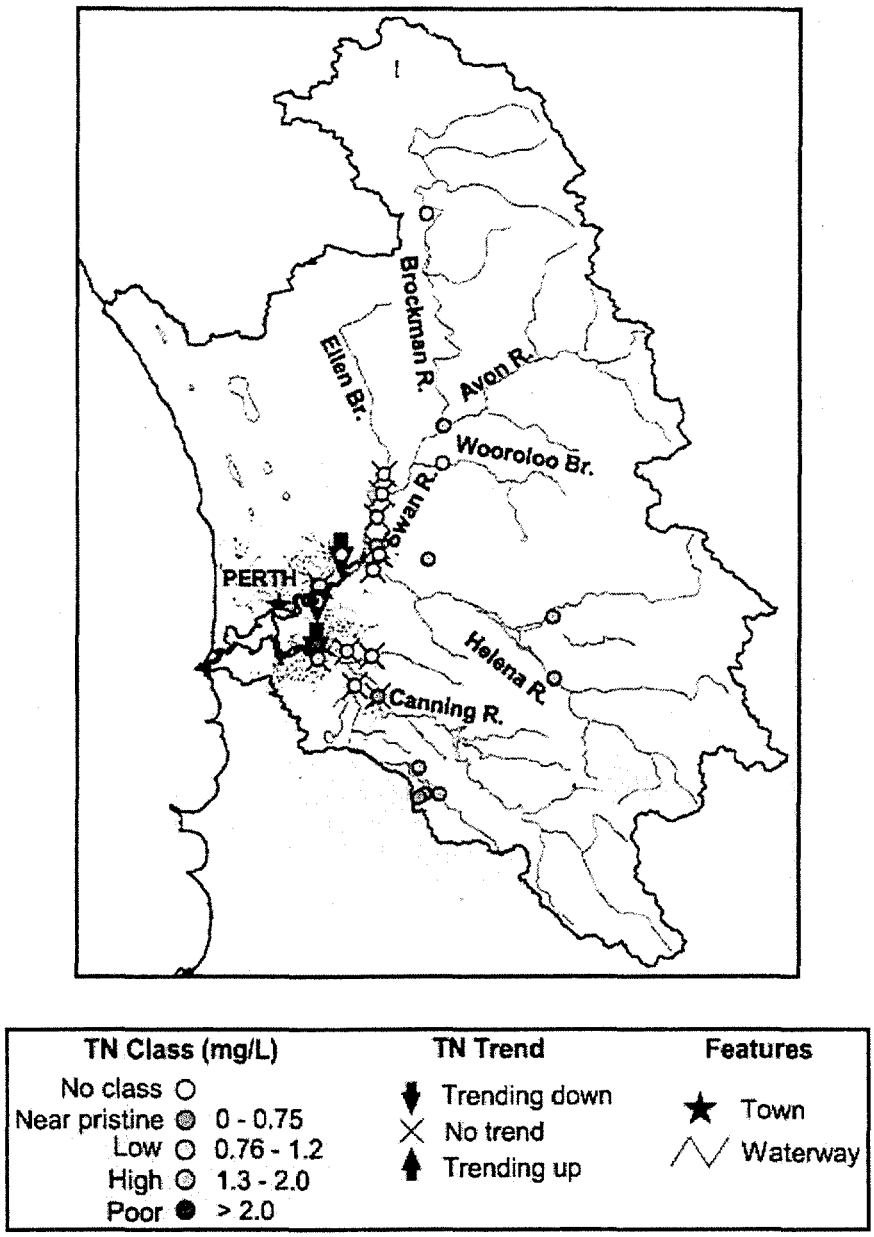


Figure 2 Total nitrogen levels in the Swan-Canning catchments
(Department of Environment, 2004a)

Table 2 Swan-Canning Cleanup Program targets for median total nitrogen and total phosphorus concentration in tributaries of the Swan-Canning Rivers
(Swan River Trust, 1999)

Target	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Short-term	2.0	0.2
Long-term	1.0	0.1

Table 3 Compliance of monitored tributaries discharging into the Swan-Canning Rivers with short and long-term nitrogen targets
(Department of Environment, 2004b)

Tributary	1998	1999	2000	2001	2002
Ellen Brook	(11) 15	(11) 16	(11) 20	(11) 19	(11) 18
Mills Street Main Drain	(12) 27	(11) 21	(11) 18	(11) 14	(12) 12
Bannister Creek	(7) 10	(11) 13	(12) 13	(12) 11	(12) 31
Bayswater Main Drain	(11) 29	(11) 28	(12) 28	(12) 27	(12) 24
Southern River	(11) 30	(11) 26	(12) 27	(12) 25	(12) 22
Bickley Brook	(7) 17	(11) 26	(12) 27	(12) 25	(12) 21
Bennett Brook	(7) 18	(11) 25	(12) 24	(11) 22	(11) 21
Yule Brook	(11) 23	(11) 19	(12) 18	(12) 17	(12) 19
Blackadder Creek	(6) 14	(11) 23	(12) 25	(12) 22	(12) 17
Canning River	(12) 22	(11) 18	(12) 19	(11) 14	(12) 11
Helena River	(11) 20	(10) 14	(11) 15	(11) 11	(21) 12
South Belmont Main Drain	(7) 14	(11) 14	(12) 11	(21) 5	(21) 7
Avon River	(20) 13	(20) 12	(21) 12	(21) 15	(21) 10
Susannah Brook	(12) 8	(18) 12	(19) 14	(18) 12	(17) 10
Jane Brook	(13) 7	(19) 10	(20) 11	(19) 8	(19) 7
Short-term target met (%)	80	80	80	87	93
Long-term target met (%)	20	20	27	33	40

	Tributary fails both long and short-term targets
	Tributary meets short-term target but fails long term target
	Tributary meets both short-term and long term targets

Table 4 Compliance of monitored tributaries discharging into the Swan-Canning Estuary with short and long-term phosphorus targets
(Department of Environment, 2004b)

Tributary	1998	1999	2000	2001	2002
Ellen Brook	(11) 30	(11) 29	(11) 31	(11) 29	(11) 29
Mills Street Main Drain	(10) 20	(11) 16	(11) 13	(11) 9	(12) 29
Southern River	(11) 15	(11) 11	(12) 28	(12) 29	(12) 27
South Belmont Main Drain	(6) 17	(11) 19	(12) 19	(12) 18	(12) 20
Bannister Creek	(7) 12	(11) 19	(12) 21	(12) 20	(12) 18
Yule Brook	(21) 9	(21) 10	(21) 7	(21) 10	(21) 12
Bayswater Main Drain	(21) 10	(21) 10	(21) 14	(21) 14	(21) 11
Bickley Brook	(14) 6	(21) 9	(21) 5	(21) 6	(21) 6
Blackadder Creek	(6) 2	(21) 4	(21) 4	(21) 4	(21) 3
Jane Brook	(13) 0	(19) 0	(20) 1	(19) 2	(19) 2
Avon River	(20) 1	(20) 1	(20) 1	(20) 1	(20) 1
Bennett Brook	(14) 7	(21) 7	(21) 2	(21) 0	(21) 0
Canning River	(21) 0	(21) 0	(21) 0	(21) 0	(21) 0
Helena River	(19) 0	(19) 1	(21) 1	(20) 1	(20) 0
Susannah Brook	(12) 0	(18) 0	(19) 0	(18) 0	(17) 0
Short-term target met (%)	80	87	87	93	93
Long-term target met (%)	67	67	67	67	67

	Tributary fails both long and short-term targets
	Tributary meets short-term target but fails long term target
	Tributary meets both short-term and long term targets

Note: The numbers in Tables 3 and 4 show whether the relevant targets have been achieved or not. The number within the brackets is the maximum number of 'high' samples expected to occur if the target is met (derived statistically by calculating the probability of various outcomes). The number outside the bracket is the actual number of samples from the tributaries that were found to contain more nitrogen or phosphorus than the target levels shown in Table 2.

Table 5 Total Nitrogen loads

Tributary	1998	1999	2000	2001	Average
Avon River	129.49	541.88	691.56	45.26	352.05
Bannister Creek	19.95	21.33	19.62	16.42	19.33
Bayswater Main Drain	5.157	12.00	16.05	4.28	9.37
Bennett Brook	9.57	9.44	9.16	7.24	8.85
Bickley Brook	2.72	3.02	3.81	2.46	3.00
Canning River	6.95	9.84	8.87	4.09	7.44
Ellen Brook	42.63	84.91	45.60	25.62	49.69
Helena River	7.35	6.97	5.88	11.70	7.98
South Belmont Main Drain	1.50	3.26	3.44	4.97	3.29
Southern River	9.49	17.87	24.45	8.25	15.02
Susannah Brook	7.48	7.52	11.81	2.58	7.35
Average	22.02	65.28	76.39	12.08	

Table 6 Total Phosphorus loads

Tributary	1998	1999	2000	2001	Average
Avon River	3.14	11.19	10.37	1.18	6.47
Bannister Creek	1.99	1.74	1.47	1.22	1.60
Bayswater Main Drain	0.40	0.83	1.06	0.23	0.63
Bennett Brook	0.93	0.67	0.72	0.40	0.68
Bickley Brook	0.15	0.17	0.16	0.12	0.15
Canning River	0.22	0.25	0.32	0.23	0.25
Ellen Brook	8.77	19.23	10.88	4.83	10.93
Helena River	0.33	0.11	0.15	0.37	0.24
South Belmont Main Drain	0.19	0.45	0.66	0.79	0.52
Southern River	1.36	2.47	4.20	1.50	2.38
Susannah Brook	0.09	0.12	0.26	0.09	0.14
Average	1.60	3.34	2.75	1.00	

Note: Load numbers are calculated in tonnes per annum and are indicative only. Mills Street Main Drain, Yule Brook, Blackadder Creek, Jane Brook data not available to calculate loads. The highest three tributary average loads are highlighted in grey for total nitrogen and total phosphorus. Annual flows were calculated using Hydsys for those sites that are gauged. The annual flow was multiplied by the average total nitrogen or total phosphorus concentration for that year and divided by 1000 to give a load in tonnes per annum.

Appendix 4

Drainage Management Forum Swan-Canning Catchment Outputs

Drainage Management Forum
Swan-Canning Catchment

Summary of Outputs

Western Australian Cricket Association, Perth, Western Australia
24-25 November 2003 & 29 March 2004

Foreword

The Drainage Management Forum, Swan-Canning Catchment was held at the Western Australian Cricket Association in Perth on 24-25 November 2003 and reconvened for a third day on 29 March 2004 to examine drainage management in the catchment.

The Swan-Canning Rivers are of high value to the community of Perth, however, the health of the system is under threat from the ongoing inflow of nutrients and other contaminants from urban and agricultural areas within the catchment. Constructed drains flowing into the Swan-Canning have traditionally been designed and maintained to manage water quantity rather than quality and have not been managed as part of the total water cycle.

The Forum was convened to explore the issues and possible solutions related to drainage management in the Swan-Canning Catchment and derive recommendations for a way forward. The Forum had a strong community focus and brought together a range of representatives from local communities, catchment management groups, State Government agencies, Local Government, researchers and consultants.

Through their deliberations during the Forum, participants identified the need to manage the drainage system as part of the whole ecosystem, for improved institutional arrangements for drainage management, greater transparency and accountability in decision making, greater community involvement, education and support, expanding the current drainage rating base and using a mix of sources to fund drainage management, and putting in place adequate monitoring and reporting systems. These key themes are reflected in the recommendations that were derived for improving drainage management within the catchment.

I thank all who attended the Forum including the participants and presenters, and in particular the organisers and facilitators for making it all possible. I believe the results of the Forum will move us towards addressing the drainage management issues in the Swan-Canning Catchment and ultimately maintain the health of our river now and into the future.



Dr Wally Cox
Forum Chair

1 Background

The Swan and Canning Rivers are of fundamental importance to the people of Perth. The rivers have been identified by the wider community as a significant icon. The community values the river system for its spiritual and cultural associations, as a place to recreate, and for its intrinsic value. However, the community as a whole is concerned over its future. The increased frequency of toxic algal blooms is considered unacceptable and the blooms highlight that more needs to be done if we are to retain a healthy and resilient river system for Perth's future.

A reduction in nutrient levels is critical in reducing the frequency and extent of algal blooms and protecting the health of the rivers. The management of urban drainage has been identified as having a significant role to play in reducing nutrients entering the rivers from the land. Traditionally, drainage systems were designed to convey stormwater run-off for flood control or lower the groundwater table to facilitate land development. These drains discharge to the rivers and wetlands and are a major transmitter of nutrients and other contaminants.

The traditional model of drainage management is considered no longer appropriate. There is a trend across Australia towards emphasising management of drainage water quality in addition to the traditional management of drainage water quantity. Also, stormwater is seen as an important resource in this time of increasing water scarcity. There is a need for total water cycle management through improving water use efficiency by increasing the capture, storage and reuse of water close to source.

The issue of drainage in the metropolitan area is becoming increasingly urgent given our anticipated population growth. Much of the land left to develop is affected by high water tables and is difficult to drain and therefore has the greatest potential to impact on the water quality of the Swan-Canning Rivers. The potential costs for development of this land in the traditional manner, without adverse impacts on the rivers, are high.

There are a number of key initiatives related to drainage management currently underway; principally the Drainage Reform Group, the Australian National University research project on regulatory design for water quality management and the updating of the Department of Environment's technical guidelines for stormwater management. Another recent initiative is the Nutrient Intervention Program under the Swan-Canning Cleanup Program.

However, more needs to be achieved if we are to protect the health of the rivers. There are a range of technical, economic, social and institutional issues in relation to drainage management and there are a number of possible solutions to overcome these issues. The challenge is to find a cost effective solution that achieves the desired outcome of reducing nutrient input into the rivers while also being acceptable to the general community.

2 Purpose

The purpose of the two-day Forum on 24-25 November 2003 was to explore the technical, economic, social and institutional issues and possible solutions related to drainage management in the Swan-Canning Catchment. The follow-up day on 29 March 2004 was to finalise conclusions and recommendations to the State Government on preferred approaches to improve drainage management in the catchment and ensure the maintenance of river health.

3 Objectives

The objectives of the Forum were to:

Day 1 and Day 2

Technical issues

- Establish a common understanding of the stakeholders, their involvement and their relative relationship to the Swan-Canning Catchment
- Identify key issues and impact of:
    - Pollutants
    - Land Use – current, past, future
- Identify timeframes for desired water quality outcomes

Economic, social and institutional issues

- Identify key issues and impact of:
    - Current social, community and cultural arrangements
    - Current economic arrangements
- Examine the current management arrangements
- Examine perceptions surrounding the operation of the current system and where it could be improved

Possible solutions to issues

- List possible solutions to be further investigated
- Establish the relative priority of each solution

Shared understanding

- Gain a shared understanding of issues from the perspective of various stakeholders

Day 3

Conclusions

- Derive a consensus view on conclusions regarding issues of drainage management

Recommendations

- Derive a consensus view on recommendations to achieve an appropriate framework for drainage management

4 Process

The Forum process involved a number of presentations providing background information on the issues related to drainage management and possible options to improve the current situation. Presentations were interspersed with 'breakout' group sessions to explore these issues and determine possible solutions.

The program for Day one involved an opening address by the Hon Dr Judy Edwards MLA Minister for the Environment, followed by presentations on understanding the current system. Charlie Welker Chairman of the Swan River Trust outlined the challenge of protecting the Swan-Canning Rivers with respect to drainage management. Garry Meinck of the Water Corporation described the current drainage system from the service provider's perspective, Darryl Miller of the Swan River Trust provided information on nutrients in the river system, while Rob Griffiths of the Department for Planning and Infrastructure outlined planning for urban development. Blair Nancarrow of CSIRO Land and Water focussed on community and social issues related to drainage, Verity Allen Chairperson of the Water and Rivers Commission outlined institutional arrangements, while Sue Metcalf Chairperson of the Swan Catchment Council provided the catchment perspective.

A panel discussion was held to explore the options on who pays for drainage management. The discussion was held with Lloyd Werner of the Water Corporation, Cliff Frewing of the Australian Local Government Association, Martin Bowman of the Urban Development Institute of Australia, Dave Morrison of the Department of Treasury and Finance and Dr Brian Martin of the Office of Water Regulation. Attendees participated in two breakout sessions to explore the technical, economic, social and institutional issues highlighted in the presentations and draw on their own experiences in relation to drainage management. The information generated by the breakout groups was summarised and reported back to the Forum for questions and comment.

Day two of the Forum involved an outline of the Eastern States experience. Professor Neil Gunningham of the Australian National University presented various water quality policy options, Dr Mike Mouritz of the Department for Planning and Infrastructure described the national experience, while Ross Young of the Water Services Association of Australia focused on the Melbourne situation. An Indigenous cultural perspective was offered by Noel Nannup, along with technical/engineering solutions presented by Marino Evangelisti of the Stormwater Industry Association and institutional arrangement options outlined by Dr Wally Cox chairman of the Environmental Protection Authority. The final breakout session involved exploring the possible solutions to the issues identified in Day 1 in the light of the options presented by speakers.

The program for Day 3 involved an overview of activities since November and an outline of the discussion papers prepared by the eight consultants during this period. Malcolm Robb of the Department of Environment presented findings on the historical land uses within the catchment, monitoring and reporting, and setting targets for the river system. Structural and non structural best management practices for improvement of urban water quality in the catchment were presented by Dr Tony Wong of the consultancy firm

Ecological Engineering. Julie Beeck of consultancy firm Market Equity outlined the community perspective on drainage, while Dr Mike Moritz discussed Water Sensitive Urban Design. Institutional arrangements for the management of water quality were presented by Dr David Annandale of Murdoch University and Mr Phil Pickering of the Water Corporation spoke of behalf of John Roberts of the consultancy firm Acil Tasman outlining options for resourcing improvements to urban drainage water quality. Sue Metcalf presented the Swan Catchment Council's perspective on drainage management within the catchment.

The breakout session following the presentations involved exploring the most appropriate governance framework for managing drainage in the catchment, resourcing for this management and the integration of Water Sensitive Urban Design into decision-making. The information generated by the groups was summarised and reported back to the Forum for questions and comment. Two plenary sessions allowed participants to use this and other information gained throughout the Forum to discuss draft conclusions and recommendations and derive a consensus view.

Approximately fifty-five participants attended the Forum representing various parts of the community from concerned individuals, catchment groups, regulatory bodies, service providers, consultants, planners and academics. This included representatives from the Swan Catchment Council, Conservation Council, Local Governments, Urban Development Institute of Australia, Stormwater Industry Association, Water Services Association of Australia and Australian National University. The breakout groups consisted of a range of stakeholders to ensure that all points of view were captured. Appendix 1 lists the attendees of the Forum.

5 Outputs

Day 1

5.1 Technical issues

Stakeholder analysis

All groups identified a large range of stakeholders involved in drainage management. Appendix 2 lists the stakeholders identified. Some groups categorised stakeholders broadly, for example 'environmental agencies' or 'regulators' while others identified specific groups or organisations.

Local Government, the Water Corporation, catchment groups, recreational groups, the Swan River Trust and the Western Australian Planning Commission/Department for Planning and Infrastructure were clearly recognised as stakeholders by all participants. The broader stakeholder groups identified included the general community, the urban development industry, agricultural land holders and industry groups. Interestingly, only one group identified the Department of Environment as a separate stakeholder and the Environmental Protection Authority was not identified at all.

In respect of the role of these stakeholders in relation to drainage management perceptions varied in some instances. For example, the role of catchment groups was

seen as ranging from education and lobbying to on-ground restoration work. One group identified the Swan River Trust as being a 'voice for the environment' while others as a manager and planner.

It was recognised by all groups that there is a significant difference in the impact of these various stakeholders. Of those stakeholders clearly recognised, the impact of their activities on drainage rated highly with the exception of the Swan River Trust, catchment groups and recreational groups. Recreational groups were recognised as having a medium or low impact and the Swan River Trust and catchment groups ranged from high to low impact. This may reflect that activities impacting on drainage could be perceived both positively and negatively. For example, agricultural land holders could be perceived as having a high negative impact on drainage while catchment group activities may have a high positive impact.

Pollutant issues

There was general consensus among groups in respect of pollutant issues and their impacts on the rivers. Key pollutant issues identified included nutrients, pesticides, industrial chemicals, sewerage, gross pollutants (litter), acid sulphate soils and landfill leachate. Two groups identified road run-off, exotic species and deciduous trees as issues. The impact of these pollutants ranged from generally polluting the waterways and impacting on ecological and human health to specifically impacting on nutrient cycling, the mobilisation of heavy metals, aesthetics, water quality and seagrass loss in Cockburn Sound.

Land use issues - current, past, future

There was generally a common understanding of the issues and impact of land uses on the Swan-Canning catchment. Current land uses that were identified as an issue included residential, industrial and agricultural land use management, inappropriate land development, drainage and clearing. The impact of these land uses ranged from increasing nutrient and chemical pollution to increased runoff and loss of remnant vegetation and wetlands.

Previous land uses that were considered an issue included landfill sites, market gardens, septic tanks, contaminated sites and river reclamation. The impacts identified from these historical land uses ranged from the continued leaching of nutrients and chemicals to groundwater and surface water to habitat degradation and changes in hydrology.

Future land uses identified as issues included those derived from urban growth and infill. As with current land uses, urban growth was seen as impacting on the rivers by increasing runoff, increasing clearing and loss of wetlands. However, many participants agreed that future urban growth provided an opportunity to utilise water sensitive urban design principles and incorporate other best management practices related to total water cycle management.

Water quality goals

There was a common desire among participants that in the short term (up to 5 years) of slowing the decline or marginally improving water quality in the rivers. In the longer term (20 years) participants sought a marked improvement in water quality. One group noted the need for a marked improvement in those areas that require it as well as the need for prioritization to address the issues that have the greatest impact on water quality.

5.2 Economic, Social and Institutional issues

Social, Community and Cultural issues

The key social issue identified by participants generally involved the need for lifestyle change. Therefore, community involvement and ownership were seen as important in bringing about the necessary change. In line with this, participants agreed to the need for a substantial shift in values, attitudes and behaviours but recognized that it was an almost unachievable goal in the short term.

Most groups felt that education may not necessarily bring about behavioural change. Many felt that to address this issue the government should provide strong leadership and provide incentives to bring about change. Others believed that it would be difficult for the broader community to be part of the solution in the short term. One group identified a need for adequate funding for social research on behavioural change. Indigenous culture, with its spiritual connection to the land was also seen as having a significant role in shifting values.

More specifically, two groups identified the issues of odour and visual amenity associated with algal blooms as impacting on the community negatively, however the impact was also seen as potentially positive in that it could raise public awareness of excessive nutrient levels in the rivers.

Strengths and challenges of current management arrangements

Participants identified a number of strengths and challenges. It was seen as beneficial that the Swan River has been named a significant WA icon which has encouraged a shared belief in the need to protect the river. The work undertaken by catchment groups was identified as a significant strength including their ownership and commitment to action. The integrated catchment management approach and partnerships between the government, community and non-government organisations are also seen as an advantage.

Significant challenges were identified surrounding the current institutional arrangements. Fragmentation with no one agency having overall responsibility for the drainage system was perceived as a serious weakness leading to confusion in the community, possible duplication of governance and inaction in respect of water quality. In particular, one group identified the current joint operational management of drainage between Local Governments and the Water Corporation as an issue. A specific concern of many participants was the lack of a holistic approach and the need for an integrated management framework that would take into account the whole catchment.

There was a perception of a lack of accountability among those responsible for drainage management. In particular, there was concern that there is no strategic plan for drainage, no overall standards for developers and lack of set regulatory standards or key performance indicators. Current management was also seen as being reactive to crises rather than proactive in bringing about long-term solutions. The feeling was that this resulted in a band-aid approach where the symptoms rather than causes were being addressed.

It was recognised by a number of participants that the current system is effective in quantity management. One group suggested the drains were over engineered in their capacity to convey water and prevent flooding. However, there was general consensus on the need to focus equally on water quality in drainage management. It was also recognised that there is significant existing research and knowledge surrounding management of the rivers, however the long time lag between action and a system response was considered a significant challenge. To address this it was felt that management actions should be taken urgently.

Economic issues

The key economic issue that was identified by groups was the need for greater transparency with the drainage rating system. It was identified that there must be more clarity on how the revenue is derived and on what it is spent, for example how much is spent on infrastructure compared to environmental management. Related to this issue is a need for equity in revenue raising. Many participants agreed that all areas should pay drainage rates, not just those serviced by Water Corporation main drains as all areas are drained and contribute towards the problem. It was felt that the rating system should also incorporate the full environmental costs of drainage.

In relation to economic incentives, it was felt by some groups that there is a general lack of knowledge surrounding the use of economic instruments, yet these need to be employed as there is currently no financial incentives or disincentives for polluters. One group suggested the pricing of water usage according to area, land use, size, amount of water used and price incentives for reduced consumption.

It was also identified by a number of participants that funding to adequately address the environmental management of the Swan-Canning Rivers was lacking, in particular work undertaken by volunteers needed to be adequately supported. A number of participants also recognised that activities should be proritised to derive the best 'bang for the buck' and minimise duplication.

Performance of the current system

The performance of the current system in terms of economic, social, policy and regulatory factors, water quality and quality, the general environment and integration of these factors varied between and within groups.

The performance of the current system was generally rated 'good' with respect to the management of water quantity, however one group noted that while the system

adequately dealt with flooding it did not take into account environmental flows. There was consensus among groups that economic factors and integration of all these factors were 'poor'. Social and public participation factors generally rated as 'neither good nor poor' and policy and regulatory factors either were considered 'poor' or were not rated. Water quality and other environmental factors were generally rated as 'poor'.

Day 2

5.3 Possible solutions to issues

The possible solutions identified by participants and their priority has been grouped into those relating to the institutional framework, monitoring and reporting, funding, land use planning and land management practices and social change.

Institutional framework

Addressing the inadequacies of the current institutional framework was seen as a high priority. Participants agreed on the need to investigate alternative institutional models and derive one model for the future. One group suggested two possible drainage management models – one model involved the separation of the regulator from the operator and the second model was based on a single agency responsible for regulation, strategic planning and operation. Another group recommended the separate regulator/operator function.

In respect of these models, participants noted that the agency responsible for regulation would need sufficient statutory powers, accountability, leadership and political support. It was the view of the groups that the agency/ies responsible for drainage management should adopt a catchment-wide approach and manage ecological function not just drainage. It was suggested that the agency/ies jurisdiction coincide with catchment boundaries. This was seen as a way of ensuring that some of the current issues of fragmentation could be avoided. Two groups proposed that a community organisation such as the Swan Catchment Council, could be responsible for drainage management. Most participants identified the need for community involvement in the decision making process with one group suggesting the formation of a Community Advisory Board to advise the agency/ies responsible for drainage.

Monitoring and reporting

Many participants prioritised the need for the responsible agency/ies to be outcome focused. The need to gather good baseline data, set targets or performance standards and put in place mandatory reporting and compliance systems was emphasised. It was acknowledged that there are a great many programs in place and there was general consensus that the monitoring programs should involve the community and be broad enough to include the whole catchment area with the added benefit of increasing awareness of drainage issues.

Funding

Participants recognised that all users and beneficiaries should share the burden of the costs of drainage. It was felt there is a need to increase and broaden the current revenue base with a mix of funding sources including polluter/beneficiary pays and Community

Service Obligation payments from government across the catchment area. This revenue base should incorporate the full environmental costs of the drainage function and part of revenue raised must be used in catchment management. In addition, the process of revenue collection and expenditure should be transparent.

Land use planning and management

Changes in land use planning and management were identified as high priority by a number of participants. Many participants emphasised the need to examine land capability to ensure appropriate land use development. Groups identified that an integrated planning approach between Local Governments and the State Government must be taken. Many also recognised the need for further research on soil types, land uses, land management practices, nutrient loads and modeling using this baseline data to predict the impact of future land uses. This information should be used in the decision making process to ensure the land use planning process is strategic and incorporates long-term goals. This may require the prioritisation of land uses and leaving some land undeveloped or taking land out of production. A shift in community perceptions regarding land use must occur and one group suggested that when making long-term land use decisions a process be used where community values are determined and translated into measurable objectives similar to that used in Dialogue with City.

With respect to land use management, possible solutions included the use of best management practices for rural and urban land use, soft engineering and in-drain technology. Participants emphasised the need to know more about technologies and further applied research, and to document these best management practices and bring them together in an easy to find location. However, one group recognised that this research tends to focus on short-term technical solutions and we need to combine this with longer-term solutions.

Social change

There was general consensus among participants of the need for community involvement and shared understanding of drainage issues to bring about social change. Many participants favored the use of a voluntary approach with education programs, incentives and codes of practice, however underpinning this with regulation to ensure the necessary behavioural change occurs. One group prioritised the need for a cross-cultural awareness program to achieve this and maximise the potential for values to be shared between both Indigenous and non-Indigenous communities and engendering a sense of 'community soul' related to the land and water.

Day 3

5.4 The way forward

Governance framework

As identified in Day 2 of the Forum, the lack of coordination within the current system was perceived as a key issue. Many agreed the way forward involves separate regulator, catchment manager and service provider functions, however participants emphasised that this model requires further investigation and clarification and there were concerns with avoiding excessive bureaucracy and duplication. There was no clear identification of

who the regulating body should be. Some participants felt it was inappropriate for the Environment and Natural Resources Management Committee of the WA Planning Commission to have this role as suggested in the Institutional Arrangements discussion paper. Other participants wanted further information about this sub-committee and some felt that if this committee was to be the regulating body it would require adequate resources and expertise. One group suggested a new regulating body be formed and stressed the need for this body to have broad representation. Some suggested the EPA could fulfil this role, however there were concerns surrounding this and many agreed that the EPA's role is assessing proposals, setting standards and environmental performance targets.

Many participants suggested a combination of the Swan River Trust and Swan Catchment Council as the Catchment Manager. There was no agreement as to how this should occur, however the need for the Swan River Trust as the Catchment Manager to have the necessary statutory powers was emphasised. For the service provider function, some explicitly identified the Water Corporation and Local Government with most participants emphasising how service providers will need to be more accountable to the Catchment Manager and incorporate water quality objectives.

Resourcing

Most participants highlighted the need for equity in determining who should pay for drainage with groups offering differing alternatives for funding drainage. Many participants favoured a combination of the polluter pays/beneficiaries pays model. In respect of a dedicated environmental levy, one group suggested that rather than implement a levy the current drainage rating base should be increased and extended to all users. Another group suggested utilising the Metropolitan Improvement Plan tax, however there were questions surrounding the suitability of this tax. Another group fully supported the levy and favoured the term 'Water Asset Protection Fund' to make it more socially acceptable, and in line with this emphasised the importance of revenue raised specifically being dedicated to drainage management. This group also suggested that polluters should pay an extra levy and be granted concessions for reduced loadings as an incentive.

With respect of agencies responsible for collecting funding, the Water Corporation was identified as responsible for collecting rates if the current rating base was broadened and Local Governments were seen as the collecting agency for the 'Water Asset Protection Fund' levy. Participants generally identified the Catchment Manger as the distributing agency.

Water Sensitive Urban Design

There was general consensus among participants of the need for changes in the current planning system with the integration of water and land use management. To address this, one group suggested a review of planning guidelines/criteria, conditions and fees for subdivision approvals and another proposed high density planning restrictions. With respect of the specific implementation of Water Sensitive Urban Design (WSUD) on-ground, many noted the need for WSUD to be site specific and designed to suit individual

sub-catchments, a need for adequate demonstration projects and consideration of whole life cost and the cost benefits of implementation of WSUD.

6 Guiding principles

During the Forum a summary of the key themes highlighted by participants was derived based on outputs. These included:

- Management of the whole ecosystem not solely the drainage system;
- Examination of improved institutional models for drainage management;
- Provision of greater transparency and accountability in decision making;
- Engagement with the community and improved integration of stakeholder input;
- Achievement of behavioural change in the community through education and regulation;
- Expansion of the current drainage rating base and using a mix of funding sources to raise revenue;
- Establishment of adequate monitoring, performance and reporting systems;
- Provision of adequate support for volunteer catchment management groups.

From these themes a number of principles to guide the development of the most appropriate solution were derived. These principles included:

- Nutrient management as part of total water cycle management;
- Community ownership of the problem and the solution;
- Standards set for receiving environments;
- Polluter pays/beneficiary pays;
- Accountability for outcomes including monitoring and reporting.

7 Conclusions

On the basis of information provided and discussions throughout the Forum, the participants concluded that:

1. The Swan-Canning Rivers are of high value to the community for their environmental value, lifestyle benefits and as an icon for Perth. The community, however lacks detailed understanding of the current state of the rivers or the contributing factors leading to decline.

2. The health of the Swan-Canning River system is under threat from the ongoing inflow of nutrients and other contaminants particularly nitrogen and phosphorus.

3. Constructed drains flowing into the Swan-Canning have traditionally been constructed and managed to control stormwater runoff and regulate water tables and consequently are now a major conveyor of nutrients and other pollutants from the landscape.

4. Ellen Brook and Southern River have the highest measured nutrient concentrations with these being derived from both point and diffuse sources.

Mills Street and South Belmont Main Drains, Bannister Creek, The Central Business District and Yule Brook are also indicated as major potential sources.

5. Environmental values and objectives, and long and short term targets have been or are being set for the whole system and subcatchments. However, there are no specific long or short term targets within subcatchments. There is confusion surrounding targets and the Forum favours rationalisation of the target setting framework.

6. The Mills Street Catchment is a medium density urban catchment that was assessed for the potential application of structural and non structural best management practices. For baseflow/groundwater management, the non structural best management practices in order of cost effectiveness are: point source regulation, town planning controls, Master Gardener style education/participation programs, water management strategies and financial incentives to lower the water table. Structural best management practices in order of cost effectiveness are: groundwater reuse, bioretention systems and constructed wetlands.
   For stormwater management, the non structural best management practices in order of cost effectiveness are: point source regulation, education, town planning controls, Master Gardener style education/participation programs, water management strategies and illegal discharge elimination programs. Structural best management practices in order of cost effectiveness are: bioretention systems, constructed wetlands and urban forestry.
   The application of these tools should take into account the need to maintain healthy wetlands

7. There are opportunities to further reduce nutrient inputs to the drainage system through additional in-fill sewerage in industrial areas and encouraging early connection to recently installed sewers in all areas.

8. WSUD is seen as a component of reducing nutrient loads and needs to be applied in strategic land use planning, planning policies, structure plans and subdivision conditions for new and redevelopment areas.

9. Acknowledging the significant contribution of resources by the community, Local Government and the State Government, there is however a need for ongoing substantial and dedicated additional resources to apply structural and non structural best management practices.

10. Any additional resources should be allocated firstly to the priority catchments.

11. The Forum favours a combination of the polluter pays and beneficiaries pays for managing storm water quality. Consolidated funding and drainage rates applying to the whole catchment are considered appropriate with the quantums to be determined following detailed costing.

12. While there was majority support for a dedicated environmental levy to address drainage issues, there were alternate views on the workability and appropriateness of such a levy.

13. The present corporate governance framework involving a number of community groups, Swan Catchment Council, Local Government and Government agencies including the Department of Environment, Swan River Trust, Environmental Protection Authority, Department of Agriculture, Water Corporation, Department for Planning and Infrastructure and WA Planning Commission does not provide clarity or accountability for improving river health. A simpler more accountable framework is required.

14. Any new governance framework needs to accommodate the following functions; environmental objectives and targets for the river system and subcatchments and best management practice performance objectives for WSUD in new and redeveloped areas, a reliable and consistent sampling, monitoring and reporting framework, strategic drainage planning in conjunction with land use planning and adequate resourcing to retrofit and operate the existing and new drainage systems. Community participation including education is also important to such a framework.

15. Any new governance model needs to be tested against the COAG principles including where practicable separate regulator, catchment manager and service provider but not at the expense of workability.

8 Recommendations

In view of the importance of the Swan-Canning to the community and maintaining the health of the river, the participants in the Forum recommend that:

1. Drainage in the Swan-Canning Catchment be managed as a water resource as part of the total water cycle with the dual objectives of optimising stormwater runoff/groundwater levels and reducing nutrient and other contaminant flows into rivers and streams.

2. A three-tiered governance model be implemented based on a Policy and Approval authority, Catchment Manager and Service Provider[4]. The Policy and Approval authority could be an existing agency or new agency. The Swan River Trust to be allocated the role of Catchment Manager, with the necessary legislative backing, in partnership with the Swan Catchment Council. The Service Providers to plan and deliver drainage services at a regional or local level.

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[4] The role of the Policy and Approval Authority would be to develop policy, review and approve catchment plans, and evaluate and report progress.
The Catchment Manager would develop catchment based whole-of-water-cycle plans including water quality targets, and monitor and report progress.
Service Providers to plan, construct, operate and maintain drainage infrastructure.

3. The Catchment Manager through a consultative process review environmental values and objectives, and long and short-term targets including nutrient, contaminant, ecosystem health and management targets for the Swan-Canning system and specific subcatchments and drains.

4. The Catchment Manager co-ordinate the establishment of a monitoring framework including sampling and analysis protocols and a reporting system including updated web access. Formal quarterly and annual reports to be provided to the community and key stakeholders.

5. The Catchment Manager develop a business plan including resourcing for the application of best management practices to the priority sources of contaminant input – Mills Street and Belmont Main Drains, Bannister Creek, Central Business District, Yule Brook, Ellen Brook and Southern River as a basis for possible implementation. Continue to explore innovative best management practices.

6. The WA Planning Commission provide the leadership for and incorporate WSUD principles, criteria and outcomes it its strategic land use planning, policies, structure plans and subdivision approval conditions.

7. Drainage rates be applied across the catchment. The rate is to cover stormwater, groundwater and nutrient management including the retrofitting of existing drains and operation of new drains.

8. Consolidated funding be provided for the role of the Catchment Manager and any Community Service Obligations implemented by other agencies.

9. The Infill Sewerage program extended to provide sewerage services to currently unsewered industrial areas within priority catchments. Incentives to be put in place to expedite connections within recently sewered areas.

Appendix 1 - List of Attendees

Participants

Day 1 and 2

Name	Organisation
Blue group	
Ms Verity Allan	Water and Rivers Commission
Mr Cam Clay	Canning Catchment Group
Ms Samantha Dowling	Office of the Minister for Environment
Mr John Ellis	Armadale Redevelopment Authority
Mr Mike Grasby	Whiteman Park Board of Management
Prof Neil Gunningham	Australian National University
Mr Mike Hollett	Water Corporation
Mr Richard P H James	Community Representative
Ms Dallas Lynch	Ellenbrook Catchment
Mr Garry Meinck	Water Corporation
Ms Blair Nancarrow	CSIRO, Land and Water.
Mr Linton Reynolds	City of Armadale
Mrs Julie Robert	Swan Catchment Council
Prof Murugesu Sivapalan	University of WA
Ms Rachel Siewert	Conservation Council
Ms Rebecca Symmans	Community Representative
Mr Charlie Welker	Swan River Trust
Red group	
Mr Harry Bastow	Swan Catchment Council BICM
Mr Colin Evans	Urban Development Institute of Australia
Mr Rob Griffiths	Department for Planning and Infrastructure
Ms Pat Hart	Community Representative
Ms Sally Lake	Community Representative
Mr John McBain	Community Representative
Mr Jos Mensink	Department of Premier and Cabinet
Mr Darryl Miller	Swan River Trust
Ms Murni Po	CSIRO
Ms Cathy Ronalds	Swan Catchment Council
Mr Greg Ryan	East Metropolitan Regional Council
Mr Francis Schnattler	Community Representative
Ms Linda Taman	Swan Catchment Council
Mr Harry Ventriss	Representing Office of Water Regulation
Mr Ross Young	Water Services Association of Australia
Yellow group	
Mr Martin Bowman	Urban Development Institute of Australia
Dr David Chatel	Community Representative
Ms Zoe Corbyn	Dept of the Premier and Cabinet
Mr Kamal Khalil	City of Gosnells

Name	Organisation
Mr David Lawn	Chittering Shire Council
Dr Brian Martin	Office of Water Regulation
Mrs Sue Metcalf	Swan Catchment Council
Ms Joan Payne	Environmental Protection Authority
Mr George Rimpas	City of Bayswater
Dr Darren Sinclair	Australian National University
Mr Dick Stone	Community Representative
Mr Lindsay Thorogood	BCCG

Green group

Mr Graham Cargeeg	Water Corporation
Ms Sheryl Chaffer	Housing Industry of Australia
Mr Peter Cock	ENV
Mr Ken Downsborough	Community Representative
Mr Marino Evangelisti	Stormwater Industry Association
Ms Susan Farr	Melbourne Water
Dr Anas Ghadouani	University of WA
Ms Rosanna Hindmarsh	Swan Catchment Council
Dr Don McFarlane	Department of Environment
Mr Noel Nannup	Consultant
Ms Anne Pettit	South East Regional Centre For Urban Land Care

Day 3

Name	Organisation
Red	
Verity Allen	Water and Rivers Commission
Harry Bastow	Swan Catchment Council BICM
James Duggie	Conservation Council
Marino Evangelisti	Stormwater Industry Association
Colin Evans	Urban Development Institute of Australia
Rob Griffiths	Department for Planning and Infrastructure
Pat Hart	Community Representative
Tom Hatton	CSIRO
Sally Lake	Community Representative
Marnie Leybourne	Department of the Environment
John McBain	Community Representative
Jos Mensink	Department of Premier and Cabinet
Darryl Miller	Swan River Trust
David Murphy	Dept of Treasury and Finance
Murni Po	CSIRO
Greg Ryan	East Metropolitan Regional Council
Francis Schnattler	Community representative
Mescal Stephens	Office of Water Policy
Adrian Tomlinson	Swan River Trust
Charlie Welker	Swan River Trust

Name	Organisation
Yellow	
Martin Bowman	Urban Development Institute of Australia
David Chatel	Community Representative
Cam Clay	Canning Catchment Group
Zoe Corbyn	Dept of the Premier and Cabinet
Martin Glover	Representing WMRC and IPWEA
Kamal Khalil	City of Gosnells
David Lawn	Chittering Shire Council
Vivian Markovich	Environmental Defenders Office
Sue Metcalf	Swan Catchment Council
Joan Payne	Environmental Protection Authority
Linton Reynolds	City of Armadale
George Rimpas	City of Bayswater
Julie Robert	Swan Catchment Council
Mike Sabatino	City of Bayswater
Darren Sinclair	Australian National University
Green	
Graham Cargeeg	Water Corporation
Peter Cock	ENV
Damien Crilly	Swan Catchment Council
David Deeley	Acacia Springs Environmental Consultancy
Samantha Dowling	Office of the Minister for Environment
Ken Downsborough	Community Representative
John Ellis	Armadale Redevelopment Authority
Rosanna Hindmarsh	Swan Catchment Council
Mike Hollett	Water Corporation
Richard James	Community Representative
Tina Klein	Town of Bassendean
Des Lord	UWA
Dallas Lynch	Ellenbrook Catchment
Dale Newsome	WALGA
Anne Pettit	South East Regional Centre For Urban Land Care
Bill Till	Department of Environment

Support staff

Name	Organisation
Ms Alison Atkins	Water Corporation
Dr Wally Cox	Drainage Forum Chairman
Dr David Deeley	Acacia Springs Environmental Consultancy (Day 1 & 2)
Ms Jessica Dorricott	Department of Environment
Dr Marnie Leybourne	Department of Environment (Day 1 & 2)
Dr David Luketina	Water Corporation
Dr Dave Morrison	Department of Treasury and Finance
Mr Mike Mouritz	Department for Planning & Infrastructure

Name	Organisation
Mr Adrian Tomlinson	Swan River Trust (Day 1 & 2)
Mr Mark Tonti	Water Corporation
Mr Lloyd Werner	Water Corporation
Ms Aileen Armstrong	Facilitator
Ms Katie Bushell	Facilitator
Mr Ron Kemp	Facilitator
Mr Sebastian Salicru	Facilitator
Ms Helen Dagnall	Scribe (Day 1 & 2)
Ms Leanne Hartley	Scribe (Day 1 & 2)
Ms Tania Perera	Scribe
Mr Brendan Toohey	Scribe (Day 1 & 2)

Visitors

Name	Organisation
Dr Jim Gill	Water Corporation
Mr Bill Till	Department of Environment (Day 1 & 2)

Appendix 2 - List of Stakeholders

Government	Federal Government Parliament/ politicians Swan River Trust Department of Environment Department for Planning and Infrastructure Western Australian Planning Commission Department of Conservation and Land Management Department of Agriculture Department of Fisheries Department of Health Tourism Commission Local Government
Utility	Water Corporation
Industry	Light Industry Businesses/commercial Commercial fishing Land development industry Mining industry Urban Development Institute of Australia Agricultural land holders Agricultural groups Consulting community
Research	Research community Universities
Community	Swan Catchment Council Catchment and conservation groups Community/consumers Traditional owners/Aboriginal groups Historical groups Recreation groups/Sporting community Recfish west Future generations
Other	The environment

Appendix 5

Presentations to the Drainage Management Forum

See attached disc

Day 1& 2

1. The Role of Drainage Management in Protecting the Swan and Canning Rivers - Charlie Welker, Swan River Trust
2. Drainage System: A Service Providers Perspective - Garry Meinck, Water Corporation
3. Understanding the System: Nutrients - Darryl Miller, Swan River Trust
4. Planning for Urban Development - Rob Griffiths, Department for Planning and Infrastructure
5. Understanding the System: Where does the Community fit in? - Blair Nancarrow, CSIRO Land and Water
6. Understanding the System: Institutional Arrangements – Verity Allen, Water and Rivers Commission
7. The Catchment Perspective - Sue Metcalf, Swan Catchment Council
8. Main Drainage Charges - Lloyd Werner, Water Corporation
9. Understanding the System: Who Pays? - Cliff Frewing, Australian Local Government Association
10. Urban Development Institute of Australia - Martin Bowman, Urban Development Institute of Australia
11. Drainage Costs: Cost Recovery in other States - Dave Morrison, Department of Treasury and Finance
12. Water Quality: Policy Instruments - Prof Neil Gunningham, Australian National University
13. Improving Stormwater Outcomes - Ross Young, Water Services Association of Australia
14. Catchment Repair - Dr Mike Mouritz, Department for Planning and Infrastructure
15. Technical/ Engineering Solutions - Marino Evangelisti, Stormwater Industry Association
16. Managing Drainage in the Swan-Canning Catchment - Dr Wally Cox, Environmental Protection Authority

Day 3

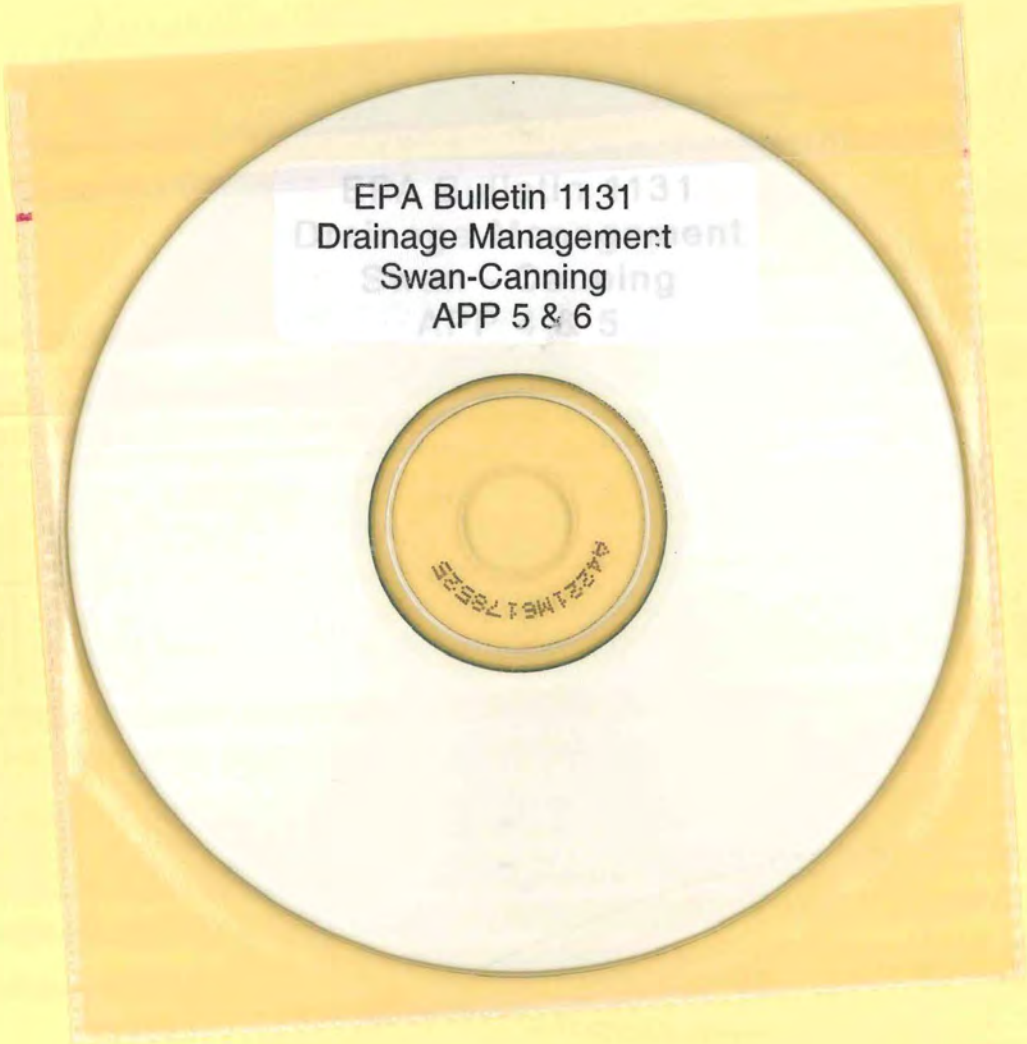
1. Outcomes of Days 1 & 2, Overview of Activities since November, Process and objectives of Day 3 and Setting the scene – What are we managing for? - Dr Wally Cox, Environmental Protection Authority
2. Historical Land Uses, Monitoring and Reporting and Target setting - Dr Malcolm Robb, Department of Environment
3. Structural and non-structural Best Management Practices – Dr Tony Wong, Ecological Engineering
4. Community Acceptance - Ms Julie Beeck, Market Equity
5. Water Sensitive Urban Design - Dr Mike Mouritz, Department of Planning and Infrastructure
6. Management Models - Dr David Annandale, Murdoch University
7. Resourcing Models - Phil Pickering, Water Corporation

Appendix 6

Consultants reports to the Drainage Management Forum

See attached disc

1. Current and historical Landuse within the Swan-Canning Catchment - Department of Environment
2. Monitoring and Reporting - Department of Environment
3. Target setting for the Swan - Canning: Context, existing targets and future directions - Department of Environment
4. Review of Best Management Practices for Improvement of Urban Water Quality on the Swan Coastal Plain - Parsons Brinckerhoff
5. The Community Perspective on Drainage - Market Equity
6. Institutional Arrangements for Management of Water Quality in the Swan-Canning Catchment - Murdoch University
7. Water Sensitive Urban Design and the Development Approvals Process: Identification if Issues and Potential Solutions for Better Implementation - Essential Environmental Services
8. Improving Urban Drainage Water Quality: Options for resourcing improvements to urban drainage water quality on the Swan Coastal Plain – Acil Tasman


EPA Bulletin 1131
Drainage Management
Swan-Canning
APP 5 & 6

DRAFT

DRAINAGE REFORM

Current and Historical Landuse Within the Swan-Canning Catchment



Prepared for: **Drainage Reform Forum**

Prepared by: **Aquatic Science Branch, Department of Environment**

March 2004

SUMMARY

This report is an initial collation of information on current and historic landuse within the Swan-Canning Catchment. Information was gathered from different areas within the Department of Environment while some external data sets were also identified. The data collected was utilised to give an overview of the catchments within the Swan-Canning Catchment in relation to the type and number of potentially polluting industries.

This report highlighted the need for land use data sets to have consistent formatting and the ability for visual interpretation. An environmental management classification scheme for the purpose of protecting surface and groundwater from potentially polluting industries also needs to be developed and promoted.

From the analysis of the six data sets utilised in this report the sub-catchments identified as having the greatest risk from potentially polluting industries were Mills Street Main Drain, South Belmont and Bannister Creek, followed by the CBD and Yule Brook.

Recommendations for the expansion of this project were made.

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Pollution Incident Response 3

External Reports and Agency Data Sets 3

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INTRODUCTION

The Swan River Trust and its predecessor organisations were put in place to address the symptoms of poor water quality in the Swan and Canning Rivers. Since the 1970's when large rafts of macroalgae choked the shores of the Freshwater Bay – Claremont area and through the CBD, the visible symptoms of nutrient enrichment have declined. This overall improvement in water quality has been due to improved sewage treatment including infill sewage programs and the reduction of obvious industrial discharges or point sources.

Point sources of contamination clearly remain however much of the future challenge is to effectively treat diffuse sources such as agricultural runoff, groundwater and stormwater discharges. This effort requires identification of both current polluting land uses and industries along with contamination sources remaining from historical land use.

BACKGROUND

In order to understand the potential for water pollution within a catchment both diffuse and point source pollution sources need to be identified. The land use component of the drainage reform aims to understand the historic and current landuse within the catchment.

The information gained from this project will not only provide a current view of potential pollution sources in the Swan-Canning Catchment but will also feed into other projects involved in modelling nutrient export rates from individual sub-catchments based on broad acre landuse. The models require accurate land use information that includes both diffuse source land use such as agricultural and residential, and point sources such as intensive animal production or food processing. Broad scale landuse in the Swan-Canning Catchment has been determined from the Metropolitan Regional Scheme and North-East Corridor Extension Strategy and incorporated into catchment models (Appendix 1). However more detailed landuse can be gained from a range of data sets held within various government agencies.

This sub-project was initiated to determine the sub-catchments that are most likely to have the greatest amount of potential point source pollution sources within the Swan-Canning Catchment. This was achieved by collecting and assimilating various data sets for visualisation, to provide a focus for further investigation as part of drainage reform.

It is important to note that businesses identified as potentially polluting industries may not be causing or have ever caused and pollution or environmental problems, and should therefore not be thought of as contaminated sites.

OBJECTIVES

The landuse identification task was divided into a series of components that have been used as the structure of this report:

1. Identify and collate information on historic and current landuse (with an emphasis on potentially polluting industries).

2. Determine priority catchments based on the number and location of potentially polluting industries.

3. Demonstrate the current knowledge of the surface water quality condition and monitoring initiatives within the Swan-Canning Catchment.

IDENTIFICATION OF APPROPRIATE LAND USE DATA SETS

In order to distinguish data sets that would assist in identifying historical and current potentially polluting industries (PPI's) the definition of what was considered to be a PPI needed to be clarified. Hirschberg (1991) compiled a comprehensive data set of known and inferred point source contamination to groundwater in the Perth basin, and thus provided a summary of significant industry types. The Department of Environmental Protection also provided guidelines on potentially contaminating activities, industries and land uses in 2001.

For the purpose of this report PPI's were defined to include industries that were associated with either animal based wastes, food based wastes, chemical waste, industrial waste, liquid disposal sites, or landfill. Agricultural activities such as irrigated agriculture (eg. horticulture, viticulture, orchards) and dryland agriculture (eg. Cropping and grazing) were categorised as diffuse pollution sources rather than specific point source pollution sources.

The DoE has a large range of spatial data sets, and these were investigated to determine what relevant data was held within the department. General knowledge of other government departments was also used to identify land use data sets that would be of assistance. The data sets identified as having components that would assist in collating PPI's are described below along with their format and public accessibility.

Internal Data Sets

Point Sources of Groundwater Contamination in the Perth Basin and their Significance.

A series of reports were generated by Klaus Hirschberg for the Western Australian Geological Survey between 1986 and 1991 detailing various components of point source pollution sources and groundwater contamination in the Perth Basin. These reports resulted in the compilation of a comprehensive assimilation of all point source contamination to groundwater in the Perth basin. Hirschberg (1991) developed a classification system for the activities investigated and these fell into seven categories: Industrial waste sources, Chemical based waste sources, Landfill sites, Liquid disposal sites, Animal based waste sources, Food production waste sources and Sites for the disposal of bodies. Data found in these reports is publicly available and reproduced in the Department's Perth Groundwater Atlas (1997). This data is no longer available on the DoE's web site due to it's historic nature and potential for misinterpretation.

National Pollution Inventory

"The National Pollutant Inventory (NPI) provides Australians with access to information on the types and amounts of pollutants being emitted in their communities." Each year particular facilities within specific industries are required to report on the amount of notable emissions occurring on their property. Various aspects of the data collected by the NPI are accessible to the public via the NPI's Web Site. The NPI distinguishes whether the reporting facilities discharge to land, water or air (or a combination of these mediums) and use the Australian and New Zealand Standard Industrial Codes to classify their data. This classification system has two levels, a general ANZSIC grouping and a more detailed ANZSIC class.

Contamination Investigation Areas

The Department of Environment holds information about potential contamination investigation areas prior to October 2000. Each investigation area was a point of focus and not specifically related to each and every cadastral parcel within its spatial extent. The areas were categorised to indicate generalised land use using a modified Hirschberg (1991) classification system. This data includes investigation sites that existed in the mid 1900's. This information is available to the public upon request, however data retrieval costs may be applicable.

Swan Region Licenses and Permits

Certain industries with a significant potential to pollute the environment must hold a Works Approval (for construction) and a Licence or Registration (for operation) under the *Environmental Protection Act 1986*. Licences and Works Approvals are issued with legally binding conditions that apply to specific premises and are intended to prevent or minimise this potential for pollution. Registrations are issued to premises that are managed through industry-generic Regulations and Codes of Practice. Copies of all Licences and Registrations issued are publicly available. Applications for Licence and Registration

are also publicly available. However, if the applicant has notified the DoE that the application contains confidential information, a Freedom of Information (FOI) application is required.

The Water and Rivers Commission (DoE) have a statutory responsibility to issue permits for potentially polluting activities within Underground Water Pollution Control Areas (UWPCA) under the Metropolitan Water Supply Sewerage and Drainage Act By-laws (1981). Permits are only required for activities that involve the storage of petrol or chemicals in quantities greater than for general household use (usually about 20 Litres). However permits are currently a voluntary process and are used to set up conditions between the premises and DoE through agreements rather than legal requirement and therefore details are not generally publicly available.

Landfill Facilities

The Waste Management Branch of the Department record information pertaining to current landfill sites in the state. Each landfill site is classified in relation to the type of waste that is permitted for disposal. Historical landfill sites are found within the Department's Contamination Investigation Areas, Licenses and Hirschberg (1991) data sets.

Swan-Canning Industry Survey

The Swan River Trust conducted a pilot survey investigating more than 550 light industrial premises within the Swan-Canning Catchment in 1997 and 1998. The aim was to determine what current practices were in place for chemical storage and bunding, waste management, wastewater management, stormwater management, emergency management and general management practices. The survey also assessed the extent to which current industrial practices pose a threat of pollutants entering the Swan–Canning River system. Of the total surveyed premises, 522 were available for analysis. Each industry was classified according to the Western Australian Standard Land Use Classification (WASLUC) system. Data from this survey has been reported on and was available in table format with no spatial component apart from street address.

Pollution Incident Response

The Department of Environment records information relating to actual pollution incidents, complaints from the public etc. This database is currently under review.

External Reports and Agency Data Sets

Department of Land Information – Cadastre

The Department of Land Information is responsible for providing cadastral information including ownership. They also provide a field with describing landuse for many of the cadastral parcels. For Crown Reserves, landuse/purpose information is derived from the Crown Reserves register. For non-reserves, landuse indicating the nature of the business activity associated with the property is based on Water Corporation assessment information. Where both are available, reserves information is shown first. Data is represented visually by areas showing the extent of each cadastral land parcel.

Department of Industry and Resources – Service Stations and Major Hazard Facilities

The Department of Industry and Resources' Dangerous Goods Branch are custodians for information about premises and businesses that store specific chemicals. Two major data sets were identified as being important for inclusion in the identification of potential pollution sources, these being the location of Service Stations and Major Hazard Facilities (MHF's). MHFs are facilities such as oil refineries, chemical plants and large fuel and chemical storage sites where large quantities of dangerous goods are stored, handled or processed. Both data sets had street addresses provided for each premise however spatial coordinates were not provided by the DIR. Information relating to these data sets is available on the DIR's web site.

Department of Planning and Infrastructure – Land use and Metropolitan Regional Scheme

The Department of Planning and Infrastructure are responsible for maintaining ownership of crown land (i.e. all land within the State). They maintain a detailed land use data set, which has several classifications systems depending on the focus and level of information required. The Planning Land Use System (PLUS) classifies development areas into Planning Land Use Categories (PLUC) providing a generalised land use for designated industrial areas under the Metropolitan Regional Scheme. Broader land use classifications for each establishment (cadastral parcel) are available using the Western Australian Standard Land Use Classification (WASLUC) system.

National Land and Water Resources Audit (NLWRA)

Agricultural land use information was collected from several different sources. A significant proportion was provided by field officers from Agriculture WA and Community Landcare Officers through written descriptions on printed 1:25000 cadastral maps. This text was later converted to WASLUC (WA Standard Land Use Classification) during data entry with primary, and sometimes secondary, land use assigned. The assigned land use was the field officer's estimation of the land use providing the primary source of income for each cadastral block. Some attribution is based on interpretation of digital and hard copy air photos acquired post 1996. Point source land use from the Water and Rivers Commission was utilised from attributing peri-urban areas around Perth. Other data sources included information provided by personnel from Local Government Authorities, Ministry for Planning and Conservation and Land Management. The data is also classified under an Australian Land Use and Management (ALUM) categories. The data was last updated in 2001 and is available to the public via the Audit's web site.

METHODS FOR IDENTIFYING PRIORITY CATCHMENTS

In order to understand the spatial extent and type of PPI's within the catchment, all known information needs to be accessible in a coherent standardised form. The first step in the process of analysing the available information was determining what format each of the data sets was in.

Assimilation of existing data sets

Format inconsistencies between different data sets

The data sets obtained were in various formats, either spatial or non-spatial. The spatial data sets contained either specific point locations (co-ordinates) or visually defined areas (polygons), which were either freely drawn or cadastral based. Other data sets were only available in a non-visually viable format with street addresses often the only spatial identifier provided. All data sets did have information relating to the business name, type of industry and the location of the premises. Unfortunately the premises location descriptions varied for each data set with some providing map plan identifiers, lot addresses, street addresses and/or a combination of descriptions within a single attribute field. While most data sets provided information about suburb and postcode, their corresponding sub-catchment wasn't. As catchment boundaries often change and don't follow suburb, postcode or LGA boundaries it was impossible to determine which sub-catchment a premise belonged to without a visual representation available.

The actual geographical location of each premise could be determined however some data sets were easier to represent visually given their initial state than others were. The visually viable data sets were the ones that were used in this report for determining priority sub-catchments given the time restraints.

Data sets used for sub-catchment analysis:

- Hirschberg's 1991 groundwater contamination data set (spatial – points)
- National Pollution Inventory – year 5 (2002/2003) (point coordinates provided → spatial)
- Contamination Investigation Areas (spatial coverage – polygons)
- Swan Region Licenses (small data set, location identified from the cadastre → spatial)
- Subset of Swan Region permits (spatial – polygons)
- Service station locations in the DLI's cadastre (spatial – polygons)

Classification inconsistencies between different data sets

When different data sets from varying sources were obtained it became clear that each author or custodian utilised different ways to classify their information to simplify interpretation or visualisation (Table 1). Some data sets were designed for planning purposes, others for recording primary financial earning land use, while others were for environmental investigations or just weren't classified.

Generation of a consistent format and classification scheme

Due to the varied classifications used by each data set obtained, a new generic classification needed to be applied to each data set based on potential environmental impact. The final classification categories used were modified from those used by Hirschberg (1991) and the NLWRA (Table 2).

Table 1: Primary classification categories for various data sets.

NLWRA (ALUM)	DPI (WASLUC)	Hirschberg (1991)	Investigation Areas (DoE)
1 Conservation and natural environments 2 Production from relatively natural environments 3 Production from dryland agriculture and plantations 4 Production from irrigated agriculture and plantations 5 Intensive uses 6 Water	1 Housing 2 Manufacturing 3 Fabricated metals manufacturing 4 Transportation 5 Trade and industries 6 Commercial land use 7 Cultural and recreational uses 8 Agriculture 9 Conservation and unused land	1 Animal based waste 2 Cemeteries, animal disposal 3 Chemicals, fertilisers 4 Food industry waste 5 Industrial waste 6 Liquid disposal sites 7 Landfill sites	1 Animal based waste 2 Cemeteries, animal disposal 3 Chemicals, fertilisers 4 Food industry waste 5 Industrial waste 6 Liquid disposal sites 7 Landfill sites 8 Mining and metals industries 9 Petrol stations and underground storage tanks 10 Residential activities 11 Unknown

Table 2: Generic classification of land use focusing on potentially polluting industries.

Category	Generic Symbol	Key industry #
Animal based waste	A	✓
Chemicals, fertilisers	C	✓
Food industry waste	F	✓
Industrial waste	I	✓
Liquid disposal sites	L	✓
Landfill sites	R	✓
Cemeteries, animal disposal	B	
Irrigated agriculture	H	
Dryland agriculture	D	
Plantations	P	
Urban / Residential	U	
Conservation and natural environments	N	
Managed resources	M	
Unclassified	X	

These were the industries that were used in the analysis of the data to set priority sub-catchments.

Process of data interpretation

Visualisation of original data sets

- The six data sets used for interpretation were plotted as points to give an indication of their spatial extent. It was felt that individual points were more appropriate in this instance than polygons or cadastral parcels, as points would fall into specific sub-catchments, while polygons or cadastral parcels were often split by sub-catchment boundaries. The process of getting each data set into a series of points is described below.

    - The Hirschberg data set already existed as points.
    - The NPI data was converted into a point cover from the raw data's coordinates.
    - The contamination investigation area covered multiple cadastral parcels, so each area was converted to a point located at its centroid irrespective of the cadastral parcels.
    - The Swan Region Licenses were converted to points by determining the cadastral parcel/s they were associated with, then assigning them a point within the central cadastre. As there were multiple lot or street addresses for some licenses it was important to only allocate one point per license. If multiple lot or street addresses for a single license were used an overestimation of industry numbers would have occurred.

- Each Swan Region Permit was originally represented by either single or multiple cadastral parcels. Each permit that was represented by multiple cadastral parcels was reduced to a single area by merging the cadastral parcels associated with it. Each area representing a single permit was then converted to a single point or centroid.
- Cadastral parcels that contained a land use of Service Station within the cadastre were selected and created into a separate spatial data set. Each cadastral parcel representing a single service station was then converted into a point or centroid.

- Revised generic classifications were associated with each data set so that a single classification system was used.
- Individual points within each data set were associated with their corresponding sub-catchment.

Analysis of key industry data for sub-catchment prioritisation

- The data sets were individually analysed to give a total number of points for each of the 6 key industry types (Table 1) within each sub-catchment. These results were then combined to give totals for each individual category and for each sub-catchment for all of the data sets used.
- The total number of points within each sub-catchment was then related to catchment size to give an indication of industry density (points/km^2). This was also done for individual key industry categories.
- Each industry type was then sorted to show the sub-catchments that had the highest number of industries, and highest industry density. The top five sub-catchments were noted.
- The number of top five industry types within each sub-catchment was then determined to give an indication of priority sub-catchments.

CATCHMENT PRIORITISATION RESULTS

The results give a generic indication of industry type and abundance within the Swan-Canning Catchment based on the six data sets used.

A total of 833 key industries were identified throughout the Swan-Canning Catchment. Chemical based industries were the most commonly identified industry type, closely followed by general industrial industries (Figure 1).

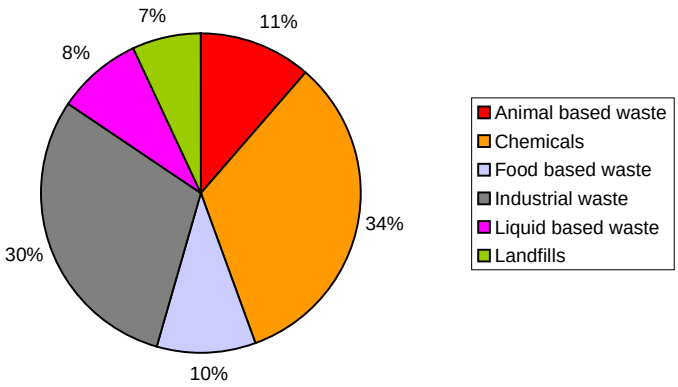


Figure 1: Distribution of key industry types within the Swan-Canning Catchment.

Priority sub-catchments based on total industries

The total number of key industries identified in each sub-catchment was highest in Mills Street Main Drain followed by Yule Brook, Southern River, Bannister Creek, Bennett Brook and Bayswater Main Drain (Figure 2).

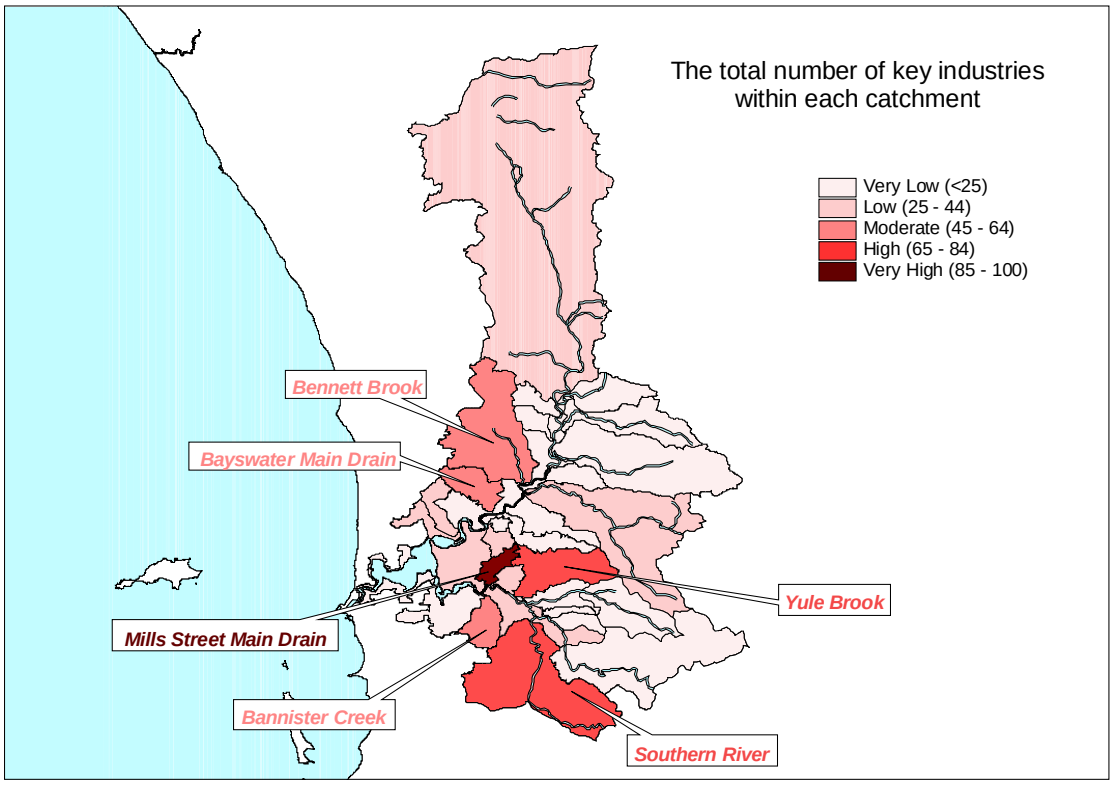


Figure 2: Total number of key industries within each sub-catchment.

Priority sub-catchments based on industry density

Once catchment size was taken into consideration the priority catchments altered. Mills Street Main Drain was also the sub-catchment with the highest density of key industries but this was now followed by South Belmont, the CBD, Bannister Creek, Bayswater Main Drain and Claisebrook Main Drain (Figure 3).

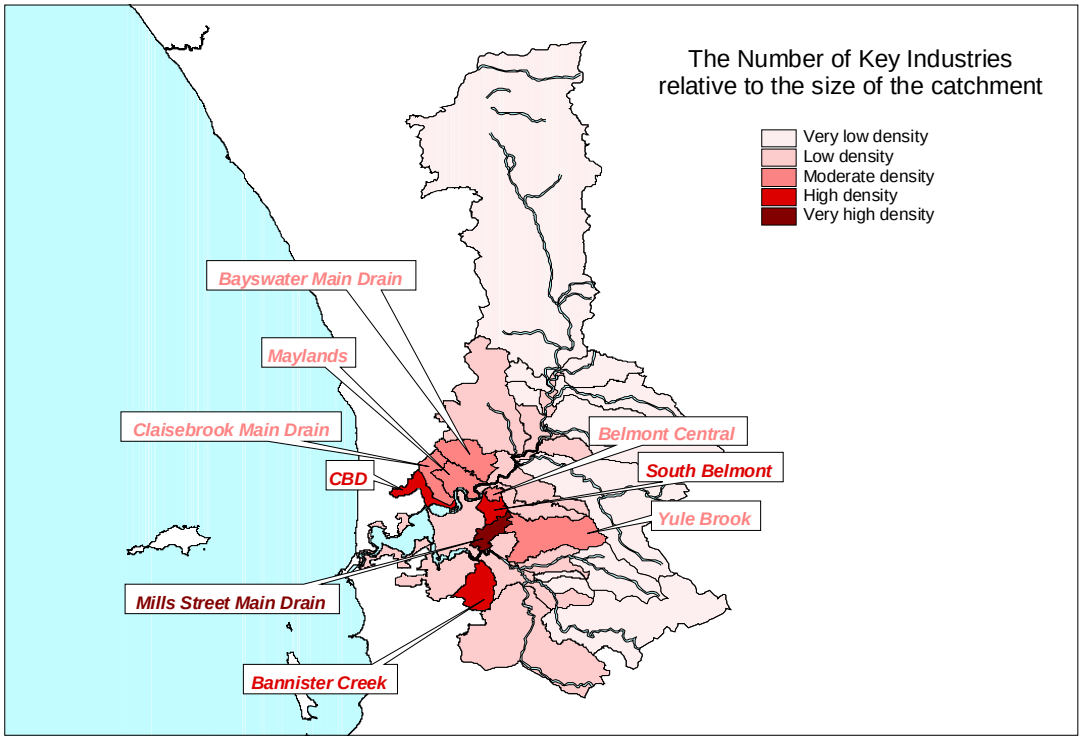


Figure 3: Density of key industries within each sub-catchment.

Priority sub-catchments based on individual industry density

When each individual industry type was analysed for its top five (density) sub-catchments, and these results combined, Mills Street Main Drain, South Belmont and Bannister Creek were the priority catchments (Figure 4).

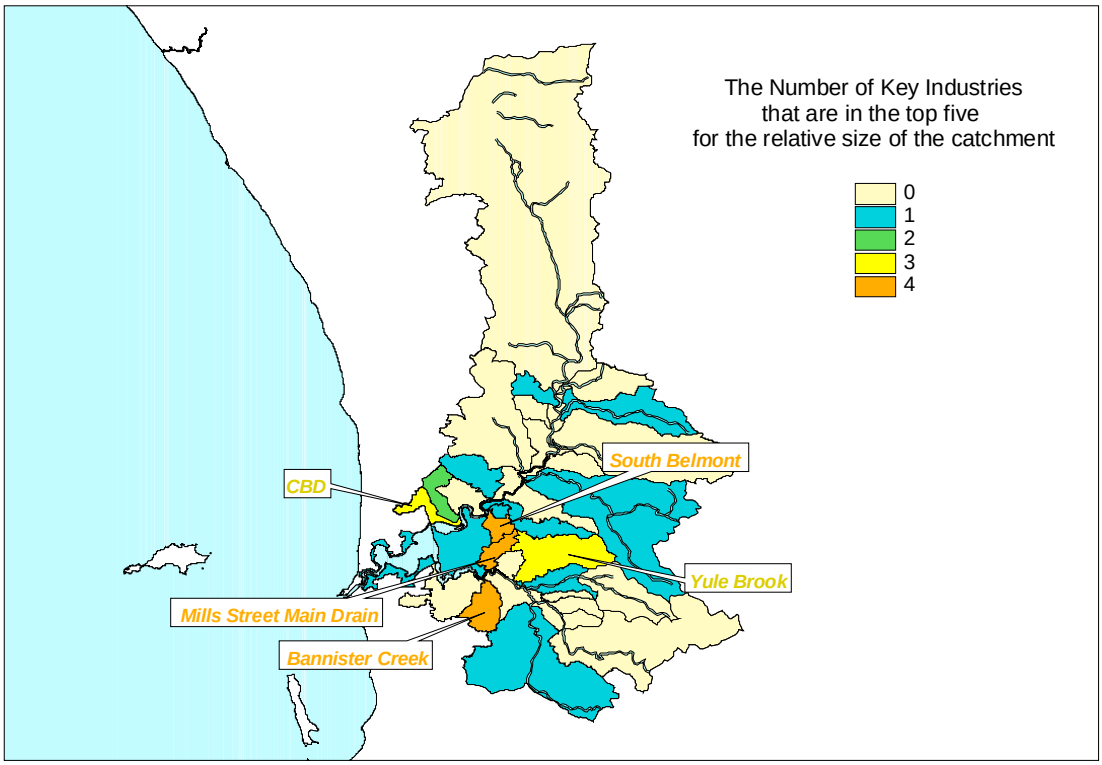


Figure 4: Priority sub-catchments based on individual industry densities.

RELATED PROJECTS

Current knowledge of catchment surface water quality condition

Water quality condition for monitored rivers in the Swan-Canning Catchment was determined by summarising monitoring data into a specific class as part of the Statewide Assessment of River Water Quality. Four classes were used to describe the range of conditions possible for total nitrogen (TN) and total phosphorus (TP) concentrations in surface waters. Classes ranged from near pristine (representing close to natural water quality), low (representing good water quality), high (representing potentially impacted water quality) to poor (representing severely impacted water quality). Data presented in this report represents surface water sampling in the 15 priority catchments identified by the Swan-Canning Cleanup Program (Appendix 2), for the 1991→1993 and 2001→2003 sampling periods.

Total nitrogen

Total nitrogen classifications for 1993 indicated that Mills Street Main Drain had the poorest classification, followed by Ellen Brook, Southern River and South Belmont (Figure 5). Ten years later (2003) total nitrogen concentrations within the catchment had generally improved, although Ellen Brook and Mills Street Main Drain were still classified as potentially impacted.

Total phosphorus

Total phosphorus classifications for 1993 indicated that Ellen Brook had the poorest classification followed by Mills Street Main Drain and Southern River, then South Belmont, Bannister Creek and Bayswater Main Drain (Figure 6). Ten years later (2003) Ellen Brook was still classified as poor while Mills Street Main Drain and Southern River had improved but were still potentially impacted. Southern River and South Belmont had improved slightly in the ten years however were still classified the same as they were in 1993. Yule Brook's total phosphorus classification worsened over the ten years and while the quality of the Helena River and the Upper Swan sub-catchments also appeared to decline they have fluctuated annually between the two cleanest classifications.

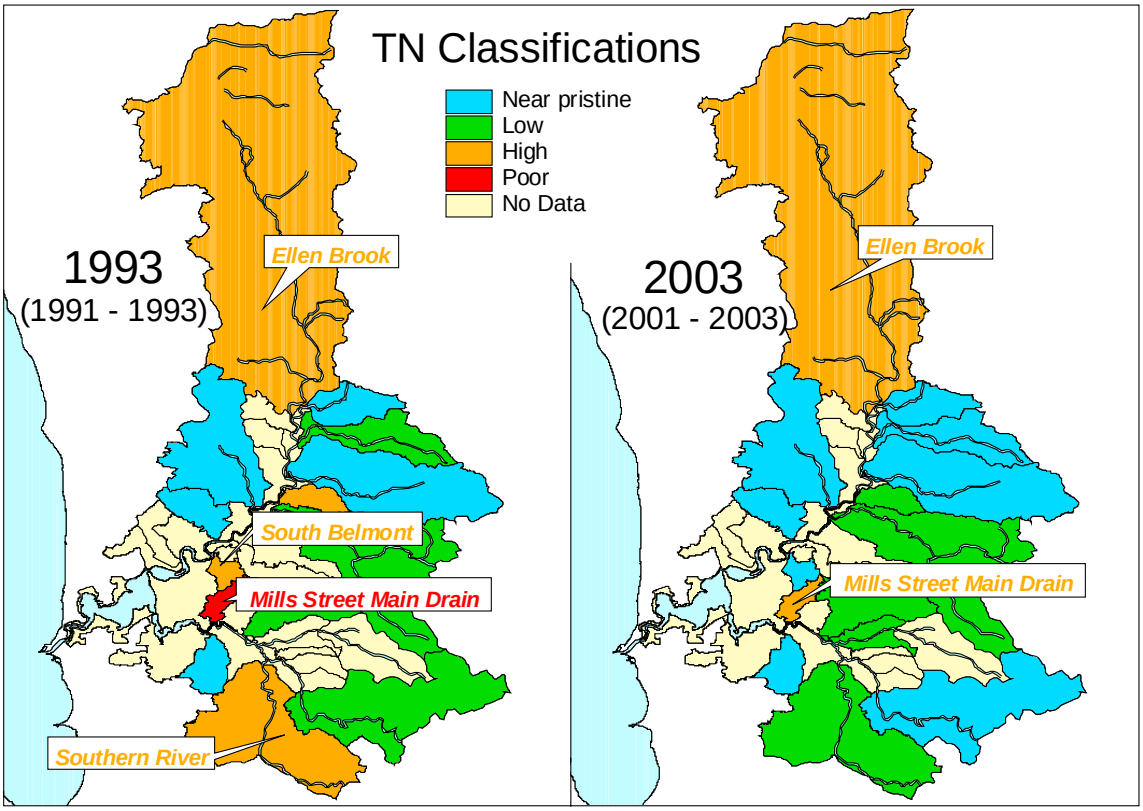


Figure 6: Total nitrogen classifications for the Swan-Canning Catchment.

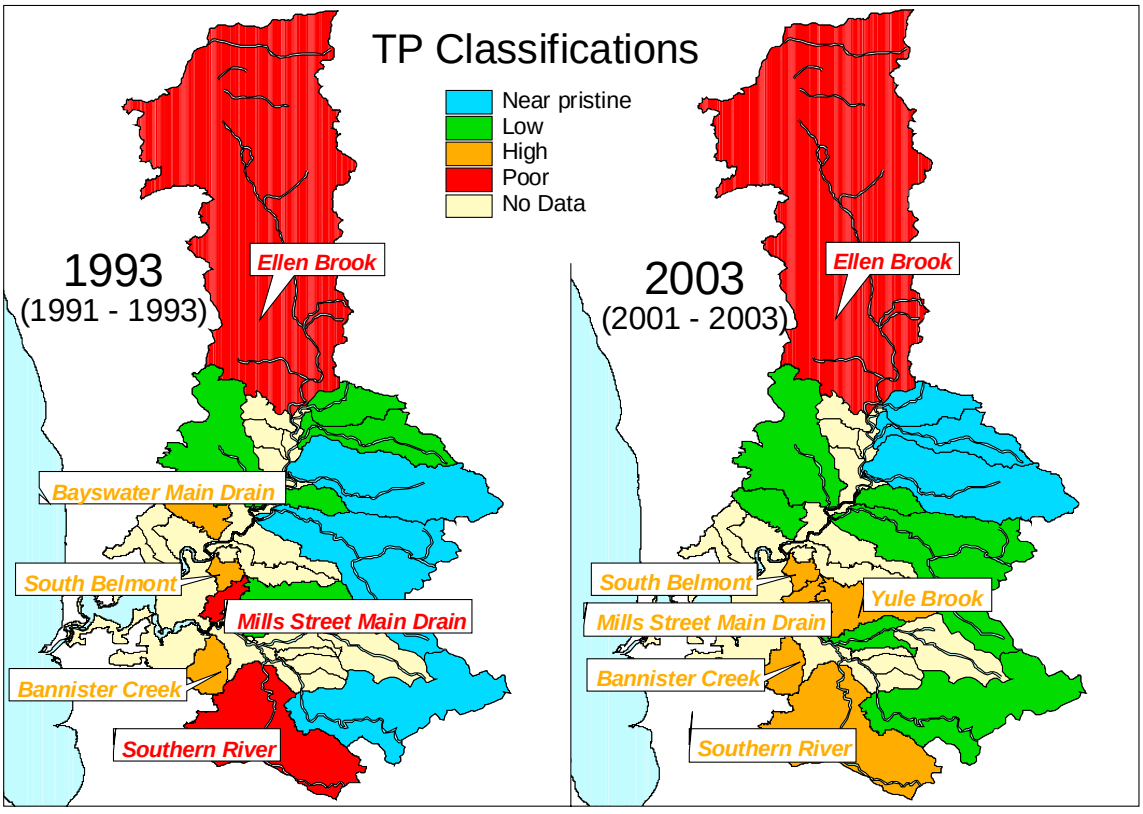


Figure 7: Total phosphorus classifications for the Swan-Canning Catchment.

Summary of monitoring initiatives within the Swan-Canning Catchment

Information on existing and proposed monitoring programs in the Swan-Canning river system has been collated as part of the Monitoring and Reporting task for the Drainage Reform Forum. The information was obtained largely through consultation with representatives from community and catchment groups, local, state and commonwealth government.

There are a number of different programs currently being conducted by the Swan River Trust, Local Government Agencies and various Community groups within the Swan-Canning Catchment (Figure 8). Ellen Brook currently has the greatest number of programs, followed by Mills Street Main Drain, Maylands and the Lower Canning. Of the 31 sub-catchments within the Swan-Canning, only 7 were identified as not currently being monitored. The sub-catchments lacking current monitoring are Belmont Central, Bullcreek, Helm Street, Henley Brook, Munday Brook, Saint Leonards Creek and the Upper Swan.

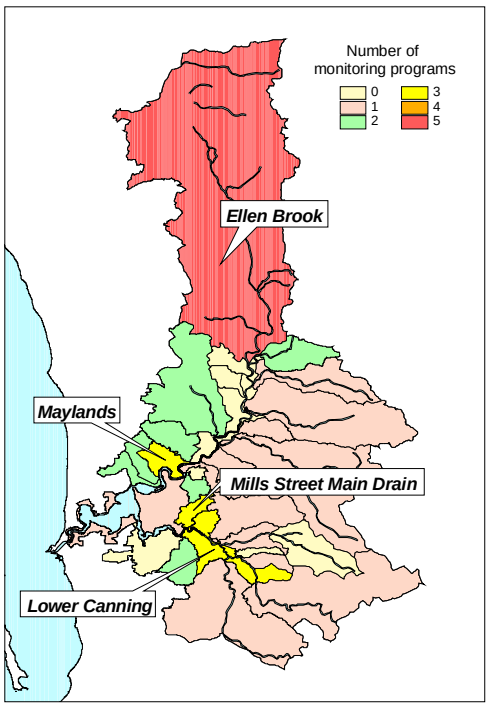


Figure 8: Number of monitoring programs within the Swan-Canning Catchment

KEY FINDINGS

Information relating to land use is used for a multitude of purposes such as future residential and rural development, industrial infrastructure and environmental management. Due to the varying needs of individual organisations different classification schemes for representing land use have been established. The majority of recognised Australian classification schemes are not appropriate for use in the environmental management of our surface and groundwater assets, as they don't necessarily encompass the wide range of potentially polluting activities that can (and do) occur.

This project identified several areas of concern when trying to assimilate data from different sources to identify areas of potential polluting industries. The major concerns related to the storage and classification of the information, which varied depending on the custodian. Some datasets provided multiple locations for one record while others had multiple records for one location. There was also concern about the duplication of sites across data sets, not that premises were represented in multiple data sets, but that their classifications differed, causing confusion about primary land use.

Analysis of the six data sets indicated that Mills Street Main Drain, South Belmont, the CBD and Bannister Creek were the sub-catchments that had the highest density of potentially polluting industries (PPI's). Mills Street Main Drain, South Belmont and Bannister Creek followed by the CBD and Yule Brook had the highest risk from PPI's. The three sub-catchments that were highlighted in all three PPI analyses (total number, density and risk) were Mills Street Main Drain, Bannister Creek and Yule Brook.

The sub-catchments highlighted as priorities were also noted as having potentially impacted total phosphorus concentrations. While Ellen Brook and Southern River are the sub-catchments with the most impacted nutrient concentrations, they did not appear to be a priority within this framework due to their greater abundance of diffuse sources opposed to PPI's.

Belmont Central was identified as having a moderate density of PPI's and, along with Henley Brook, was identified as having one industry in the "top 5 by density". Neither of these sub-catchments are currently monitored.

RECOMMENDATIONS

- Continue to capture, standardise and reclassify data sets relating to historic and current land use into a visually viable (spatial) format.
- Promote the inclusion of standardised premises location in corporate data sets enabling them to be visually viable (minimum of site coordinates; preferably captured in ArcView).
- Ground truth the key data sets including land use type and location of noxious industries.
- Interview knowledgable staff in the DoE to identify additional historical sites that may be contributing to current diffuse contamination sources.
- Undertake sampling and analysis programs in identified high-risk catchments to further refine understanding of sources.
- Incorporate spatial data sets into existing catchment DSS models for the purpose of identifying appropriate management actions.

APPENDICIES

Appendix 1: Broad acre land use within the Swan-Canning Catchment

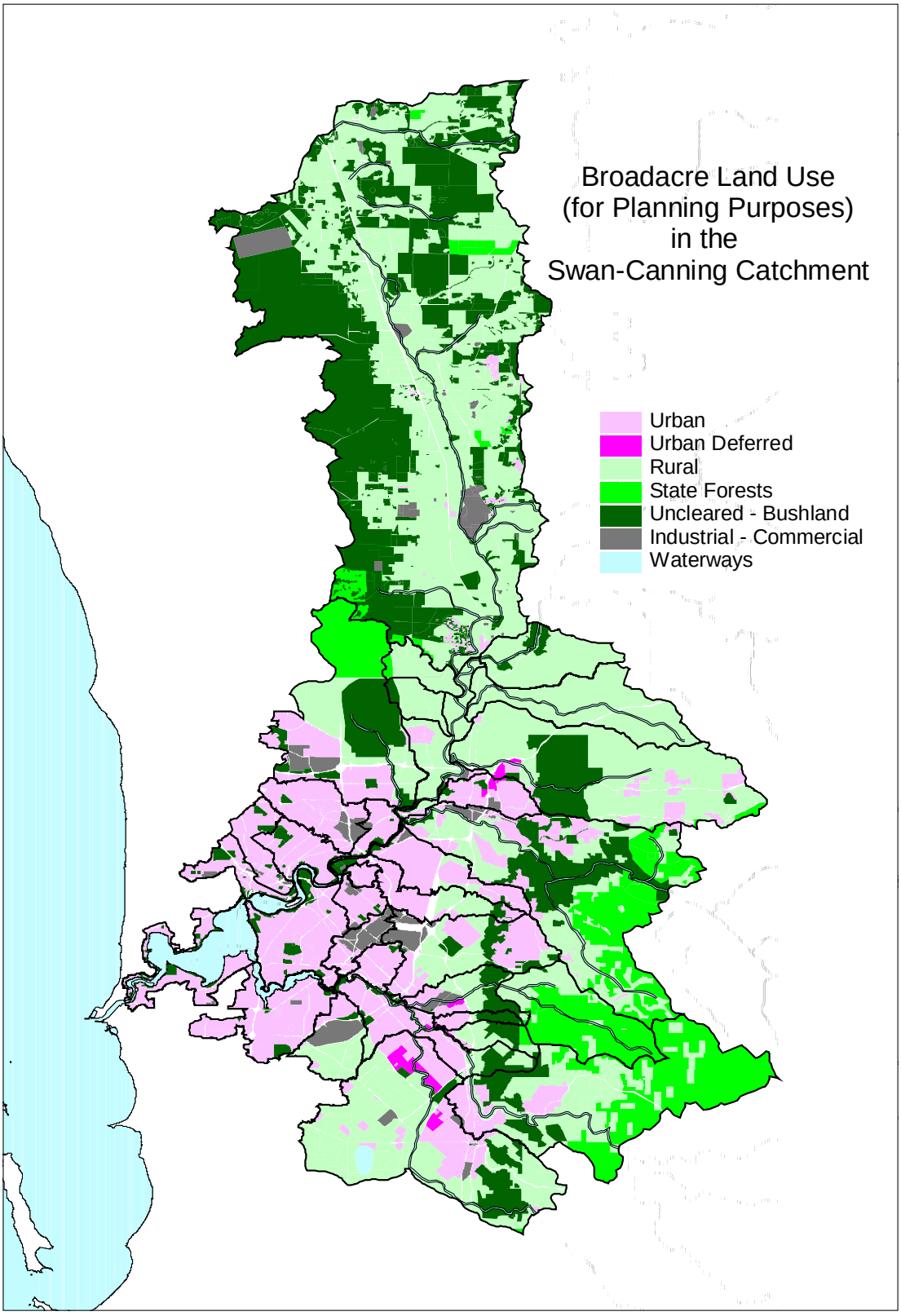


Figure 9: Broad acre land use (for planning purposes) within the Swan-Canning Catchment.

Appendix 2: Swan-Canning sub-catchments

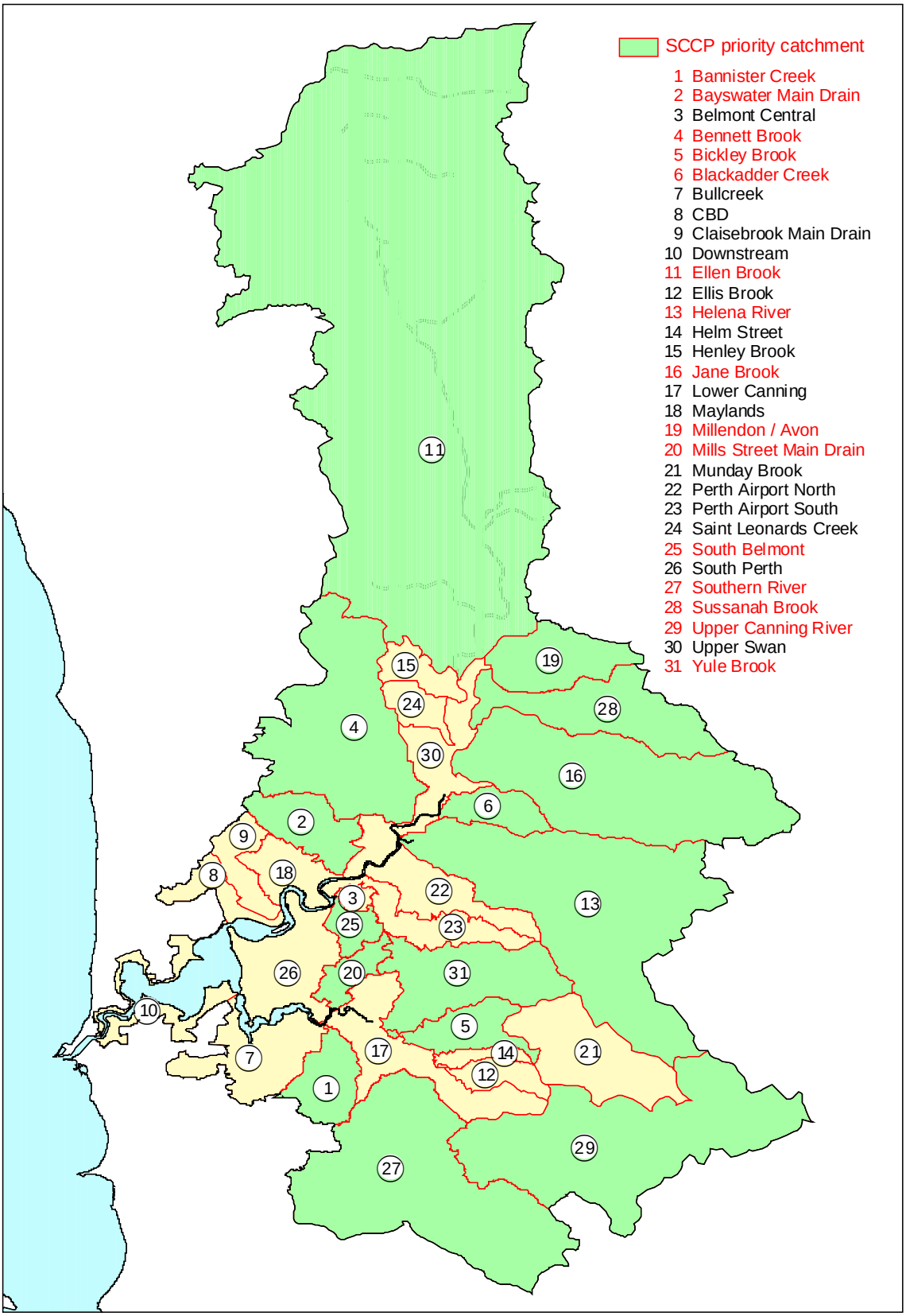


Figure 10: Swan-Canning Catchment showing SCCP priority catchments.

INSTITUTIONAL ARRANGEMENTS FOR MANAGEMENT OF WATER QUALITY IN THE SWAN-CANNING CATCHMENT

PRODUCED FOR THE DEPARTMENT OF THE ENVIRONMENT

PRODUCED BY: GEORGE BOUMA (MURDOCH ENVIRONMENT), AND DAVID ANNANDALE (SCHOOL OF ENVIRONMENTAL SCIENCE, MURDOCH UNIVERSITY)

MARCH 2004



1. INTRODUCTION

The primary purpose of this project was to identify the most appropriate institutional governance models necessary to achieve improved water quality in the Swan-Canning catchment. Due to its genesis in the Drainage Forum of November 2003, the project focused substantially on reform of the 'drainage function'.

The Terms of Reference supplied to the project by the Department of Environment required the consultancy to:

1. Identify existing processes and responsibilities for the planning, design, construction and management of drainage systems.
2. Identify improved processes to achieve better water quality outcomes.
3. Develop a management model(s) to achieve improved water quality outcomes.
4. Identify steps required to implement the new model(s).

The consultancy took place over a 6-week period in January and February 2004. It was based in a straightforward methodology of stakeholder consultation and review of previous work. Before starting the project we had the view that we would need to look beyond WA to find appropriate alternative governance models. It became obvious early on, however, that a substantial amount of thought and prior study has already been undertaken on this issue in WA. We found 10 studies and/or comments on the issue of institutional reform for drainage that have taken place in the last 4 years. We were also aware that some stakeholders have been involved in many consultations on this issue in recent years.[1]

With this in mind, the consultancy came to focus more pointedly on evaluating the alternatives that have been presented on institutional reform for drainage in the Swan-Canning catchment by previous commentators. What this project offers, therefore, is the most rigorous analysis yet undertaken of all of the possible governance model alternatives presented in recent years.

This report consists of 9 sections, and 2 appendices. Section 2 begins the report proper by outlining what the stakeholders believe are the 'problems' with governance

[1] At the Drainage Forum on November 24/25 2003, the UDIA claimed to have participated in 11 such discussions in recent years.

structures as the currently exist. It moves on in Section 3 to examine the existing processes and responsibilities for the planning and management of drainage systems. This section reviews both the legal underpinnings, and the institutional/policy overlay of the system that we currently work within. Section 4 of the report briefly lists the collection of recent work on drainage governance models.

Section 5 and Section 6 move the report towards evaluation of governance models, by outlining the criteria that might be used to compare all of the alternatives, and by presenting the alternatives themselves. The criteria and the alternative governance models were obtained from the stakeholder interviews, and from the review of previous reports.

Section 7 consists of the evaluation of 15 alternative governance models against 15 criteria. This complex comparison required the use of multi-criteria analysis software to sort through the alternatives and rank them.

Section 8 discusses the highest ranked management model alternatives, and Section 9 lists the references used in the consultancy. Appendix 1 presents the outcome of the multi-criteria analysis work, and Appendix 2 consists of the list of interviewed stakeholders.

2. WHAT ARE THE PROBLEMS WITH GOVERNANCE STRUCTURES?

One thing that can be stated with certainty is that there is a profound sense of discomfort with the way in which the drainage function is governed in WA, and particularly in the Perth metropolitan region. All of the reports reviewed for this consultancy, and all of the people interviewed, claimed that there were problems with institutional arrangements for drainage. Concerns covered the spectrum from high-level policy-setting, through to the maintenance of local drains.

In brief, the most consistent concerns were expressed as follows:

* Land use planning is occurring in the absence of prior consideration of environmental outcomes.

* Planning is not occurring in an holistic way. Rather, planning occurs to meet the needs of a specific parcel of land. The current planning system is ad hoc, and works "subdivison by subdivision".

* Responsibility for drainage in the Perth metropolitan area is fragmented. There are too many managers. Approximately 80% of the urban drainage network (local drains) is managed by 29 local authorities, with the Water Corporation managing the remaining 20% (main drains).

* Drainage should be managed on a total water cycle basis. The nutrient problem must be tackled at source, and the focus should shift from flood control to quality control.

* Groundwater modelling and monitoring is not occurring in a planned, systematic way.

* The relationship between groundwater, drainage, and water quality is not well understood.

The ANU (2003, p.10) report summarizes the perceived 'failure of institutional governance' with the following statement:

> " historically the various public authorities involved in drainage have had different priorities and responsibilities, and the plethora of State and regional natural resource, planning, and environmental strategies, rather than providing a clear strategic direction, have tended to further compound the complexity and lack of

accountability for outcomes. Many stakeholders point to a lack of clarity and appropriate demarcation between the setting of overall statutory policy for drainage management, responsibility for statutory compliance (including within different arms of government) and regulatory enforcement, and operational planning and service delivery by government departments, utilities and local authorities".

3. EXISTING PROCESSES AND RESPONSIBILITIES FOR THE PLANNING AND MANAGEMENT OF DRAINAGE SYSTEMS

3.1 Introduction

The previous section supported the view that governance for drainage in WA is fragmented. So significant is this problem that even describing the existing institutional framework is a substantial task. In this section of the report, we start by attempting to define the legal basis of the existing drainage governance model. We then go on to outline the collection of institutions and policies that underpin the law.

3.2 Law Relating to Drainage

3.2.1 Introduction

The planning and management of drainage in WA is controlled by water law, land use planning law, and environmental protection law. In Section 3.2.2 and Section 3.2.3 we examine these laws as they relate to construction of drainage systems, and management and regulation of drainage systems.

3.2.2 Construction of Drainage Systems

Subject to obtaining all necessary approvals (see below) the owner of freehold land may undertake drainage works on his or her property.

However, these works are likely to be relatively minor in both number and scope compared to the drainage works carried out by the various local governments and the Water Corporation as part of their public works programs. This is even more likely to be the case in the Swan-Canning catchment, which contains a relatively high proportion of urbanised, densely populated land.

Local government

The general function of a local government is to provide for the good government of people in its district.[2] One of the executive functions that local government may exercise is to undertake drainage works and these may be done on any land, even land that is not local government property.[3] This may be done without the consent of the owner or occupier of the land unless the land is outside the local government district.[4]

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[2] Local Government Act 1995, s3.1
[3] Local Government Act 1995, s3.27(1), Schedule 3.2
[4] Local Government Act 1995, ss3.27(1) and 3.20

However, notice must be given to the owner or occupier of the land unless the work needs to be done in response to an emergency.5 Further, compensation may be payable to the owner or occupier of the land should they sustain damage as a result of the local government's actions.6

Water Corporation

The Water Corporation also has powers to carry out drainage works. The functions of the Corporation include the collection and disposal of surplus water.7 These functions are performed under the provisions of the Land Drainage Act 1925, which provides for the Corporation to construct and maintain drainage works within drainage districts.8

The Land Drainage Act 1925 also allows the Corporation to make arrangements with landowners within a drainage district for the construction of branch drains to drain their land.9

In performing its functions under the Land Drainage Act 1925, the Corporation has wide powers, including the power to enter land.10 Entry onto any land not owned by the Corporation is subject to similar requirements with regard to consent, notice and compensation as those that bind local governments.11 However, the Land Drainage Act provides for the reduction of any compensation payable by the value of any benefit accruing to the owner or occupier as a result of the drainage works.12

The Corporation is also bound by additional public notice requirements contained in Part VIII, Division 2 of the Water Agencies (Powers) Act 1984 and requires the authorisation of the Minister to carry out major works.

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[5] Local Government Act 1995, ss3.32 and 3.34
[6] Local Government Act 1995, s3.22
[7] Water Corporation Act 1995, s27
[8] Land Drainage Act 1925, s60
[9] Land Drainage Act 1925, s61
[10] Water Agencies (Powers) Act 1984, s83. NB: This does not appear to extend to the performance of the functions of the Corporation pursuant to the Water Corporations Act, which is not a relevant Act for the purposes of the Water Agencies (Powers) Act (see section 5(1)).
[11] Water Agencies (Powers) Act 1984, ss70, 72, 74 and 62
[12] Land Drainage Act 1925, s65A

Arterial drains, main drains and drainage courses

Local governments and the Water Corporation are primarily responsible for the provision of drains, drainage works and drainage services. However, the responsibility for the overall planning and co-ordination of drainage services within the metropolitan area, which includes a large proportion of the Swan-Canning Catchment, rests with the Water and Rivers Commission who administer the Arterial Drainage Scheme pursuant to the Metropolitan Water Authority Act 1982.13 The Commission is further responsible for the over-all administration of arterial drainage works included in the Scheme notwithstanding that the management or control of a particular arterial drain or drainage work may be vested in somebody else.14

The Act also allows the Corporation to declare some existing or proposed drains as main drains.15 The Corporation has the control and management of all main drains.16 Any person or local government authority that loses control of a drain as a result of it being declared a main drain is not entitled to compensation.17 Before a drain can be declared a main drain the Corporation must publish a notice of the proposed declaration in the Gazette and any person aggrieved then has one month to object to the declaration.18

The declaration of a drain as a main drain is significant as the Act includes a number of offence provisions concerning the obstruction of, or interference with, main drains as well as regulating the way in which other drains may connect with the main drain.19

The Corporation can also require the owner or occupier of any land that in the opinion of the Corporation benefits from or contributes to the need for a main drain to enter

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[13] Metropolitan Water Authority Act 1982, s98
[14] Metropolitan Water Authority Act 1982, s99
[15] Metropolitan Water Authority Act 1982, s100. NB: for limitations on power to declare see s100(5).
[16] Metropolitan Water Authority Act 1982, s100(1)
[17] Metropolitan Water Authority Act 1982, s100(4)
[18] Metropolitan Water Authority Act 1982, s100(9)
[19] Metropolitan Water Authority Act 1982, ss101 and 102

into an agreement with the Corporation.[20] These agreements deal with the provision of works or water services necessary for drainage purposes.[21]

The Commission as part of the preparation and revision of the Arterial Drainage Scheme may identify land as drainage courses.[22] Drainage courses consist of an area of land around an arterial or main drain sufficient to contain the drainage works associated with that drain.[23] The Commission must advertise the delineation of drainage courses for public submissions and objections.[24]

A planning authority must have regard to the existence of a drainage course (and the associated requirements for drainage works) when determining what conditions to impose upon a development or subdivision on land that includes part of a drainage course.[25]

The Corporation may, subject to compliance with the works provisions of the Water Agencies (Powers) Act 1984 do drainage works in a drainage course.[26]

3.2.3 Management and Regulation of Drainage Systems

Local Government

Local authorities make most planning decisions related to development approvals[27]. In this context development is broadly defined and includes the carrying out on land of any excavation or other works. The definition is sufficient to include all drainage works.[28]

Each local government may prepare a Town Planning Scheme for its district (or may be required to do so by the Minister for Planning and Infrastructure) and must make subsequent planning decisions in accordance with the scheme.[29] The differences between the districts mean that there are inevitably differences between Town

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[20] Metropolitan Water Authority Act 1982, s105
[21] Metropolitan Water Authority Act 1982, s105
[22] Metropolitan Water Authority Act 1982, s98(3)(d) and 106
[23] Metropolitan Water Authority Act 1982, s106(1)
[24] Metropolitan Water Authority Act 1982, s106(2)
[25] Metropolitan Water Authority Act 1982, s107
[26] Metropolitan Water Authority Act 1982, s108
[27] Except within redevelopment areas, which are usually subject to a separate statutory regime. Relevant redevelopment areas are Midland, East Perth and possibly Subiaco.
[28] Town Planning and Development Act 1928, s2(1)
[29] Town Planning and Development Act 1928, ss7(1) and 18

Planning Schemes. However, Town Planning Schemes prepared since October 1999 must be broadly in line with the Model Scheme Text contained in the Town Planning Regulations 1967, Appendix B.30 As part of the process for creating or modifying a town planning scheme the scheme or the variation must be referred to the Environmental Protection Authority for Environmental Impact Assessment (see below).31

Town Planning Schemes control development by dividing districts into zones. Within each type of zone, certain land uses and associated developments may be permitted, prohibited or allowed subject to the approval of the local government. If the development is allowed subject to approval, the scheme may provide for different means of public consultation before the local government makes its decision. Approval may be granted subject to conditions.

It is an offence to proceed with any development without an approval required by the relevant Town Planning Scheme or in contravention of any condition imposed on the approval. A maximum fine of $50,000 applies with a maximum daily penalty of $5,000 for continuing offences.32 The developer may be forced to remove or rectify the development or the local government may do so and recover the cost from the developer.33

Government departments and local governments performing public works (including drainage) are not generally required to obtain approval for that work.34 However, the work should conform to the scheme as much as possible and the local government must be consulted before the work is done.35 Local government approval pursuant to a Town Planning Scheme may be required within the area covered by the Perth Metropolitan Region Scheme.36

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[30] Town Planning Regulations 1967, reg.11(1) and Appendix B
[31] Town Planning and Development Act 1928, s7A1
[32] Town Planning and Development Act 1928, s10(7)
[33] Town Planning and Development Act 1928, s10(3) and (8)
[34] Town Planning and Development Act 1928, s32
[35] Town Planning and Development Act 1928, s32(a) and (b)
[36] City of Bayswater v Minister for Family and Children's Services, unrep., Sup. Ct. (WASC 151), 1 June 2000

Western Australian Planning Commission

The Western Australian Planning Commission (WAPC) is responsible for planning at the regional and state levels (as well as for subdivisions). It is also responsible for developing planning policies and guidelines and providing advice to local governments on the preparation and amendment of town planning schemes.

The WAPC has delegated responsibility for deciding most development applications to local governments. The exceptions to this are planning control areas, those developments referred to in clause 29 of the Metropolitan Region Scheme, and areas covered by the Redevelopment Authorities.

The WAPC may, with the approval of the Minister for Planning and Infrastructure, declare any land within the metropolitan region, except any land or waters within the management area of the Swan River Trust,37 to be a planning control area by publishing a notice to that effect in the Gazette.38 If the land is in the Swan Valley the WAPC must invite the Swan Valley Planning Commission to make submissions on the matter before seeking the approval of the Minister.39 Similarly, the WAPC must consult the Heritage Council if it is of the opinion that the Heritage of Western Australia Act 1990 applies to any of the land the WAPC wants to declare a planning control area.40

No development may occur within a planning control area without the approval of the WAPC.41 Applications for approval must be lodged with the relevant local government who must forward the application together with its recommendation concerning the development to the WAPC within 30 days.42 The WAPC can approve the development subject to conditions.43

It is an offence to proceed with any development without the WAPC's approval, or in contravention of any condition imposed on the approval.44 The developer would be

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[37] Metropolitan Region Town Planning Scheme Act 1959, s35B(3)
[38] Metropolitan Region Town Planning Scheme Act 1959, s35C(1)
[39] Metropolitan Region Town Planning Scheme Act 1959, s35C(5)
[40] Metropolitan Region Town Planning Scheme Act 1959, s35C(4)
[41] Metropolitan Region Town Planning Scheme Act 1959, s35D
[42] Metropolitan Region Town Planning Scheme Act 1959, s35E
[43] Metropolitan Region Town Planning Scheme Act 1959, s35E(3)
[44] Metropolitan Region Town Planning Scheme Act 1959, s35D

liable for a fine of $2,000 and a daily fine of $200 for continuing offences, although the relevant Region Planning Scheme may prescribe further fines.45

Government departments and local governments performing public works must obtain any approvals required under the Metropolitan Region Scheme.46

Swan River Trust

Where a development is to occur entirely on land managed by the Swan River Trust and is neither within a local government district or abutting a local government district then applications for development approval are lodged with the Trust.47

The Trust must then consult with each public authority that has relevant functions and each local government for whom the development is a relevant matter (usually as a result of proximity to the local authority's district).48

The Trust must notify the public and allow for submissions if it considers that the development is of significant public interest or the Minister for the Environment directs it to do so.49

The Trust must then prepare a report for the Minister, which must include any advice received from public authorities or local governments that were consulted and a summary of any submissions received.50 The Minister must send a copy of the report to anyone who commented or made a submission.51

The Minister must then decide whether or not to approve the development.52 Alternatively, the Minister may remit the matter to the Trust for reconsideration or appoint a review committee for the same purpose.53

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[45] Metropolitan Region Town Planning Scheme Act 1959, s35D, see also Peel Region Scheme, Part 5.
[46] City of Bayswater v Minister for Family and Children's Services, unrep., Sup. Ct. (WASC 151), 1 June 2000
[47] Swan River Trust Act 1988, s52(1)(b)
[48] Swan River Trust Act 1988, s53
[49] Swan River Trust Act 1988, s54
[50] Swan River Trust Act 1988, s55(1) and see Trust website www.wrc.wa.gov.au/srt follow Approvals Process link.
[51] Swan River Trust Act 1988, s55(2)
[52] Swan River Trust Act 1988, ss56(1)(a) and 59
[53] Swan River Trust Act 1988, ss56(1)(b) and 57

This procedure does not apply to land within the Midland or East Perth redevelopment areas or to developments lawfully being carried out immediately before the commencement of the Swan River Trust Act 1988.54

If a development is to occur on land partly within the area managed by the Trust and partly within a local government district or on land wholly within the management area that abuts a local government district the development application must be sent to the local government. The local government then has 14 days to forward the application to the Trust together with their advice as to how to decide the application.55 The procedure is then the same as above.

Clause 30A of the Metropolitan Region Scheme contains a different procedure for development approvals for land covered by the Metropolitan Region Scheme that abuts waters managed by the Trust.

In this case development applications are lodged with the local government who forwards them to the Trust. The Trust reports to the Minister for the Environment. The Minister for the Environment advises the Minister for Planning and Infrastructure as to how to decide the application. The Minister passes this advice to the WAPC and the WAPC then decides in accordance with the advice.

Clause 30A also sets out a procedure to be followed for development applications for land abutting land managed by the Trust or likely to affect waters managed by the Trust.

The application is lodged with the local government who must seek advice from the Trust. In the event that the local government does not want to follow the Trust's advice, the application must be sent to the WAPC for determination.

Environmental Protection Act

The *Environmental Protection Act* allows for regulation of drainage development through the EIA process, through licensing of developments, and by way of promulgation of Environmental Protection Policies.

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[54] Swan River Trust Act 1988, s49(5) and (3)
[55] Swan River Trust Act 1988, s52(1)(a) and see website

The Environmental Protection Authority (EPA) can assess proposals that are likely, if implemented, to have a significant effect on the environment.56

The definition of proposals is very broad57 and would include any drainage works and any determination concerning future drainage works that has legal effect (but not plans etc that merely make recommendations).58

Any person can refer a proposal to the EPA.59

Decision-making authorities such as local governments, the Commission or the Swan River Trust must refer a proposal to the EPA if they believe that it is likely, if implemented, to have a significant effect on the environment.60

It should also be noted that the *Environmental Protection Act* provides powers to develop Environmental Protection Policies (of which the Environmental Protection [Swan and Canning Rivers] Approval Order 1998 is an example) and to develop Regulations that might be used to set drainage standards, and to 'prescribe' drains.

3.3 The Institutional and Policy Structure

Section 3.2 has provided an indication of the fragmentation of the legislative system as it relates to drainage. The institutional and policy underpinning is even more difficult to grasp. Table 1 presents an outline of roles and responsibilities in water resources management, as defined by URS (2003).

[56] Environmental Protection Act 1986, Part IV
[57] Environmental Protection Act 1986, s3(1)
[58] Case authority? See EDO Fact Sheet
[59] Environmental Protection Act 1986, s38(1)(b)
[60] Environmental Protection Act 1986, s38(1)(a)

Table 1: Roles and Responsibilities in Water Resources Management in WA

Organisation	Function					
	Policy	**Strategic Planning**	**Local Planning**	**Site Planning**	**Management**	**Monitoring**
State Water Taskforce	Implement State Water Strategy	Advise and review				
Natural Resources Management Council	NRM policy advice to Cabinet	Advice and review				
Floodplain Management Council	Floodplain management advice to Cabinet	Advise and review				
Catchment Councils	Advice to Peak Bodies	Catchment NRM strategies	Ensure NRM included in sub-catchment strategies	Advise and review		
WAPC	Advice to Minister, preparation of SPPs	Statutory region schemes. Approve/advise/review	Town planning schemes. Approvals	Subdivision plans. Approvals		
DPI	Advice to Peak Bodies. Management of SPPs	Incorporate WRM in structure planning	Ensure WRM included in TPSw	Site approvals if relevant		Advise and review
DoE	Develop State Policy. Management of EPPs	Undertake strategic WRM planning at catchment scale	Ensure WRM included in sub-catchment plans	Advise and review	Licensing/allocations, advise management	Undertake, review outcomes, advise EPA
DAWA	Advice to Peak Bodies. Management of SLCA	Support strategic WRM planning at catchment	Support WRM planning at sub-catchment	Advise and review	Inland drainage approvals, advise management	Review outcomes, advise EPA
SRT	Advice to planning authorities	Advice on nutrient targets for the Swan and Canning river system, implementation of Riverplan (Swan-Canning EPP)	Ensure targets addressed in planning	Advise and review	Advise management	Review outcomes, advise EPA
Water Corp	Advice to Peak Bodies	Advise and review, especially in stormwater use	Contribute to local planning and design	Contribute to detailed design	Advise/ manage services	
WALGA	Advice to Peak bodies, I.G policy	Advise and review				
ROCs*						
Local Governments (LG)		Support strategic WRM planning at catchment	Coordinate WRM planning at sub-catchment	Contribute to detailed design	Advise/ manage services	Monitor own inputs (ICLEI)
OWR	Advice to Peak bodies				Licensing, regulate service providers	Review and advise
Treasury	Advice to Peak bodies				CSO arrangements	Review and advise
Community NRM groups		Support strategic WRM planning at catchment	Support strategic WRM planning at sub-catchment			

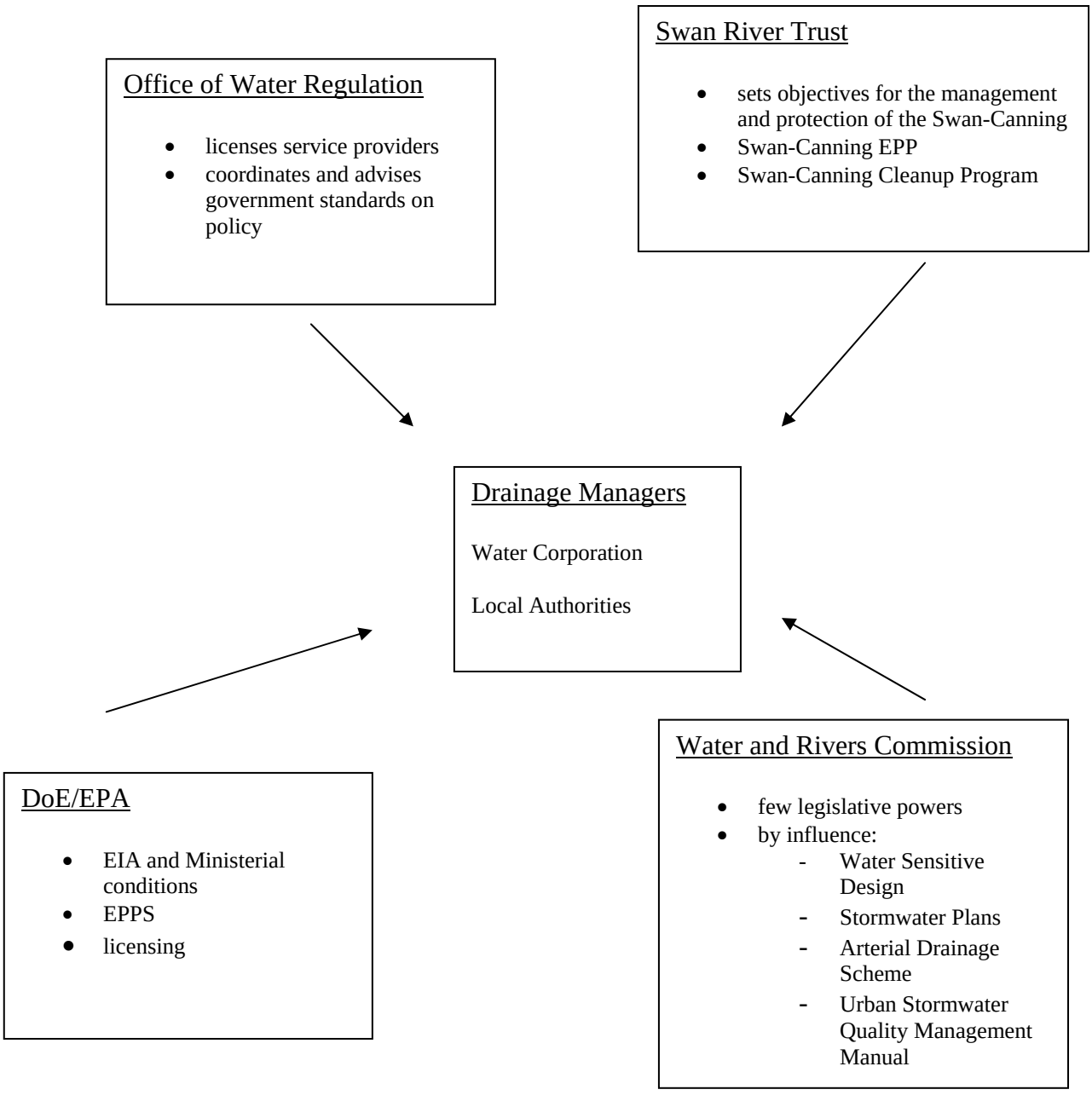
Industry rep bodies	Advice to Peak bodies, DoE, DPI	Advise and review	Advise and review	Advise on management needs	Advise management	
Land use industries	Advice to Peak bodies, DOE, DPI	Support strategic WRM planning at catchment	Support WRM planning at sub catchment	Detailed design work	Advise/ manage services	
Service providers			Advise on service needs	Advise on service needs	Service provision	Undertake monitoring
EPA	Advice to Minister	Advise and review as required, strategic assessments		Approvals if required		Review and advise

Source: URS (2003)

In addition to all of this, ANU (2003, appendix 2) has listed 76 laws, strategies, or plans that are relevant to drainage in the Swan-Canning Catchment.

In combination, Section 3.2 and Table 1 make it difficult to discern a pattern of institutional arrangements for drainage in the Swan-Canning Catchment. We believe that Figure 1 summarizes this information in a simpler form.

Figure 1: Summarized Institutional Arrangements for Drainage Management in the Swan-Canning Catchment



Source: Strategic Environmental Solutions (2002), Advice to EPA Chairman on Drainage. Final Report, May 8.
Note: Since 2002, the Office of Water Regulation's functions have been split between the Economic Regulation Authority, and the Office of Water Policy.

4. RECENT WORK ON DRAINAGE GOVERNANCE MODELS

Alternative governance models for drainage management in Perth have been extensively studied in research projects and stakeholder meetings. It is fair to say that the issue has been 'overstudied' in recent times. There are now almost too many options, and too many studies that come to different conclusions. It is perhaps not surprising that governments have found it difficult to proceed with institutional reform, given the plethora of conflicting advice that has been presented over the course of the last 5 years. This consultancy attempted to review all of the recent work that has proposed models for drainage governance. In our view, and in no particular order, the most significant efforts include the following:

Gunningham, N., Rutherford, P., Gordon, S. and Eames, R. (2003), Regulatory Design for Water Quality Management in Perth, Western Australia: Institutional and Governance Issues. School of Resources, Environment and Society: Australian National University

CSIRO Land and Water (2004), Reforming Drainage: Moving Towards Total Water Cycle Management in Western Australia. Draft White Paper prepared for the Drainage Reform Group.

URS (2003), A Discussion Paper on Drainage Reform in WA. Prepared for the Drainage Reform Group

Strategic Environmental Solutions (2002), Advice to EPA Chairman on Drainage. Final Report, May 8.

Water Corporation (2001), Urban Drainage in Western Australia: An Overview of its Environmental Effects and Current Administrative Arrangements. Infrastructure Planning Branch/Environment Branch.

Author Unkown (2001), Discussion Paper on Stormwater Management in Western Australia – A Way Forward. Presented at EPA Meeting on 8/11/2001.

Water Corporation: Water Cycle Project (2004), Models of Management for Urban Drainage.

Cox, W. (2003), Managing Drainage in the Swan-Canning Catchment: Institutional Arrangement Options. Presentation to the Drainage Forum, November.

Some of this work proposed, and justified, one model. Others outlined more than one alternative, and did a more or less rigorous job of evaluating them. The purpose of this consultancy was to look at all of the proposed models, and to evaluate them in as rigorous a fashion as possible.

5. CRITERIA FOR COMPARING AND EVALUATING GOVERNANCE STRUCTURES

The main purpose of this project is to compare and contrast governance options for drainage management in the Swan Canning Catchment. Making comparisons requires the development of criteria against which the various options can be assessed.

Only some of the studies mentioned in the previous section have attempted to systematically compare alternative governance structures. Dr Cox's presentation at the Drainage Management Forum in August 2003, compared four governance options against six "guiding principles" that are effectively evaluation criteria.[61] The October 2003 URS report prepared for the Drainage Reform Group, compared "proposed arrangements for planning and management in drainage" against a series of "tasks" or "stages". These were listed in a hierarchy from high-level policy development, down to detailed planning at the site scale.

Other reports have used comparison criteria in a less explicit manner. For example, the ANU 2003 report examined four options for institutional governance, but did not explicitly compare them against consistent criteria.

In our view, a rigorous examination of possible institutional arrangements necessarily requires the development of a transparent list of evaluation criteria. This is especially the case when there are many options, and many ways of comparing them. It is arguably possible to undertake a comparison of 3 or 4 options against a small number of implicit criteria, and make a reasoned decision as to the best outcome. The psychology literature indicates that this kind of approach will not work, however, when there are more than 4 options and 7 criteria. In addition, we believe that in complex policy situations, decision-makers usually attempt to satisfy more than one objective simultaneously. Often these objectives can meet all of the so-called 'triple bottom line' aims of social, economic, and environmental outcomes.

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[61] These were:

- nutrient management as part of total water cycle management
- community ownership of problem and solution
- separate planning/regulator and operator functions
- standards set for receiving environment(s)
- use pays/beneficiary pays
- accountability for outcome(s) including monitoring and reporting

The label 'criterion' covers a continuum from relatively well defined and easily measured quantities, such as area of land required for a train line, to less well defined concepts such as visual amenity.

Some commentators suggest that the number of criteria used should be restricted because of the cognitive limitations of the human mind, and because of the need to gather the necessary information for each alternative. Others say that a forced limiting of criteria increases potential for conflict, similar to presenting a limited number of alternatives.

We gathered comparison criteria from our reading of previous reports, and from extensive interviews with stakeholders. We saw no reason to limit criteria, as we did not intend to quantitatively "score" them against each governance option. In addition, because we were not able to develop criteria in an open stakeholder forum, we did not want to risk conflict by artificially restricting criteria.

In contemporary policy analysis, comparison criteria are often categorised according to whether they are measuring environmental, social, or economic outcomes. We decided to use a different approach in our work. This was primarily because all of the possible institutional arrangements are intended to meet the same environmental goal of reduced nutrient discharge to the catchment. We also decided to further disaggregate "social" issues to focus more carefully on the "political viability" and "administrative operability" of the alternative arrangements. This categorisation scheme matches that presented in the well-known policy evaluation text by Patton and Sawicki (1986). Finally, we did not want to distract from the comparison by attempting to artificially fit criteria into categories. We are aware that the act of categorisation can sometimes be a source of conflict in and of itself. As a consequence of the above, the comparison criteria presented in Table 2 are not listed in any particular order.

Table 2: Comparison Criteria

Criterion	Explanation
1. Ability to synchronize land and water resources planning and improve development coordination	Land use planning should occur in an holistic way, with prior consideration being given to environmental outcomes.
2. Ability to exercise jurisdiction over the entire catchment, and at the local level	The management model should be able to operate at the level of the whole catchment, as well as at sub-catchment and site levels.
3. Ability to exert control over the total water cycle	Drainage should be managed on a total water cycle basis. The nutrient problem must be tackled at source, and the focus should shift from flood control to include quality control.
4. COAG requirement to separate regulator and operator	Based on the concept that entities with prime responsibility for policy and planning functions should be different to those with prime responsibility for management functions.
5. Ability to encourage community "ownership" of problem and solution	Based on the idea that good environmental outcomes will best be promoted when a governance model allows for the community to accept a problem, and assist in its resolution.
6. Shock to organisational culture/degree of cultural change required	Radical institutional reform can be threatening to staff and more difficult to implement than incremental change.
7. Ability to reduce complexity	A new management model should be less complex than the current system.
8. Implementation cost	Cost to the State government of implementing the required institutional reform
9. Degree of conflict of interest	Some governance models will result in agencies being both regulator and manager.
10. Existence of 'social licence"	Recognition of the authority and legitimacy of the governance system
11. Degree of overall cohesiveness	Current system is fragmented with no agency having overall responsibility
12. Degree of accountability	Accountability among those responsible for drainage management

13. Ability to make provisions for triple-bottom-line issues	The management model should make provision to address environmental, social, and economic issues at all stages
14. Ability to appear ‘seamless’	Land developers, land owners, and community members should be provided with a ‘one-stop shop’
15. Ability to develop high-level policy, as well as implement local drainage service delivery	The management model should be able to deal with high-level policy issues, as well as local level implementation concerns.

6. ALTERNATIVE GOVERNANCE MODELS

The reports listed in Section 4 presented a number of alternative models for drainage governance in the Swan-Canning Catchment. Intensive interviews with stakeholders added to this list, and allowed for refinements to be made to models that have been developed over the last 5 years.

Fifteen different models were defined in this stage of our research, and these are presented and explained in Table 3. In our view, these models are mutually exclusive and distinct enough to allow for rigorous comparison. In Section 7 we attempt to categorise these models to allow for more effective comparison.

We believe that it is worth noting that 'decoupling/unlinking' drainage governance models from overall State-level NRM or environmental policy models is difficult. To some extent, reform of drainage institutions at the catchment level requires a prior analysis of State-level governance models. This point has been specifically noted by the ANU (2003) research project. It predicated its 4 models for Swan-Canning drainage management on the acceptance of 3 models for State-level reform (see the footnotes to Table 3).

Table 3: Alternative Governance Models for Drainage in the Swan-Canning Catchment

Model	Origin	Description	Evaluation Category
1. Evolution of current model	W. Cox	DoE to license discharge to river from drains. Local authorities and Water Authority (?) to manage water and nutrient discharge to main drains and river. Role of Swan River Trust reduced in managing the impact of nutrients. Accountability focuses on Water Corporation and Local government.	Multi-agency
2. Single agency model – water cycle management	W. Cox	Total water cycle managed by one agency.	Single-agency
3. Single agency model – management only	W. Cox	DoE would be the regulator. Management agency could be the Water Corporation, Swan River Trust, or new agency.	Dual-agency
4. Three roles model – Policy and Approval Authority, Regional Catchment Manager, and Service Provision	Drainage Reform Group	Role 1: A state-level Policy and Approval Authority defines catchments and develops policy in consultation with catchment managers. It incorporates state, regional, industry, and community representation and answers to the Minister for the Environment via the Standing Sub-Committee on Water. Role 2: Catchment Managers to be formed with statutory powers and responsibilities governing the whole of water cycle planning and management (but not water resource allocation and wastewater management). Members of management bodies to be appointed by Minister, and possibly elected in the future. Catchment Managers would takeover all Water Corporation responsibilities for management and maintenance of regional drainage assets. Role 3: Service providers would design local schemes and maintain them. These could be public utilities or private companies	Dual-agency
5. Government agency model – operating through DoE	URS Discussion Paper for the Drainage Reform Group	Political commitment: State Water Task Force Policy development/establishing regulation: Department of Environment, with advice from NRM and Floodplain Management Councils Strategic planning for water resource management at catchment scale: DoE Local planning for water resource management at sub-catchment scale: DoE	Multi-agency

		Detailed planning at site scale: proponents Management: DoE through sub-committee of the Board Service provision: ? Monitoring performance: DoE and service provider	
6. Utility – operating through Water corporation	URS Discussion Paper for the Drainage Reform Group	Political commitment: NRM and Floodplain Management Councils Policy development/establishing regulation: Department of Environment, with advice from RCCs , DPI and others Strategic planning for water resource management at catchment scale: RCCs Local planning for water resource management at sub-catchment scale: Water Corporation Detailed planning at site scale: Water Corporation Management: Water Corporation Service provision: Water Corporation and local authorities under licence Monitoring performance: Service provider and DoE	Multi-agency
7. Regional organisation of councils/community/local government approach	URS Discussion Paper for the Drainage Reform Group	Political commitment: Regional Catchment Councils (RCCs) Policy development/establishing regulation: Department of Environment, with advice from RCCs, DPI, ROCs, and others Strategic planning for water resource management at catchment scale: RCCs Local planning for water resource management at sub-catchment scale: ROCs Detailed planning at site scale: local authorities Management: ROCs Service provision: tendered process Monitoring performance: ROCs and DoE	Multi-agency
8. Single agency model: transfer coordination and strategic planning responsibilities to Water Corporation	ANU 2003*	The Water Corporation has access to the necessary organisational resources and skills base needed to extend its activities to coordinate the planning and management of drainage infrastructure across the Perth metro area. Existing powers under the Water Corporation Act could be used to declare the metro area a	Single-agency

		drainage catchment. The EPP sets water quaility-related performance targets that apply to all public authorities, and the Water Corporation's operating licence could be amended to reflect these obligations.	
9. Single agency model: establish a new catchment-wide body responsible for drainage	ANU 2003*	Remove drainage responsibilities from the Water Corporation. Need to buy out Water Corporation and local authority drains. Otherwise, the model is similar to option 8. MoG principles would suggest establishing a statutory utility. Another possibility would be to expand the role of the Swan River Trust. This would require its Act to be amended to include powers similar to those currently in the Water Corporation Act and Metropolitan Water Authority Act relating to drainage.	Single-agency
10. Make local government responsible for all drainage management	ANU 2003*	This option would require significant changes to local government operations. Local government already has powers over land use, and these could be extended to encompass polluting activities. The problem of drainage moving across local government boundaries could be dealt with by Regional Organisations of Councils taking this responsibility.	Multi-agency
11. Councils and State Agencies manage drainage in contractural partnership	ANU 2003*	Closest to the status quo. Local authorities would continue to manage local infrastructure, and the Water Corporation would continue to manage main drains, but the two functions would be more closely coordinated. Better cooperation would occur through commercial contracts or MOUs. Statutory water quality performance criteria could be set through the EPP, once sub-catchment level environmental quality criteria have been set through the Implementation Strategy.	Multi-agency
12. Management through the EPP	Riverplan	EPA is responsible for the EPP and its implementation. Swan River Trust is delegated responsibility by the EPA for coordination of Strategy. State agencies, local governments, community, and industry groups would be responsible for implementing management activities, and reporting progress.	Multi-agency
13. Two agency model	Discussion Paper on Stormwater Management in Western Australia – A Way Forward. Presented at EPA	DEWCP takes full responsibility for drainage management planning. Implementation and delivery of necessary services such as source control, water treatment assets, flood management and maintenance, would be provided by a catchment manager (catchment management authority).	Dual-agency

	Meeting on 8/11/2001		
14. Multi-agency responsibility	Strategic Environmental Solutions. Advice to EPA Chairman on Drainage (2002)	EPA sets environmental objectives. Strategic drainage planning to be undertaken by the WC, or the WRC, or private industry.	Multi-agency
15. Coordination committee approach	Water Cycle Project: Models of Management for Urban Drainage	Influenced by the City of Melbourne model. Facilitated by a Coordination Committee which drives a Strategic Environmental Outcomes group (made up of EPA, DPI, and DoE [WRC]) and a Strategy and Service Delivery Group (made up of multiple stakeholders and service delivery organisations)	Multi-agency

* All four drainage management options are considered to be dependent on 3 broader models for Statewide environmental policy. These are:

1. two agency model where all policy, EIA, water allocation, regulation and enforcement are given to the EPA, and operational functions are given to the Water Corporation.
2. ICM law and regional statutory catchment management authorities.
3. existing but more targeted (existing with SRT as catchment coordinator).

7. THE EVALUATION

Now that we have comparison criteria and alternatives listed (in Tables 2 and 3), it is possible to fill in the cells of a corresponding matrix, and begin to rank the governance models.

Table 4 shows the alternative governance models evaluated against all 15 comparison criteria. The values in the cells are 'scores'. There are ordinally-scaled numbers representing points on a continuum. For all criteria except 6, 8, and 9, high numbers are a 'good' outcome. For the exceptions, high numbers represent a 'bad' outcome. For the purposes of this exercise a five-point scale was used. We scored each alternative against each criterion using the experience gained during the course of the consultancy. No stakeholder input was used in the scoring process. We could have scored cells using different scales[62]but would have needed to convert them to numerical values to allow for further computer manipulation. We therefore took a more efficient route, and scored them numerically from the beginning.

With such a large comparison, we needed to use software to help us sort out rankings of outcomes. Merely adding columns would have been mathematically inappropriate because the scores are ordinally-scaled.[63] We therefore used a multi-criteria analysis pair-wise comparison technique known as 'concordance analysis' to sort out the rankings of alternative governance models. Appendix 1 provides details on the outcomes of the concordance analysis.

[62] For example …. "good to bad", or "yes-perhaps-no", or "ticks/circles/crosses".
[63] See Annandale and Lantzke (2000) for an explanation of this concept.

Table 4: Evaluating the Alternative Governance Models against the Comparison Criteria

	Single Agency				Dual Agency			Multi-agency							
	A DoE	**B** Water Corporation	**C** New Catchment-wide Body	**D** Swan River Trust	**E** DoE or the EPA is the regulator. Management agency is Water Corporation, SWT, or new agency	**F** Policy and Approval Authority and Catchment Manager	**G** DoE is the planner and policy-maker. Management agency is a Catchment Manager	**H** Cox evolution of current model	**I** URS Govt agency model	**J** URS Utility model	**K** URS Regional Organisation of Councils model	**L** ANU local govt. model	**M** ANU contractural partnership model	**N** Management through the EPP	**O** Coordination Committee approach
Ability to synchronize land and water resources planning and improve development coordination	3	3	3	3	2	4	3	2	1	1	2	2	2	1	3
Ability to exercise jurisdiction over the entire catchment, and at the local level	3	4	5	4	3	5	5	1	2	2	2	2	2	1	3
Ability to exert control over the total water cycle	3	4	4	4	4	5	4	2	3	3	2	2	2	3	4
COAG requirement to separate regulator and operator	1	1	1	1	5	5	5	3	1	3	1	1	2	1	4
Ability to encourage community “ownership” of problem and solution	1	1	3	2	2	4	4	2	1	1	2	2	2	2	2
Shock to organisational culture/degree of cultural change required	3	3	5	4	1	4	3	1	1	2	5	5	3	4	4
Ability to reduce complexity	5	5	5	5	3	4	3	2	2	2	1	1	2	2	3
Implementation cost	2	1	3	2	1	3	3	1	2	1	4	4	3	4	3
Degree of conflict of interest	4	4	4	4	1	1	1	2	3	3	2	2	2	3	1
Existence of ‘social licence’	4	3	3	4	3	3	3	2	2	2	2	2	3	3	2

Degree of overall cohesiveness	3	3	4	3	2	4	4	2	1	1	2	1	2	2	3
Degree of accountability	4	3	4	4	3	4	4	3	2	2	2	3	3	2	3
Ability to make provisions for triple-bottom-line issues	1	2	3	2	2	3	3	1	3	2	3	3	2	1	3
Ability to appear ‘seamless’	5	5	5	5	3	4	4	1	1	1	2	2	2	3	2
Ability to develop high-level policy, as well as implement local drainage service delivery	2	3	4	4	4	5	4	3	3	3	1	1	2	3	4

We undertook two 'runs' of the software programme. The first run assumed that all of the 15 comparison criteria were worthy of equal 'weight'.

Table 5: Rankings of Alternative Governance Models When Equal Criteria Weights are Applied

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Rank	8	5	3	4	6	1	2	8	11	11	11	11	10	11	6

The table indicates that alternative F (Policy and Approval Authority plus Catchment Manager) is the highest ranked outcome. This is followed by alternative G (DoE is the planner/policy-maker plus a Catchment Manager) and on to alternative C (new catchment-wide body) as the third-ranked outcome.

It seems clear, however, that different stakeholders would provide different 'weights' to criteria, depending on their interests and values. We took an independent decision to weight some of the criteria differently. Our stakeholder interviews pointed to the following criteria as being possibly more important than others:

* COAG requirement to separate regulator and operator;
* Ability to reduce complexity;
* Ability to encourage community 'ownership' of problem and solution;
* Ability to synchronize land and water resources planning and improve development coordination; and
* Ability to exercise jurisdiction over the entire catchment, and at the local level.

We decided to weight the first two of these criteria as "10" (on a 1-to-10 scale), and the remaining three as "8" (on the same scale). We then reran the concordance analysis programme, and obtained the ranking outcomes presented in Table 6.

Table 6: Rankings of Alternative Governance Models When Equal Criteria Weights are Applied

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Rank	8	5	3	4	5	1	2	10	11	11	11	11	9	11	5

Applying different weightings to the five criteria makes very little difference to the rankings of alternative governance models. The first four highest ranked alternatives remain the same when different weights are applied to the five 'important' criteria identified in stakeholder interviews.

8. CONCLUSIONS, RECOMMENDATIONS, AND IMPLEMENTATION STEPS

8.1 Introduction

Our analysis has shown that the highest ranked alternative governance models are:

1. Policy and Approval Authority plus Catchment Manager (this is the option proposed by the Drainage Reform Group).
2. DoE as the planner/policy-maker plus Catchment Manager.
3. New catchment-wide body.

The first two alternatives are versions of the 'dual-agency' approach, while the last alternative is a 'single-agency' model. Most of the recent work that we reviewed indicated that the COAG requirement of a split between regulator/policy-maker and manager/operator functions was inviolable. As a consequence, we believe that the third alternative in the above list would not be worth pursuing further.

This leaves a choice to be made between the first two options. We believe that the best way to make this choice is to undertake another round of evaluation, this time focusing on implementation in the current political environment, and on the implications of each option for existing governance arrangments. To this extent, our new comparison criteria will relate to the three governance hierarchy levels of "policy-making and approval", "catchment management", and "service provision".

8.2 Policy-making and Approval at the State Level

Option 1 proposes a "Policy and Approval Authority" that would develop policy, coordinate Catchment Plans, evaluate progess, and assist adaptive management. The Drainage Reform Group suggests that this role could be fulfilled by the EPA, the Board of the Water and Rivers Commission, or the Environment and Natural Resources Management Committee of the WA Planning Commission. All currently focus at the State level. However, the Board of the WRC will soon be dissolved when the WRC itself becomes part of the Department of the Environment. The EPA would also appear not to be an appropriate model for a Policy and Approval Authority, as this proposed role may compromise its ability to assess new drainage schemes under Part IV of the Environmental Protection Act 1986. This leaves the Environmental and Natural Resources Management Committee of the WAPC as the only viable

choice from the list of three presented by the Drainage Reform Group. With appropriate statutory backing that would allow for broad representation, there appears no reason why the WAPC committee could not be established as a Policy and Approval Authority for the specific purpose of drainage governance at the State level. It would, of course, be possible to establish an entirely new statutory Drainage Policy and Approval Authority under Option 1, although this would be difficult given the Machinery of Government concentration on removing statutory authorities.

With regard to this last-mentioned issue, Option 2 is attractive because it does not require the establishment of a new Authority, or the substantial reform of an existing body. Instead, it proposes that the "policy and approval" role be taken by the new Department of the Environment. In essence, there would be little difference between this proposal and the status quo because the Water and Rivers Commission already substantially assumes the drainage policy and approval role, and the WRC will soon become part of the Department of the Environment.

However, a significant disadvantage of Option 2 is that it would not allow for the incorporation of regional, industry, and community representation that is implicit in the Policy and Approval Authority concept.

8.3 Catchment Management

Option 1 and Option 2 both propose the establishment of Catchment Managers at the regional level. These bodies are seen as being given statutory powers and responsibilities governing the whole of water cycle planning and management, with the exception of water resource allocation and wastewater management. Option 1 has the most detailed outline for the proposed functions of a Catchment Manager. It suggests that such bodies would:

* develop a "vision" for the water catchment;
* derive water cycle plans;
* assess local development proposals;
* oversee the outsourcing of management and maintenance of regional assets; and
* report to the Policy and Approval Authority.

To this list, we would also add the need for a Catchment Manager to implement the newly agreed ANZECC water quality management guidelines.[64] This would require the establishment of environmental values (EVs), environmental quality objectives (EQOs), and environmental quality criteria (EQCs).

In the Swan Canning Catchment, the current candidates for Catchment Manager would be the Water Corporation, the Swan River Trust, and the Swan Catchment Council. We believe that it would be difficult for the Water Corporation as currently constituted to take the role of Catchment Manager in the Swan Canning Catchment. The Corporation's remit is statewide and it has a responsibility as a drainage service provider. In our view, a more appropriate candidate for Catchment Manager would be some combination of the Swan River Trust and the Swan Catchment Council. Enhancing the Board of the Swan River Trust by substantially widening its membership, and perhaps allowing for elected representation, would enable community input to be substantially upgraded and would allow for the concept of total water cycle management to be properly addressed.

8.4 Service Provision

So far we have not discussed the role of 'service provision' in either of the two highest ranked options. Both models have it that drainage assets would become the responsibility of the Catchment Manager. Under COAG principles, drainage assets would be maintained through a process of competitive outsourcing. Under this approach, service providers could be any one of the Water Corporation, other Water Service Providers (such as local authorities), or private companies.

8.5 Recommendation

Given the second round of evaluation presented in this section, we believe that the most effective option for institutional governance of drainage in the Swan Canning Catchment would be as follows:

* Policy and Approval Authority role to be taken by a revamped version of the Environment and Natural Resources Management Committee of the WAPC, or a newly designed Statutory Authority;

[64] Government of WA (2004). State Water Quality Management Strategy no.6: Implementation Framework for Western Australia for the Australia and New Zealand Guidelines for Fresh and Marine Water Quality.

* Catchment Manager role to be taken by a “widened” Swan River Trust; and

* Service provision to be controlled by the Catchment Manager, and to be undertaken on a competitive outsourcing basis.

Implications for existing governance would be as follows:

Water Corporation

* retains current arrangements for water supply and wastewater management.

* could tender for drainage service provision.

* would transfer drainage management personnel to Catchment Manager.

Department of the Environment

* retains current responsibility for allocation of water resources.

* provides technical assistance to Policy and Approval Authority and Catchment Manager.

Local Authorities

* provide local technical assistance to Catchment Manager.

* can bid for local drainage service provision.

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10. APPENDIX 1: MULTI-CRITERIA ANALYSIS

Criteria	Weights		Alternatives															c, or
	1	2	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	b
1	5	8	3	3	3	3	2	4	3	2	1	1	2	2	2	1	3	b
2	5	8	3	4	5	4	3	5	5	1	2	2	2	2	2	1	3	b
3	5	5	3	4	4	4	4	5	4	2	3	3	2	2	2	3	4	b
4	5	10	1	1	1	1	5	5	5	3	1	3	1	1	2	1	4	b
5	5	8	1	1	3	2	2	4	4	2	1	1	2	2	2	2	2	b
6	5	5	3	3	5	4	1	4	3	1	1	2	5	5	3	4	4	c
7	5	10	5	5	5	5	3	4	3	2	2	2	1	1	2	2	3	b
8	5	5	2	1	3	2	1	3	3	1	2	1	4	4	3	4	3	c
9	5	5	4	4	4	4	1	1	1	2	3	3	2	2	2	3	1	c
10	5	5	4	3	3	4	3	3	3	2	2	2	2	2	3	3	2	b
11	5	5	3	3	4	3	2	4	4	2	1	1	2	1	2	2	3	b
12	5	5	4	3	4	4	3	4	4	3	2	2	2	3	3	2	3	b
13	5	5	1	2	3	2	2	3	3	1	3	2	3	3	2	1	3	b
14	5	5	5	5	5	5	3	4	4	1	1	1	2	2	2	3	2	b
15	5	5	2	3	4	4	4	5	4	3	3	3	1	1	2	3	4	b

Concordance Matrix 1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A		0.6	0.6	0.633	0.567	0.633	0.633	0.433	0.4	0.467	0.233	0.233	0.333	0.3	0.5
B	0.4		0.633	0.567	0.5	0.7	0.667	0.367	0.3	0.333	0.233	0.267	0.333	0.233	0.467
C	0.4	0.367		0.467	0.367	0.667	0.567	0.267	0.267	0.267	0.167	0.167	0.267	0.2	0.367
D	0.367	0.433	0.533		0.4	0.667	0.6	0.3	0.267	0.3	0.2	0.2	0.267	0.167	0.4
E	0.433	0.5	0.633	0.6		0.767	0.667	0.2	0.1	0.067	0.167	0.167	0.2	0.133	0.433
F	0.367	0.3	0.333	0.333	0.233		0.4	0.133	0.167	0.133	0.033	0.033	0.133	0.067	0.133
G	0.367	0.333	0.433	0.4	0.333	0.6		0.133	0.167	0.133	0.033	0.033	0.1	0.033	0.233
H	0.567	0.633	0.733	0.7	0.8	0.867	0.867		0.367	0.4	0.4	0.4	0.5	0.4	0.767
I	0.6	0.7	0.733	0.733	0.9	0.833	0.833	0.633		0.5	0.5	0.5	0.6	0.5	0.8
J	0.533	0.667	0.733	0.7	0.933	0.867	0.867	0.6	0.5		0.5	0.5	0.567	0.467	0.833
K	0.767	0.767	0.833	0.8	0.833	0.967	0.967	0.6	0.5	0.5		0.5	0.7	0.567	0.867
L	0.767	0.733	0.833	0.8	0.833	0.967	0.967	0.6	0.5	0.5	0.5		0.7	0.567	0.833
M	0.667	0.667	0.733	0.733	0.8	0.867	0.9	0.5	0.4	0.433	0.3	0.3		0.333	0.733
N	0.7	0.767	0.8	0.833	0.867	0.933	0.967	0.6	0.5	0.533	0.433	0.433	0.667		0.8
O	0.5	0.533	0.633	0.6	0.567	0.867	0.767	0.233	0.2	0.167	0.133	0.167	0.267	0.2	

Concordance Matrix 2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A		0.596	0.612	0.638	0.553	0.654	0.638	0.431	0.362	0.441	0.245	0.245	0.351	0.298	0.516
B	0.404		0.638	0.569	0.484	0.707	0.665	0.378	0.282	0.335	0.245	0.271	0.351	0.245	0.473
C	0.388	0.362		0.441	0.346	0.665	0.569	0.266	0.239	0.266	0.16	0.16	0.266	0.186	0.362
D	0.362	0.431	0.559		0.388	0.681	0.612	0.309	0.239	0.293	0.202	0.202	0.282	0.176	0.404
E	0.447	0.516	0.654	0.612		0.787	0.681	0.191	0.08	0.053	0.165	0.165	0.191	0.122	0.436
F	0.346	0.293	0.335	0.319	0.213		0.378	0.106	0.133	0.106	0.027	0.027	0.106	0.053	0.106
G	0.362	0.335	0.431	0.388	0.319	0.622		0.106	0.133	0.106	0.027	0.027	0.08	0.027	0.229
H	0.569	0.622	0.734	0.691	0.809	0.894	0.894		0.351	0.404	0.383	0.383	0.489	0.378	0.798
I	0.638	0.718	0.761	0.761	0.92	0.867	0.867	0.649		0.527	0.505	0.505	0.638	0.5	0.84
J	0.559	0.665	0.734	0.707	0.947	0.894	0.894	0.596	0.473		0.479	0.479	0.559	0.447	0.867
K	0.755	0.755	0.84	0.798	0.835	0.973	0.973	0.617	0.495	0.521		0.5	0.713	0.548	0.878
L	0.755	0.729	0.84	0.798	0.835	0.973	0.973	0.617	0.495	0.521	0.5		0.713	0.548	0.851
M	0.649	0.649	0.734	0.718	0.809	0.894	0.92	0.511	0.362	0.441	0.287	0.287		0.309	0.771
N	0.702	0.755	0.814	0.824	0.878	0.947	0.973	0.622	0.5	0.553	0.452	0.452	0.691		0.824
O	0.484	0.527	0.638	0.596	0.564	0.894	0.771	0.202	0.16	0.133	0.122	0.149	0.229	0.176	

Dominance Matrix 1

Threshold = 0.6 0.6

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A		1	1	1	0	1	1	0	0	0	0	0	0	0	0
B	0		1	0	0	1	1	0	0	0	0	0	0	0	0
C	0	0		0	0	1	0	0	0	0	0	0	0	0	0
D	0	0	0		0	1	1	0	0	0	0	0	0	0	0
E	0	0	1	1		1	1	0	0	0	0	0	0	0	0
F	0	0	0	0	0		0	0	0	0	0	0	0	0	0
G	0	0	0	0	0	1		0	0	0	0	0	0	0	0
H	0	1	1	1	1	1	1		0	0	0	0	0	0	1
I	1	1	1	1	1	1	1	1		0	0	0	1	0	1
J	0	1	1	1	1	1	1	1	0		0	0	0	0	1
K	1	1	1	1	1	1	1	1	0	0		0	1	0	1
L	1	1	1	1	1	1	1	1	0	0	0		1	0	1
M	1	1	1	1	1	1	1	0	0	0	0	0		0	1
N	1	1	1	1	1	1	1	1	0	0	0	0	1		1
O	0	0	1	1	0	1	1	0	0	0	0	0	0	0	
Sum:	5	8	11	10	7	14	12	5	0	0	0	0	4	0	7

Dominance Matrix 2

Threshold = 0.622 0.622

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A		0	0	1	0	1	1	0	0	0	0	0	0	0	0
B	0		1	0	0	1	1	0	0	0	0	0	0	0	0
C	0	0		0	0	1	0	0	0	0	0	0	0	0	0
D	0	0	0		0	1	0	0	0	0	0	0	0	0	0
E	0	0	1	0		1	1	0	0	0	0	0	0	0	0
F	0	0	0	0	0		0	0	0	0	0	0	0	0	0
G	0	0	0	0	0	1		0	0	0	0	0	0	0	0
H	0	1	1	1	1	1	1		0	0	0	0	0	0	1
I	1	1	1	1	1	1	1	1		0	0	0	1	0	1
J	0	1	1	1	1	1	1	0	0		0	0	0	0	1
K	1	1	1	1	1	1	1	0	0	0		0	1	0	1
L	1	1	1	1	1	1	1	0	0	0	0		1	0	1
M	1	1	1	1	1	1	1	0	0	0	0	0		0	1
N	1	1	1	1	1	1	1	1	0	0	0	0	1		1
O	0	0	1	0	0	1	1	0	0	0	0	0	0	0	
Sum:	5	7	10	8	7	14	11	2	0	0	0	0	4	0	7

Alternatives:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Rank (equal wts):	8	5	3	4	6	1	2	8	11	11	11	11	10	11	6
Rank (unequal wts):	8	5	3	4	5	1	2	10	11	11	11	11	9	11	5

Alternatives:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Rank (equal wts):	8	5	3	4	5	1	2	10	11	11	11	11	9	11	5

DRAFT

DRAINAGE REFORM

MONITORING AND REPORTING



Prepared for: **Drainage Reform Forum**

Prepared by: **Aquatic Science Branch, Department of Environment**

March 2004

SUMMARY

This report is a collation of information on existing and proposed monitoring programs in the Swan-Canning river system. The information has been obtained largely through consultation with representatives from community and catchment groups, local, state and commonwealth government. A draft of the report was then provided to the representatives and other relevant stakeholders for review and comment.

The focus of drainage reform is on surface water quality monitoring in the Swan-Canning river system. Many activities are occurring or are proposed that are related but not directly within the drainage reform scope such as discrete sampling events (rather than ongoing monitoring), monitoring of waterways outside the Swan-Canning river system, monitoring of media other than surface water (for example monitoring of groundwater or sediment independent of surface water monitoring) and monitoring of variables other than water quality (for example monitoring of macroinvertebrates or habitat independent of surface water monitoring).

The key outcomes of the report are:

Current programs

- The Swan-Canning Cleanup Program is the only monitoring program that conducts regular water quality monitoring in the Swan and Canning estuaries;

- The measurement of physical properties (eg. conductivity and pH) and analysis of nutrient concentrations are variables common to most monitoring programs in the Swan-Canning river system. There is minimal monitoring of contaminants other than nutrients;

- There is minimal monitoring of drainage directly connected to the Swan-Canning estuary. More than half of the local governments that provided information, do not currently conduct water quality monitoring in the Swan-Canning river system;

- Minimal information regarding methods, data management and reporting/outputs was available for many of the existing monitoring programs. The methods and data management used by local government monitoring programs varied. Most monitoring conducted by catchment/community groups was in accordance with Ribbons of Blue methods and was stored in the Waterwatch database. The majority of monitoring program results are only reported within the organisation conducting the monitoring;

- The objectives of existing state government monitoring programs included:
  - providing chemical, physical and biological information on water quality and information on water quality trends in the estuary and coastal catchment;
  - assessing whether SCCP water quality targets are being met;
  - providing information to help public health authorities assess hazards to public health and recreational use of the rivers associated with algal blooms;
  - helping to establish environmental standards and assess trends in environmental quality;
  - identification of nutrient and pollutant hot spots in the main drainage system;
  - assessing the relative severity of water quality problem areas and recognising the causes of these problems; and
  - investigation of water quality in urban drains.

- The objectives of existing local government monitoring programs included:
  - establishing baseline water quality;
  - identifying changes in water quality and water quality trends;
  - assessing the water quality or health of lakes;
  - identifying seasonal stormwater quality patterns;
  - assessing the impacts of particular land uses; and
  - ensuring the quality of water used for irrigation.

- The objectives of existing community/catchment group monitoring programs included:
  - identifying changes in water quality;
  - assessing the impact of catchment management on water quality;
  - assess water quality of sub-catchments to determine health;
  - assess the impact of sub-catchments on river water quality;
  - determining the extent to which water and sediment quality are affected by contaminant sources; and
  - raising community awareness of water quality and catchment management issues (common to all community/catchment groups monitoring programs).

Proposed monitoring/monitoring needs

- Many of the proposed monitoring programs were a continuation of an existing monitoring program;

- Several local governments are developing catchment management plans that are likely to comprise monitoring programs;

- Minimal information regarding methods, data management and reporting/outputs was provided in relation to proposed monitoring or monitoring needs;

- The objectives of proposed state government monitoring programs included:
  - assessing non-nutrient contamination throughout the Swan-Canning river system;
  - obtaining baseline data on contaminants in the Swan-Canning river system;
  - identifying contaminant 'hotspots' within Swan-Canning catchments;
  - investigating known contamination 'hotspots';
  - assessing the ecosystem health of the Swan-Canning river system;
  - identifying primary nutrient and contaminant sources; and
  - assessing the stormwater quality in urban drains.

- The objectives of proposed local government monitoring programs included:
  - identifying 'hotspots' to assist targeting of catchment management;
  - assessing the stormwater quality of urban drains and groundwater;
  - determining the efficacy of stormwater and other catchment management activities;
  - locating the source of nutrients within sub-catchments; and
  - identifying contaminated drains and the source of the contamination.

- The objectives of proposed community/catchment group monitoring programs included:
  - establishing baseline river condition from which resource condition targets can be generated;
  - assessing compliance with natural resource management targets (management action and resource condition);
  - assessing biological condition (river health) of waterways;
  - determining the effect of catchment management activities on water quality;
  - isolating nutrient 'hotspots';
  - identifying changes in water quality;
  - determining the influence of groundwater on surface water in relation to nutrient loads;
  - identifying how and where nutrients enter waterways; and
  - determining the effect of historical land uses on current water quality.

Recommendations

With the development of the monitoring and evaluation framework for Natural Heritage Trust/National Action Plan co-funded regional strategy and new programs to be undertaken to meet the Riverplan requirements, there exists an excellent opportunity to integrate many of the existing and proposed monitoring programs, thus optimising the information gathered from monitoring expenditure.

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INTRODUCTION

An opportunity to understand and rationalise monitoring and reporting across the Swan-Canning into a collaborative partnership now exists with the:

- establishment of the Swan-Canning Environmental Protection Policy;
- development of the Swan Regional strategy for NAP/NHT2;
- focus on drainage reform; and
- proposed new role for the Swan River Trust.

This report contributes to the development of collaborative partnerships for monitoring and reporting in the Swan-Canning river system by:

- Collating information on existing and proposed monitoring activities;
- Identifying opportunities for an integrated framework; and
- Providing case studies and examples of successful monitoring and reporting frameworks.

It is proposed to continue these activities beyond the Drainage Reform Forum in partnership with the Swan-Canning Catchment Council, the Swan River Trust and other key stakeholders.

BACKGROUND

The *State Water Strategy* in 2002 addressed key water issues facing Western Australia and aimed to provide a practical platform from which water shortage solutions could be implemented. A key objective of the State Water Strategy is 'new supplies and total water cycle management' comprising:

- Ensuring reliable, cost effective water supplied;
- Balancing source development with conservation; and
- Establishing total water cycle management principles as a requirement within new developments and maximise the recovery of stormwater.

A key response to the 'new supplies and total water cycle management' objective was that

> **'the regulation and institutional arrangements for drainage be reviewed to achieve reform, which recognises the harvesting potential and includes management of water reuse and water quality'.**

The Drainage Reform Group (DRG) was formed to review the regulation and institutional arrangements for drainage. The *Discussion Paper on Drainage Reform in WA* was commissioned by the DRG to set out the background, issues and possible actions required for drainage reform in Western Australia. The Drainage Reform Project was commissioned by the Western Australian Government to address shortcomings in how drainage and flood mitigation is designed, implemented and managed. There is wide acceptance across government and private sectors that current institutional and administrative arrangements are not adequate or sufficiently coordinated to support or encourage best practice in drainage or flood mitigation.

The *CSIRO White Paper* on drainage management recommended that it should be mandatory for drainage managers to include monitoring programs to enable regulatory agencies (Swan River Trust, Department of Environment) to assess performance against targets.

OBJECTIVES

The object of the Drainage Reform – monitoring and reporting task was to develop an indicative monitoring program for contaminant loads in tributaries of the Swan-Canning estuary including urban drains with provision for data analysis and reporting.

The monitoring and reporting task was required to support a coherent monitoring and evaluation framework that illustrated the relationship between each current and required monitoring program.

The development of the Swan regional strategy requires a monitoring and evaluation program as core component of the investment plan for NHT funding. This program will include many components other than water quality and will allow broader measures of river health to be included. Current community, Waterwatch and Ribbons of Blue programs will be placed in the context of the overall monitoring program.

The monitoring and reporting task was divided into a series of components which have been used as the structure of this report:

1. Collate information on current monitoring activities in the Swan-Canning river system through consultation with community and catchment groups, local, state and Commonwealth government.

2. Collate information on proposed monitoring activities and monitoring needs in the Swan-Canning river system through consultation with community and catchment groups, local, state and Commonwealth government.

3. Develop an overall monitoring and reporting framework that lists all key current and proposed monitoring programs and relevant reporting relationships.

SCOPE

The scope of the Drainage Reform – monitoring and reporting task is surface water quality monitoring programs in the Swan-Canning river system. Some discussion of the scope of this task has been included in this section of the report.

Water quality monitoring is the systematic and careful collection and analysis of samples, observations and in situ measurements with the aim of providing information and knowledge about a water body (ANZECC and ARMCANZ, 2000).

The National Water Quality Management Strategy is a key source of information on all aspects of designing and implementing water quality monitoring programs in Australia (ANZECC and ARMCANZ, 2000).

Water Quality

For the purposes of this task 'water quality' has been restricted to the measurement or sampling of surface water. Measurement or sampling of other media such as groundwater or sediments and parameters/indicators such as macroinvertebrates or habitat have not been included in this report unless directly associated with the measurement or sampling of surface water. Understanding the influence of groundwater on surface water quality is critical in the Swan-Canning river system and as such repeating this exercise for groundwater monitoring programs is recommended.

Monitoring

Discrete (one-off) sampling events have not been included in this report. The scope of 'monitoring' has been restricted to continued sampling (US EPA), or sampling that occurs over a period of time (Cambridge dictionary), to the exclusion of discrete sampling events.

Clear and realistic objectives are necessary for effective monitoring programs. Common environmental monitoring program objectives include detecting changes and trends, determining causes and effects, providing a spatial and temporal summaries of average or extreme conditions and establishing base-line data for future reference (National Environmental Monitoring and Research Workshop, USA, 1996 and Statistical Methods for Environmental Pollution Monitoring). To achieve these objectives, environmental monitoring programs generally require ongoing or continuing measurement or collection of data.

Swan-Canning river system

For the purposes of this task, the Swan-Canning river system has been restricted to the 31 major sub-catchments in the coastal portion of the system (Swan-Canning Cleanup Program – Action Plan, 1999). Many of the sub-catchments are based on urban drainage systems and have a number of small drainage catchments and drains that flow into the rivers and have been grouped into one general area. A map illustrating the sub-catchments, the catchment regions and the local government authority boundaries has been included (see over).


Swan-Canning Catchment Sub-Regions
Shire of Gingin
Shire of Chittering
Shire of Toodyay
City of Wanneroo
Avon River
Bullsbrook
City of Swan
City of Joondalup
City of Stirling
Shire of Mundaring
Mundaring
Town of Cambridge
Town of Vincent
City of Subiaco
Perth
City of Perth
City of Bayswater
Town of Bassendean
City of Belmont
Shire of Kalamunda
Town of Mosman Park
Town of East Fremantle
City of Melville
City of Fremantle
City of Canning
City of Gosnells
City of Cockburn
Armadale
Swan River
Canning River
City of Kwinana
City of Armadale
N
Projection Information
LEGEND
LOCALITY MAP
SWAN RIVER TRUST

CURRENT MONITORING AND REPORTING ACTIVITIES

COMMONWEALTH GOVERNMENT

Perth Airport water quality monitoring program

Custodian(s) Perth airport.

Objective(s) Assess surface water quality flowing off the airport property.

Parameters pH, pesticides, nutrients (total nitrogen & total phosphorus), hydrocarbons, surfactants, ions of iron and total dissolved solids.

Frequency Quarterly.

Sites/Spatial characteristics
12 sites around the Airport.

Methods (sampling, analysis, QA/QC)
No information.

Data Management
No information.

Reporting/Outputs
Results are stored on an internal database.

STATE GOVERNMENT

Swan-Canning Cleanup Program

Custodian(s) Swan River Trust (Water and Rivers Commission/ Dept. of Environment)

Objective(s) a) Provide chemical, physical and biological information on water quality and information on water quality trends in the estuary and coastal catchment; b) assess whether SCCP water quality targets are being met; c) provide information to help public health authorities assess hazards to public health and recreational use of the rivers associated with algal blooms; and d) help establish environmental standards and assess trends in environmental quality.

Parameters Estuary: salinity, temperature, dissolved oxygen, turbidity, pH (surface to bottom at half to one metres depth intervals) chlorophyll a, phytoplankton cell counts (throughout the water column), total suspended solids, total nitrogen, total oxides of nitrogen, ammonium, total phosphorus, filterable reactive phosphorus (surface and bottom).
Catchments: specific conductivity, total suspended solids, total nitrogen, total oxides of nitrogen, ammonium, total phosphorus, filterable reactive phosphorus (surface) and flow/stage height.

Frequency Estuary: weekly, 9 years of monitoring data
Catchments: fortnightly during flow year (~March to November), 16 years of monitoring data

Sites/Spatial characteristics
Estuary: 10 sites on Swan River, 7 sites on Canning River, an additional 4 sites are monitored in the Canning River during summer and autumn, one random site in Melville Water is sampled between January and May to support annual target compliance assessment.
Catchment: 15 sites one in each of the priority catchments (Ellen Brook, Susannah Brook, Bennett Brook, Jane Brook, Blackadder Creek, Bayswater Main Drain, Avon River, South Belmont Main Drain Helena River, Mills Street Main Drain, Yule Brook, Bickley Brook, Bannister Creek, Upper Canning River, Southern River)

Methods (sampling, analysis, QA/QC)
Estuary and catchment sampling guidelines available, strict quality control procedures, National Association of Testing Authorities certified laboratories used for analysis, strict quality assurance procedures.

Data Management
All estuary and catchment monitoring data collected as part of the Swan-Canning Cleanup Program is stored in the WIN database managed by the Water and Rivers Commission/Dept. of Environment.

Reporting/Outputs
All estuary and catchment monitoring data collected as part of the Swan-Canning Cleanup Program is reported via the Swan River Trust Annual Report, RiverScience newsletters, the Swan River Trust website, Swan-Canning Cleanup Program Action Plan Implementation updates, Algal Activity Reports as part of Channel 9 6pm news every Friday, various technical reports and monitoring data stored in the WIN database is publicly available. Catchment report cards are being developed using information from the Swan-Canning Cleanup Program and Swan-Canning Loads Monitoring Program.

Swan-Canning Loads Monitoring Program

Custodian(s) Swan River Trust (Water and Rivers Commission/ Dept. of Environment)

Objective To accurately measure nutrient loads in rivers and develop standard methods of measuring loads in WA with consistency and repeatability.

Parameters total nitrogen, total phosphorus and total suspended solids.

Frequency Automatic sampling triggered by flow conditions in addition to fixed interval sampling during flow year (~March to November). Automatic sampling operates at Mills Street Main Drain throughout the year.

Sites/Spatial characteristics

Autosamplers are located in the Mills Street Main Drain, Ellen Brook and Avon River (2 sites: Upper Swan Bridge and Walyunga National Park).

Methods (sampling, analysis, QA/QC)

Methods developed by the Water and Rivers Commission in 1997/98 (in Ellen Brook). National Association of Testing Authorities certified laboratories used for analysis, strict quality assurance procedures.

Data Management

All monitoring data collected as part of the Loads Monitoring Program is stored in the WIN database managed by the Water and Rivers Commission/Dept. of Environment.

Reporting/Outputs

Software developed in 1997/98 is used to analyse monitoring data to determine loads. Load estimates support Swan-Canning Cleanup Program modelling of Swan and Canning Estuaries. Loads estimates are reported in technical reports describing the load measurement system, the reliability of estimated loads for existing programs and effective design of reliable load measurement programs. A River Science newsletter on load estimation has been proposed. Catchment report cards are being developed using information from the Swan-Canning Cleanup Program and Swan-Canning Loads Monitoring Program.

Nutrient and contaminant assessment for the Mills Street Main Drain catchment

Custodian(s) Swan River Trust (Water and Rivers Commission/ Dept. of Environment)

Objective(s) Identification of nutrient and pollutant hot spots in the main drainage system, assessing the relative severity of the problem areas and recognising the causes of these problems.

Parameters Drain water: conductivity, temperature, dissolved oxygen, pH, total suspended solids, nutrients (total nitrogen, total oxides of nitrogen, ammonium, total phosphorus, filterable reactive phosphorus), biological oxygen demand, metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury, zinc), total petroleum hydrocarbons, methylene blue active substances, non-ionic surfactants, volatile organic compounds, pesticides (?).
Drain & basin sediment: total nitrogen, total phosphorus, metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury, zinc), total petroleum hydrocarbons (only in basins).
Groundwater: nutrients (total nitrogen, total oxides of nitrogen, ammonium, total phosphorus, filterable reactive phosphorus).

Frequency Baseflow: April 2000 (7 sites), January 2001 and February 2002.
First flush: June 2000 (7 sites) and April 2002.

Sites/Spatial characteristics

18 sampling sites: 6 in Abernethy Road Branch Drain, 1 in Patterson Road Branch Drain, 1 in Bunnings Branch Drain, 1 in Mars Street Branch Drain, 5 in Mills Street

Main Drain, 1 in Ewing Street Branch Drain, 2 in Welshpool Road Branch Drain, 1 in Wyong Road Branch Drain and 1 in Wilson wetland.

Methods (sampling, analysis, QA/QC)

Water and Rivers Commission sampling guidelines available, strict quality control procedures, National Association of Testing Authorities certified laboratories used for analysis, strict quality assurance procedures.

Data Management

All monitoring data collected as part of the nutrient and contaminant assessment for the Mills Street Main Drain catchment is stored in the WIN database managed by the Water and Rivers Commission/Dept. of Environment.

Reporting/Outputs

Monitoring data from this program has been presented in the nutrient and contaminant assessment for the Mills Street Main Drain catchment report, March 2003. The monitoring data stored in the WIN database is publicly available.

Nutrient and contaminant assessment for Canning River Drains (1999 & 2000)

Custodian(s) Swan River Trust (Water and Rivers Commission/ Dept. of Environment)

Objective(s) Investigation of water quality in 5 urban drains discharging into the Canning River upstream of Kent Street weir.

Parameters Nutrients (total nitrogen, total phosphorus, ammonia, nitrate, nitrite, filterable reactive phosphorus), Total suspended solids, Biological oxygen demand, Total heavy metals (including arsenic, cadmium, chromium, copper, mercury, nickel, lead and zinc), Total petroleum hydrocarbons (C6-C36), Volatile organic compounds (benzene, ethylbenzene, toluene and xylene) and thermotolerant coliforms.
(Plus *E. coli* & ammonium in 2000).

Frequency Sampling for nutrients, total suspended solids and biological oxygen demand occurred on 14 occasions at irregular intervals between 19th Feb to 18th May 1999, with timing of sampling related to rainfall events and duration.
Sampling was extended to include volatile organic compounds, hydrocarbons and heavy metals from 14th April to 18th May 1999 on 7 occasions from all 5 drains
Samples were taken for analysis of faecal coliforms on four occasions from 5 May to 18 May 1999.

In 2000 sampling for nutrients, Total Suspended Solids and Biological Oxygen Demand commenced on 10 December 1999 and continued weekly until 17 May 2000 with a total of 22 samples being taken at each site. Heavy metals, Total petroleum hydrocarbons and volatile organic compounds were sampled between 6th Jan and 17th May 2000 and sampling for thermotolerant coliforms and *E. coli* started on 23rd Dec 1999 and continued until 17th May 2000.

Sites/Spatial characteristics

Bottom end of catchment sampling. Five sampling sites in 1999; Wharf St Main Drain, Cockram St Main Drain, Liege St Main Drain, Lacey St Main Drain & Menzies Rd Main Drain. In 2000, five sampling sites; Menzies Rd Main Drain, Lacey St Main Drain, Cockram St Main Drain, Liege St Main Drain & Cockram – Liege confluence.

Methods (sampling, analysis, QA/QC)

Water and Rivers Commission sampling guidelines available, strict quality control procedures, National Association of Testing Authorities certified laboratories used for analysis, strict quality assurance procedures.

Data Management

All monitoring data collected as part of the Nutrient and contaminant assessment for the Canning River drains are stored in the WIN database managed by the Water and Rivers Commission/Dept. of Environment.

Reporting/Outputs

Monitoring data from this program has been presented in the Canning River drain study –1999: Water quality in five urban main drains report, March 2003 and the draft Canning River drain study – 2000: Water quality in four urban main drains report, June 2003.

Nutrient and contaminant assessment of Swan Coastal Drains (2002 onwards)

Custodian(s) Swan River Trust (Water and Rivers Commission/ Dept. of Environment)

Objective(s) Investigation of water and sediment quality of urban drains discharging into the Swan-Canning rivers on a snapshot basis.

Parameters Nutrients (total nitrogen, total phosphorus, ammonia, nitrate, nitrite, filterable reactive phosphorus), Total suspended solids, Biological oxygen demand, Total heavy metals (including arsenic, cadmium, chromium, copper, mercury, nickel, lead and zinc), Total petroleum hydrocarbons (C6-C36), methylene blue active substances, non-ionic surfactants. Sediments were also taken and analysed for total nitrogen, total phosphorus, total metals (arsenic, cadmium, chromium, copper, lead, nickel, mercury and zinc) and total petroleum hydrocarbons.

Frequency Sampling of baseflow for nutrients, total suspended solids, biological oxygen demand, metals and physical parameters occurred on 5 to 7 February 2002 throughout the subcatchments of Wharf St MD, Cockram St MD and Bannister Creek and at the bottom end of Wilson Rd MD.

Sampling for conductivity, temperature, dissolved oxygen, pH, total suspended solids, nutrients (total nitrogen, total oxides of nitrogen, ammonium, total phosphorus, filterable reactive phosphorus), metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury, zinc) occurred on 20 May 2003 in the South Belmont Main Drain catchment.

Sites/Spatial characteristics

One site in Wilson Rd Main Drain catchment, two sites in Wharf St Main Drain catchment, four sites in Cockram St Main Drain catchment and five sites in Bannister Creek catchment. South Belmont Main Drain sampling occurred at seven sites throughout the catchment.

Methods (sampling, analysis, QA/QC)

Water and Rivers Commission sampling guidelines available, strict quality control procedures, NATA certified laboratories used for analysis, strict quality assurance procedures.

Data Management

All monitoring data collected as part of the Nutrient and contaminant assessment for the Swan-Canning catchment drains are stored in the WIN database managed by the Water and Rivers Commission/Dept. of Environment.

Reporting/Outputs

Not yet reported on. Data from South Belmont Main Drain subcatchment sampling is intended to be reported on as part of a Drainage Improvement Framework report for South Belmont Main Drain Catchment.

Water Quality – Main Roads

Custodian Main Roads Western Australia

Objective(s) To establish the quality of stormwater run-off from the metropolitan road network and the potential for pollution to enter wetlands and waterways.

Parameters Nutrients and heavy metals.

Frequency Sampling focus was first flush events. Program ran for 4-5 years and ceased in 2001.

Sites/Spatial characteristics
20 sample sites. Located to capture road run-off in the metropolitan area.

Methods (sampling, analysis, QA/QC)
No information provided.

Data Management
Main Roads Western Australia manages the water quality data collected by this program.

Reporting/Outputs
The information from Water Quality Main Roads has been used to determine the likely pollutant loads and contaminants in road run-off. The water quality results, in conjunction with receiving environment sensitivity assessments, have been used by Main Roads to target 'hotspots' on the road network where run-off treatment measures are required.

Water Quality Monitoring of Main Drain Outfalls (1997-2001?)
- Details not confirmed

Custodian Water Corporation

Objective(s) Provide ongoing background information about water quality and quantity from Water Corporation drainage systems discharging to the environment, particularly other receiving waters.

Parameters Water quality: conductivity, nutrients (total nitrogen, total phosphorus, filterable reactive phosphorus), heavy metals (cadmium, chromium, copper, zinc, mercury and lead) and bacteriological (total coliforms, thermotolerant coliforms, *escherichia coli* and faecal streptococci).
Water quantity.

Frequency Water quality: Minimum of three 'grab' samples per year.
Water quantity: level and peak level recorded a minimum of three time per year (sites without continuous flow measurement). Monitoring program commenced 1997.

Sites/Spatial characteristics
32 sample sites. Rockingham Central branch drain, Rockingham Road compensating basin, Waikiki main drain, Helm Street main Drain, Lacey Street main drain, Wharf Street main drain, Williams Road main drain, Second Road main drain, Forrestdale main drain, Rundle Street main drain, Westfield Park main drain, Menzies Road main drain, Bannister Creek main drain, Majorie Road main drain, Modillon Avenue main drain, Beatrice Avenue main drain, Bull Creek main drain, Brent Wood main drain, Central Belmont main drain, Southern Belmont main drain, Collier Pines main drain, Perth Airport Southern main drain, Victoria Park main drain, Macao Road main drain, Brickworks main drain, Dirk Brook, Poison Gully Creek, Yule Brook main drain, Mills Street main drain, Neerigen Brook main drain, Woodlupine Brook and Bickley Brook. Sample sites in main drains that discharge into the Swan and Canning Rivers and Ocean Outfalls.

Methods (sampling, analysis, QA/QC)

No information provided.

Data Management

Water Corporation manages water quality and quantity data. Water quality information is generally not available to the public.

Reporting/Outputs

No information provided.

Water Quality Monitoring of the Wonga Road and Emu Swamp Main Drains (1997-2001?) - Details not confirmed

Custodian Water Corporation

Objective(s) No information provided.

Parameters Water quality: nutrients (total nitrogen, total phosphorus, filterable reactive phosphorus, ammonia, nitrate and nitrite).
Water quantity: surface level and flow.

Frequency Water quality: 'grab' samples collected monthly per year.
Water quantity: level and peak level recorded monthly. Monitoring program commenced 1997.

Sites/Spatial characteristics

5 sample sites. Emu Swamp main drain (2 sites), Widgee Road branch drain and Wonga Road main drain (2 sites).

Methods (sampling, analysis, QA/QC)

No information provided.

Data Management

Water Corporation manages water quality and quantity data. Water quality information is generally not available to the public.

Reporting/Outputs

No information provided.

LOCAL GOVERNMENT

Lake Claremont water testing.

Custodian Town of Claremont

Objective To assess the health of Lake Claremont.

Parameters conductivity, pH, total suspended solids, turbidity, chlorophyll a, phosphorus, metals (cadmium, chromium, copper, lead, mercury, nickel and zinc)

Frequency 6 sampling events per year, commenced 13 October 2003.

Sites/Spatial characteristics
Lake Claremont.

Methods (sampling, analysis, QA/QC)
Grab samples collected for laboratory analysis.

Data Management
Town of Claremont will manage monitoring data.

Reporting/Outputs
Monitoring program outputs will be reported to the Lake Claremont Committee and the Claremont Council.

Water quality monitoring of lakes, wetlands, main stormwater drains and outlets.

Custodian City of Perth (Compliance Services)

Objective To provide baseline information on physical and chemical water quality for future water quality improvement.

Parameters pH, salinity, conductivity, dissolved oxygen, turbidity, temperature, biological oxygen demand, total suspended solids, total phosphorus, total kjeldahl nitrogen, (nitrate, nitrite and ammonium only sampled October 2003), metals (aluminium, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, zinc), oil & grease.

Frequency 2-3 sampling events per year, grab samples – May and September 2000, May and September 2001, March and October 2002, 24 hour composite samples of main drains – April, June and October 2003), 4 years of monitoring.

Sites/Spatial characteristics
Lakes/wetlands: Queens Gardens, Claisebrook Lake, Narrows Lake, Hamilton Lake, Monger Lake (only sampled May 2001).
Drains: Claisebrook Main Drain, Point Fraser Main Drain, Mounts Bay Main Drain.

Methods (sampling, analysis, QA/QC)
Grab samples as per National Water Quality Management Strategy and 'Selection of containers and preservation of water samples for chemical and microbiological analysis – Chemical' Australian Standards 2031.1 (superseded). Chemical samples are analysed by MPL.

Data Management
Monitoring data stored by City of Perth in Microsoft Excel spreadsheets.

Reporting/Outputs
Regular meetings with contractor, discussion of results and any practical action.

Note City of Perth also collects microbiological samples, which are analysed by the Department of Health Pathcentre.

Lake Monger Water Quality Monitoring.

Custodian Town of Cambridge

Objective(s) a) To provide chemical, physical and biological information on water quality and information on water quality trends in Lake Monger; and
b) To monitor the water quality of Lake Monger for safety of human health and environmental standards.

Parameters nutrients (ammonia, ortho-phosphorus, total nitrates and nitrites, total phosphorus and total nitrogen), chlorophyll and phaeophytin.

Frequency Monthly (1998 onwards – although not always monthly)

Sites/Spatial characteristics

5 sites around Lake Monger. Site 1 - 'boat ramp' at southern end of lake near Lake Monger drive car park, Site 2 - 'water outlet' at south eastern end of lake near dog exercise area, Site 3 - 'nutrient drainage area' at north east end of lake adjoining freeway, Site 4 - 'right side of the jetty' at north end of lake with viewing platform and Site 5 - 'power box area' at west side of lake in middle of western edge.

Methods (sampling, analysis, QA/QC)

Two water samples are collected simultaneously from each site. A water sample is collected in a sterile container and then sent to the Government Analytical Laboratory QEII for bacteriological analysis and assessment of algae toxicity. The remaining set of water samples are transferred to Murdoch University (Marine and Freshwater Research Laboratory) for algae and chemical analysis.

Data Management

The results are obtained (in hard copy) and stored by the Town of Cambridge for future use in water quality reporting.

Reporting/Outputs

The results of the chemical analysis performed by Murdoch University are formulated into a report that is submitted to council on an annual basis. The QEII results are sent monthly to the Town of Cambridge to alert the council to the existence of toxic algae or potential risks to human health. Additional algae sampling and analysis may be undertaken following the appearance of an algal bloom on Lake Monger.

Water monitoring of east and west lakes within Hyde Park.

Custodian Town of Vincent

Objective(s) Monitoring stormwater run-off that is collected within the Hyde Park to establish a pattern during seasonal changes.
Monitoring of water quality in the Hyde Park compensating basin has been conducted by the Town of Vincent in the past.

Parameters pH, dissolved oxygen, total dissolved solids, temperature, nutrients (total nitrogen, total phosphorus, nitrate, nitrite and free ammonia)

Frequency Every 3 months, commenced August 1999.

Sites/Spatial characteristics

4 sites. Smith Lake - north, Smith Lake - south, Hyde Park – east and Hyde Park – west. Smith Lake and the Hyde Park lakes are connected to the Claise brook drainage system.

Methods (sampling, analysis, QA/QC)

Town of Vincent – Horticulture and Turf Diagnostics Services staff collect water measurements and samples. Samples are analysed by MPL's National Association of Testing Authorities accredited laboratory.

Data Management

Monitoring data is managed by the Town of Vincent.

Reporting/Outputs

Results are compared to National Water Quality Management Strategy guideline trigger values for aquatic ecosystem protection (ANZECC & ARMCANZ, 2000).

Tiwest water quality monitoring program.

Custodian Shire of Chittering

Objective(s) To assess the impact of the Tiwest operation (adjacent to Ellen Brook) on the surrounding surface and groundwater water quality.

Parameters conductivity, pH, sulfate, iron, radionuclides (α and β).

Frequency annual following first heavy rainfall, commenced in 1989.

Sites/Spatial characteristics

9 sites, 3 groundwater sites (1 bore within Tiwest operation and 2 bores within 2-3km radius), 6 surface water sites, all within 2-3km radius of Tiwest operation.

Methods (sampling, analysis, QA/QC)

No information provided.

Data Management

Shire of Chittering manages monitoring data.

Reporting/Outputs

The monitoring results are collated annually, compared with the previous year's monitoring results and analysed for the existence of trends. The outcome of the analysis of the monitoring results is presented to the Shire of Chittering council.

Muchea water quality monitoring program.

Custodian Shire of Chittering

Objective To assess the extent of groundwater contamination from domestic septic systems in the Muchea townsite area.

Parameters conductivity, pH, sulfate, chloride, total anions, nutrients (total nitrogen, total Kjeldahl nitrogen, nitrate-nitrogen, and nitrite-nitrogen, ammonia-nitrogen and total phosphorus), coliforms and thermotolerant coliforms.

Frequency twice annually (peak low flow and peak high flow), commenced in 1993.

Sites/Spatial characteristics

7 sample sites. All sites are groundwater bores located in or around Muchea townsite.

Methods (sampling, analysis, QA/QC)
No information provided.

Data Management
Shire of Chittering manages monitoring data.

Reporting/Outputs
The monitoring results are collated annually, compared with the previous year's monitoring results and analysed for the existence of trends. The outcome of the analysis of the monitoring results is presented to the Shire of Chittering council.

Marbeling Brook water quality monitoring program.

Custodian Shire of Chittering

Objective To assess the impact of the Merriville Downs residential development on the water quality within Marbling Brook a tributary of the lower Brockman River.

Parameters conductivity, pH, nutrients (total nitrogen, nitrate-nitrite, ammonium, total phosphorus), bicarbonate, chloride and fluoride.

Frequency no information provided. Commenced in 1994.

Sites/Spatial characteristics
2 sample sites in Marbeling Brook.

Methods (sampling, analysis, QA/QC)
No information provided.

Data Management
Shire of Chittering manages monitoring data.

Reporting/Outputs
The monitoring results are collated annually, compared with the previous year's monitoring results and analysed for the existence of trends. The outcome of the analysis of the monitoring results is presented to the Shire of Chittering council.

Shire of Peppermint Grove water monitoring program.

Custodian Shire of Peppermint Grove

Objective No information provided.

Parameters conductivity, pH and total dissolved solids.

Frequency No information provided.

Sites/Spatial characteristics
4 sites: Manner's Hill Park (Reserve 7802, Bay View Terrace), Keane's Point (Reserve 22156, Lilla Street), Council Park (Reserve 1944, Leake Street) and The Esplanade foreshore reserve (Reserve 17113, The Esplanade).

Methods (sampling, analysis, QA/QC)
No information provided.

Data Management
No information provided.

Reporting/Outputs

No information provided.

Peninsula Golf Course, Maylands – NIMP report and aquifer review.

Custodian City of Bayswater.

Objective To ensure groundwater used for irrigation is within limits and is of suitable quality.

Parameters pH, conductivity, salinity, nutrients (total nitrogen, total phosphorus, ammonium-nitrogen, phosphate-phosphorus, nitrate), metals (sodium, potassium, calcium, magnesium, lead, cadmium, total iron, aluminium, zinc, manganese and copper), hydrocarbons, pesticides, carbonate, bicarbonate, chloride, sulfate and silica.

Frequency Twice yearly.

Sites/Spatial characteristics
6 drainage lakes, 3 river sites, 4 production bores (1 artesian, 3 superficial) and 8 monitoring bores.

Methods (sampling, analysis, QA/QC)
Sampling undertaken by Agro-Nutritional Research Laboratory and Water Direct Ltd.

Data Management
Monitoring data is submitted to the Department of Environment (Water and Rivers Commission).

Reporting/Outputs
An annual report is submitted to the Department of Environment (Water and Rivers Commission).

Peninsula Estate (Maylands)

Custodian City of Bayswater.

Objective To ensure groundwater used for irrigation is within limits and is of suitable quality.

Parameters conductivity, total dissolved solids, hardness, alkalinity, metals (calcium, magnesium, sodium, potassium, aluminium, iron and manganese), carbonate, bicarbonate, chloride, sulfate, nitrate and silica.

Frequency Annually for chemical parameters and monthly for ground water levels.

Sites/Spatial characteristics
1 artesian bore near freshwater lake.

Methods (sampling, analysis, QA/QC)
Undertaken by Jim Davies & Associates. All necessary QA/QC procedures undertaken.

Data Management
Monitoring data is submitted to the Department of Environment (Water and Rivers Commission).

Reporting/Outputs
An annual report is submitted to the Department of Environment (Water and Rivers Commission).

Wetlands Water Quality Monitoring

Custodian City of Stirling.

Objective(s) Assess nutrient status of wetlands.

Parameters pH, electrical conductivity, total dissolved salts, nutrients (total nitrogen, total phosphorus, phosphate, nitrate and ammonium).

Frequency Twice annually (winter and summer). Monitoring commenced in 1995. Annual sediment sampling has occurred in most years since monitoring commenced.

Sites/Spatial characteristics

40 Sample sites. Bradford Street compensating basin, Colin Ventnor compensating basin, Waverley Pola compensating basin, Yokine Reserve compensating basin, big and little Carine Lakes (6 sample sites), Careniup Swamp (4 samples sites), Jackadder Lake (6 sample sites), Lake Gwelup (4 sample sites), Dog Swamp (3 sample sites), Spoonbill Shearwater Lakes (4 sample sites), Cedric Grebe Lake, Antonio Scarfo Lake, Beach Marmion Lakes (2 sample sites), Star Swamp (4 sample sites) and Caley Street Wetland.

Methods (sampling, analysis, QA/QC)

Analysis of samples is done through a contract laboratory.

Data Management

No information available.

Reporting/Outputs

No information available.

Canning River Restoration Project

Custodian City of Gosnells

Objective(s) a) Provide water quality information on the reach of the Canning River to determine if restoration activities have been successful.
b) Undertake photo monitoring of sites for future review.

Parameters Temperature, pH, turbidity, conductivity, total nitrogen, total phosphorous, macroinvertebrates, photopoints

Frequency Quarterly (more often when in-stream works occur).

Sites/Spatial characteristics

1 kilometre reach of the Canning River in Gosnells, from the Station Street bridge to the Albany Highway Bridge.

Methods (sampling, analysis, QA/QC)

Ribbons of Blue sampling and analysis procedures.

Data Management

Data stored and managed at the City of Gosnells and the Armadale-Gosnells Landcare Group.

Reporting/Outputs

No reports/outputs compiled.

Stormwater Monitoring of Priority Catchments (lake and bore water quality and sediment quality monitoring)

Custodian City of Subiaco, Technical Services

Objective to determine lake and bore water quality and sediment quality.

Parameters pH, conductivity, total dissolved solids, nutrients (ammonia-N, nitrate-N, nitrite-N, total kjeldahl nitrogen, total nitrogen, filterable reactive phosphorus and total phosphorus), metals (arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc) and total petroleum hydrocarbons (C_{6-9}, C_{10-14}, C_{15-28} and C_{29-36}).

Frequency monthly/quarterly

Sites/Spatial characteristics

6 sample sites. Lake Jualbup in Shenton Park (2 sample sites), Mabel Talbot Lake in Jolimont (2 samples sites) and JH Abrahams Reserve (also Subi centro irrigation/stormwater lake?)

Methods (sampling, analysis, QA/QC)

No information provided.

Data Management

No information provided.

Reporting/Outputs

Jim Davis & Associates prepare reports on the results of the Stormwater Monitoring of Priority Catchments program. Recent results are tabulated in these reports and compared with National Water Quality Management Strategy Guidelines (ANZECC and ARMCANZ, 2000), Swan-Canning Cleanup Program nutrient targets and with previous results.

Water Monitoring program in Melville

Custodian City of Melville

Objective No information provided.

Parameters pH, temperature, conductivity, total dissolved solids, dissolved oxygen, turbidity, nutrients (nitrate, nitrite, total kjeldahl nitrogen, organic phosphorus, phosphate-P and total phosphorus) and metals (arsenic, cadmium, chromium, copper, iron, mercury, nickel, lead, zinc).

Frequency Twice annually. Monitoring has occurred in most years since commencement in the 1970's.

Sites/Spatial characteristics

9 sample sites. Piney Lake Reserve, Hospital Swamp in Murdoch, Bull Creek Park (2 samples sites), Frederick Baldwin Park in Kardinya, Blue Gum Lake in Mount Pleasant, Booragoon Lake, Marmion Reserve in Myaree and Bateman Park in Brentwood.

Methods (sampling, analysis, QA/QC)

No information provided.

Data Management

No information provided.

Reporting/Outputs

No information provided.

Custodian City of Swan

City of Swan does not conduct water quality monitoring, however some incident response sampling does occur with the support of North Eastern Catchment Committee.

Custodian Shire of Kalamunda (EMRC)

There is no routine monitoring of creeks in the Shire of Kalamunda.

Custodian City of Armadale

City of Armadale does not conduct water quality monitoring.

Custodian City of Cockburn

City of Cockburn does not conduct water quality monitoring in waterways in the Swan-Canning catchment.

Custodian City of Fremantle

City of Fremantle does not conduct water quality monitoring.

Custodian City of Wanneroo

City of Wanneroo does not conduct water quality monitoring.

Custodian Town of Victoria Park

Town of Victoria Park does not conduct regular monitoring of the drainage network.

Custodian Town of Bassendean

Town of Bassendean does not conduct water quality monitoring.

Custodian Shire of Serpentine-Jarrahdale

Shire of Serpentine-Jarrahdale does not conduct water quality monitoring.

Custodian City of South Perth

City of South Perth does not conduct water quality monitoring.

Custodian Shire of Gingin

Shire of Gingin does not conduct water quality monitoring.

Custodian Town of Mosman Park

Town of Mosman Park does not currently undertake any surface water quality monitoring. Town of Mosman Park completed a surface water quality monitoring program in Mosman Bay to assess the effectiveness of gross pollutant traps. The program lasted for 2 years, was completed a year ago and was part funded by the Natural Heritage Trust. The results of the monitoring program have been compiled into a report.

Custodian City of Canning

City of Canning does not conduct a water quality monitoring program. City of Canning has conducted background water quality monitoring in the past. Targeted water quality relating to complaints or determining the effectiveness of management actions such as the installation of gross pollutant traps is conducted by City of Canning on an as-needs basis.

Custodian City of Swan

City of Swan does not conduct water quality monitoring.

Custodian Town of East Fremantle

Town of East Fremantle does not conduct water quality monitoring.

Custodian City of Belmont

No information provided.

Custodian Shire of Mundaring

No information provided.

Custodian City of Nedlands

No information provided.

Custodian Town of Cottesloe

No information provided.

REGIONAL CATCHMENT GROUPS

Ellen Brook Water Quality Monitoring Program.

Custodian Ellen-Brockman Integrated Catchment Group

Objective Identify nutrient hotspots to prioritise land management.

Parameters Nutrients (total nitrogen, total phosphorus, nitrates, nitrites, filterable reactive phosphorus) & pH

Frequency Monthly from May – November (during flow).

Sites/Spatial characteristics

19 sites – Ellen Brook Main Channel (All Saints, Millhouse Rd, Gauging Station, Warren Rd, Rutland Rd, Brand Hwy & Airfield Rd). Chandala Brook (Brand Hwy & Tiwest). Yal Yal Brook (Reserve Rd). Rocky Creek (Old Gingin Rd). Lennards Brook (Cockram Rd). Tributaries (CSW8 old Gingin Rd, Railway Pde & Neeves Rd). Nutrient stripping pond (inflow, outflow, monitoring port north & inflow monitoring port south).

Methods (sampling, analysis, QA/QC)

No information provided (Ribbons of Blue sampling methods?)

Data Management

Monitoring data provided to Ribbons of Blue for entry into National Waterwatch database for the last three years.

Reporting/Outputs

No reporting outputs for this monitoring program.

Upper Canning Southern Wungong Catchment Monitoring Program

Custodian Armadale Gosnells Landcare Group (South East Regional Centre for Urban Landcare).

Objective(s) Provide information on water quality from each of the sub catchments to determine the health of the catchments, their impact on the Southern and Canning Rivers and whether community education programs are required or are making an impact.

Parameters salinity, temperature, turbidity, pH (surface to bottom at half to one metres depth intervals) total nitrogen, total phosphorus

Frequency quarterly during flow year (~March to November), 1-3 years of monitoring data

Sites/Spatial characteristics

19 sites (Slab Gully, Stony Brook, Brookton, Patterson, Rundle, Gosnells, Wright, Pries Park, Mills, Ellis Brook, Helm Street, Bickley Brook - Pioneer Cemetery, Thornlie Huntingdale, Forrestdale Main Drain, Banjup South East, Southern River, Second Road and Neerigen Brook).

Methods (sampling, analysis, QA/QC)

As instructed by Ribbons of Blue.

Data Management

Provided to Ribbons of Blue.

Reporting/Outputs

No reports compiled.

Bennett Brook water and sediment quality monitoring program

Custodian — Bennett Brook Catchment Group (North East Catchment Committee).

Objective — To determine the extent to which water quality and sediment quality in the waterways of the Bennett Brook catchment are affected by industrial, residential and other contaminant sources.

Parameters — Water: salinity, conductivity, pH, dissolved oxygen, temperature, total nitrogen, total oxidised nitrogen, total phosphorus, filterable reactive phosphorus, heavy metals (arsenic, cadmium, chromium, copper, lead mercury, nickel, zinc), halogenated solvents, organochlorine pesticides, organophosphorus pesticides, herbicides and fungicides and total petroleum hydrocarbons.
Sediment: heavy metals (arsenic, cadmium, chromium, copper, lead mercury, nickel, zinc) and total solids.
Note – water samples were not analysed for halogenated solvents, organochlorine pesticides, organophosphorus pesticides, herbicides and fungicides and total petroleum hydrocarbons in 2003.

Frequency — Annual, 2 years of monitoring data (September/October 2002, December 2003)

Sites/Spatial characteristics
14 sites within Bennett Brook catchment, 4 in Widgee Road Branch Drain, 3 in Emu Swamp Drain, 1 in Wonga Road Branch Drain, 2 in Whiteman Park, 1 in the future Albion townsite drain and 3 in Bennet Brook.
Note – 1 Whiteman Park, 1 Bennett Brook and the future Albion townsite drain sites were not monitored in 2003.

Methods (sampling, analysis, QA/QC)
Sampling and analysis plans available, strict quality control procedures, National Association of Testing Authorities (NATA) certified laboratories used for analysis, strict quality assurance procedures. Monitoring program conducted as a North East Catchment Committee and Water and Rivers Commission/Dept. of environment partnership.

Data Management
All monitoring data is stored in the WIN database managed by the Water and Rivers Commission/Dept. of Environment.

Reporting/Outputs
Bennett Brook monitoring data is reported via technical reports (2002 and 2003 reports currently being prepared by the North East Catchment Committee) and monitoring data stored in the WIN database is publicly available.

Swan Region Long-term Water Quality Monitoring Programs

Custodian — Ribbons of Blue / Waterwatch WA

Objective(s) — The Swan Region Ribbons of Blue objectives are to: increase community awareness and understanding of water quality issues in a whole of catchment context; provide school and community educational opportunities; encourage collaborative local action projects to identity and resolve water-related catchment issues and maintain partnerships to support continued water quality outcomes.

Parameters — temperature, pH, electrical conductivity, turbidity, dissolved oxygen, nutrients (nitrate and phosphate), macroinvertebrates (taxa richness and diversity), phytoplankton and visual assessments (vegetation, water, smell, banks, animal life, litter, pipes and drains, land use and human use).

Frequency

dependent on the objectives of individual long-term monitoring programs. Most long-term programs sample physical and chemical parameters monthly and usually include the first flush in May-June.

One-off (snapshot) sampling includes 'Water Wonders' (2 week period May/June, physical properties and macroinvertebrates), National Macroinvertebrate Snapshot (2 week period September, physical properties and macroinvertebrates) and Nutrient Snapshot (physical properties, nutrients, heavy metals and macroalgae).

Sites/Spatial characteristics

Ribbons of Blue provide support to community and catchment groups conducting environmental monitoring. The current long-term water quality monitoring programs Ribbons of Blue are involved with are: Ballajura Lakes Ratepayers and Residents Association, Bannister Creek Catchment Group, Bayswater Integrated Catchment Management (including John Forrest SHS and Chisholm College Bushrangers), Two Rivers Catchment Group, Calix Group, Canning River Residents Environmental Protection Association, Claise Brook Catchment Group, Cockburn Wetlands Education Centre, Ellen Brockman Integrated Catchment Group, Friends of Eric Singleton Bird Sanctuary, Friends of Heron Reserve, Friends of Mary Carrol Park, Midland Friends Restoring Our Green Spaces, Wilson Wetlands Action Group and Yellagonga Catchment Group (including Greenwood SHS).

Methods (sampling, analysis, QA/QC)

The tests, methods, equipment, safety guidelines, designing monitoring programs and data confidence procedures followed by Ribbons of Blue/Waterwatch WA are in accordance with the Waterwatch Australia National Technical Manual prepared by the Waterwatch Australia Steering Committee and published by Environment Australia. Waterwatch Australia and Ribbons of Blue/Waterwatch WA follow ANZECC 2000 guidelines to Australian water quality criteria for fresh and marine waters and for Australian guidelines for water quality monitoring and reporting. The Australian River Assessment System (AUSRIVAS) is also followed in specific monitoring programs (living stream projects) for the assessment of macroinvertebrates.

Data Management

Ribbons of Blue/Waterwatch WA data (subject to confidence checks) is recorded on the Waterwatch Australia Access database managed by Ribbons of Blue Regional Coordinators. Information recorded in the database includes site code, sample date, sample time, sample type, test type, test name, result, units of measurement, sampler and sample history. Waterwatch Australia published the database in 1997.

Data collected from specific water quality snapshot events (eg Nutrient Snapshot 2003) is also imported into the WIN database managed by the Department of Environment.

Reporting/Outputs

Water quality data is sent to stakeholders on request in the form of printed reports. Some interpretation and analysis is provided, particularly relating to the long-term monitoring programs.

Custodian Claise Brook Catchment Group (North East Catchment Committee)

The Claise Brook Catchment Group does not conduct water quality monitoring.

Custodian Two Rivers Catchment Group

No information provided.

PROPOSED MONITORING AND REPORTING (NEEDS)

COMMONWEALTH GOVERNMENT

Perth Airport water quality monitoring program

Custodian Perth airport.

The Airport proposes to continue its' current regime of water quality monitoring and has proposed a series of meetings with interested stakeholders to discuss current and future water quality monitoring activities.

STATE GOVERNMENT

Contaminant (non-nutrient) monitoring program (Swan-Canning Cleanup Program)

Custodian Swan River Trust and Water and Rivers Commission/ Dept. of Environment.

The objective(s) of the proposed non-nutrient monitoring program are to obtain baseline data on contaminants in the Swan and Canning Rivers, obtain catchment-wide information to assist in identifying 'hotspots' in Canning Plain catchments and receiving River environment and further investigate established 'hotspots'. The monitoring program outputs will be linked to land use and industry placement so as to guide source control, education and remediation activities. A detailed sampling and analysis plan consistent with the National Water Quality Management Strategy and relevant Australian Standards has been developed for this program.

Ecosystem Health / River Health monitoring program (Swan-Canning Cleanup Program)

Custodian Swan River Trust, Water and Rivers Commission/ Dept. of Environment and Swan Catchment Centre.

A monitoring program has been proposed to assess the ecosystem health of the Swan and Canning estuaries and catchment waterways. Indicators such as macroinvertebrate populations and species, aquatic plants, fish species, foreign species and benthic habitat are being considered.

Nutrient and contaminant assessment for the Mills Street Main Drain catchment

Custodian Swan River Trust (Water and Rivers Commission/ Dept. of Environment)

Identify primary nutrient and contaminant sources through further spatial sampling, investigate 'hotspots' within the catchment to identify intermittent point sources, investigate lead concentrations in Wilson wetland, investigate pesticides at Ewing Street Compensating Basin, investigate the accumulation of contaminated sediments within the compensating basins and investigate the quality of groundwater intercepted by the drainage system and identify areas for remediation and/or treatment. Sampling of shallow bores in the Mills Street Main Drain catchment for nutrients and metals has been proposed for March/April 2004.

Stormwater quality monitoring

Custodian Swan River Trust (Water and Rivers Commission/ Dept. of Environment)

Stormwater sampling in the Canning Plain catchment and in City of Belmont drains has been proposed to commence during 2004.

Stormwater quality monitoring

Custodian Main Roads Western Australia

Water quality monitoring before and after the installation of road drain retrofitting is currently being conducted at select locations within the metropolitan area. The water quality monitoring is aimed at assessing the efficacy of the retrofitting measures in improving water quality.

Drainage water quality monitoring (2001-?)

Custodian Water Corporation

The immediate objective of the drainage monitoring program is to gain knowledge of the quality of water discharging to receiving water bodies from each of the urban Water Corporation drains in the Perth Region. Of primary importance is the identification of 'dirty' drainage catchments. Following the classification of each drain in terms of selected water quality parameters the objective is likely to shift to a more specific one. Gaining spatial knowledge of catchments will enable the identification of sources of pollutants to drains and assist in the identification of appropriate infrastructure to reduce pollutant loads.

The objective is to understand the sources and forms of pollutants contributing to those measured at the discharge point. This data will enable decisions to be made about the location and type of drainage water quality infrastructure necessary to improve drainage water quality.

Water Corporation's commitment to drain water quality monitoring and the results of the monitoring programs should be publicised appropriately to contribute to the Water Corporation's good corporate citizen image.

LOCAL GOVERNMENT

Custodian City of Armadale

A one-off 'hotspot' survey to identify where intervention would be worthwhile has been proposed. Monitoring of loads in relation to Armadale Re-development Authority areas in collaboration with CSIRO has been proposed. Further funding for water quality monitoring is unlikely.

Custodian Shire of Kalamunda

No monitoring plans have been contemplated. Groundwater monitoring is conducted as part of development conditions for Forrestfield Marshalling Yards Industrial Estate.

Custodian City of Perth

Continue existing water quality monitoring of lakes, wetlands, main stormwater drains and outlets to provide baseline information on physical and chemical water quality for future water quality improvement.

Custodian Town of Claremont

The Town of Claremont will be participating in the Western Suburbs Regional Organisation of Councils (WESROC) - Regional Stormwater Quality Study. The objective of this study is to assess the stormwater quality of drains (3 sites), groundwater and surface water through measuring pH, total dissolved solids, conductivity, nutrients (total nitrogen, total Kjeldahl nitrogen, total phosphorus, nitrate, nitrite, ammonia, filterable reactive phosphorus), metals (cadmium, copper, lead, zinc). Proposed sampling will occur 4 times a year. Two of the monitoring sites will be located in stormwater drains leading to Lake Claremont and 1 site will be located in the stormwater drain leading to the Swan River.

The Town of Claremont and WESROC (Regional Stormwater Quality Study Committee) will manage monitoring data and monitoring program outputs will be reported to the WESROC (Regional Stormwater Quality Study Committee), Lake Claremont Committee and the Claremont Council.

Custodian Town of Vincent

The monitoring of water quality in Smith Lake and the Hyde Park lakes by the Town of Vincent is ongoing. The Town of Vincent is investigating other options for future monitoring.

Custodian City of Fremantle

The City of Fremantle is contemplating investment in catchment improvement, which may comprise water quality monitoring.

Custodian City of Wanneroo

The City of Wanneroo has identified a need for monitoring of stormwater quality in drains that discharge into Lake Joondalup. A proportion of Lake Joondalup is within the City of Joondalup.

Custodian Town of Victoria Park

The Town of Victoria Park is considering development of a stormwater management plan. The stormwater management plan is likely to comprise development of a monitoring program to determine the effectiveness of the proposed stormwater management.

Custodian Town of Bassendean

The Town of Bassendean is developing an environmental plan in consultation with the community. It is possible that the need for a water quality monitoring program will be identified as part of the environment plan.

Custodian Shire of Serpentine-Jarrahdale

The Shire of Serpentine-Jarrahdale has identified the need to locate the sources of nutrients in catchments, monitor the quality of surface water to support modelling, obtain information to support state of environment reporting and determine the quality of, and issues associated with groundwater within the shire. The monitoring needs of Shire of Serpentine-Jarrahdale are directed towards the Serpentine catchment rather than the Swan-Canning river system.

Custodian City of South Perth

The City of South Perth is developing an integrated catchment management plan that will comprise a monitoring and community education component. The integrated catchment management plan will focus on issues such as drainage, hydraulics, ground water and water quality and will be completed in late June 2004.

Custodian Shire of Gingin

The monitoring needs of Shire of Gingin are directed towards the Moore River rather than the Swan-Canning river system. The Shire of Gingin has identified a need to re-commence the Moore River estuary water quality and hydrodynamics monitoring program that was run in partnership with the Water and Rivers Commission from 1998 until 2002.

Custodian Town of Mosman Park

The Town of Mosman Park is commencing a monitoring program this year aimed at assessing the effectiveness of 'at source' catchment management strategies, such as street sweeping, on stormwater quality. The monitoring program will commence this winter and comprise four sampling events over the next two years throughout the Bird Street precinct. The monitoring program is part of the regional stormwater quality management strategy.

The Town of Mosman Park is also planning to commence a two–year monitoring program of pollutant levels, particularly nutrients, oil and grease, metals (chromium, copper, iron and lead) and hydrocarbons, in groundwater at wells in Nash Field and Mann Oval. The majority of surface water in the Town of Mosman Park is directed to gullies for infiltration and as such the monitoring program is aimed at determining whether this process has had an impact on the local groundwater.

Custodian City of Bayswater

A program is being considered to further investigate rising salinity in two superficial bores and variations in acidity/alkalinity of some drainage lakes. This may entail sinking extra monitoring bores and sampling lake sediments.

Custodian Shire of Chittering

Continue existing Tiwest, Muchea and Marbeling Brook water quality monitoring programs.

Custodian City of Perth

The City of Perth has identified a need to monitor residential estate lakes (nutrient sources) and to carry out an industry appraisal (oils and other aquatic pollutants) and audit where the polluted drains and water courses are, and how they being polluted (& by whom).

Custodian City of Stirling

The city of Stirling proposes to extend the parameters of its' wetland monitoring program to include macroinvertebrates and chlorophyll a.

Custodian Town of East Fremantle

The Town of East Fremantle proposes monitoring the water quality of the main drainage outfall into the Swan River at Stirling Highway Bridge. This accounts for about 50% of the drainage network for the Town of East Fremantle.

Custodian City of Swan

City of Swan has identified a need for information on the quality of stormwater being discharged from drainage directly into the Swan River. Ideally, the information would then be used to guide the installation of stormwater quality improvement devices such as gross pollutant traps and buffering zones and to determine the effectives of such devices.

Custodian City of Canning

City of Canning has identified a need for information on water quality once all premises within the City are sewered. This information could then be compared with past monitoring data to determine resulting changes/improvements in catchment and drainage water quality. City of Canning is finalising a catchment management plan for Mills Street Main Drain and associated catchments that may comprise a water quality monitoring component.

Custodian Shire of Peppermint Grove

No information provided.

Custodian Town of Cambridge

No information provided.

Custodian City of Belmont

No information provided.

Custodian Shire of Mundaring

No information provided.

Custodian City of Melville

No information provided.

Custodian City of Gosnells

No information provided.

Custodian City of Subiaco

No information provided.

Custodian City of Nedlands

No information provided.

Custodian Town of Cottesloe

No information provided.

REGIONAL CATCHMENT GROUPS

Custodian Swan Catchment Council

Monitoring of management actions and resource condition will be required pursuant to the draft Swan Region Natural Resource Management Strategy. The development of a monitoring and evaluation framework has been proposed. The draft Strategy has proposed a monitoring program to establish baseline river condition from which resource condition targets can be generated. A need to establish a biological/river condition monitoring program has been identified along with the need to coordinate existing monitoring programs to minimise duplication and strengthen partnerships.

Custodian Eastern Hills Catchment Management Project.

Investigate the impact of revegetation projects on water quality. Future monitoring needs have specified a need to initiate and coalesce a monitoring program throughout the Eastern Hills Catchment Management Project region to investigate the impact of revegetation projects on water quality. The monitoring would be based on macroinvertebrate sampling on a quarterly basis (hopefully). The data would be linked to a global information system (GIS) program on a database at Mundaring Shire. Development of monitoring points to investigate seedling survival rates, weed cover, vegetation condition, erosion and water quality assessment using macroinvertebrates is being considered.

Custodian Ellen Brook Catchment Group (Ellen-Brockman Integrated Catchment Group).

Continue catchment water quality monitoring program, isolate nutrient hotspots, show change in water quality over time (trends), monitor catchment health and relate to activities. Develop an inventory of management actions outside of EBICG scope. Develop catchment health indicators and conduct a foreshore assessment.

Custodian Bannister Creek Catchment Group (South East Regional Centre for Urban Landcare).

To examine the nutrient (and possibly heavy metal) stripping effectiveness of the Tom Bateman constructed wetland. A ten-year water quality monitoring program of the Tom Bateman wetlands has been proposed. Assistance from Murdoch University, Curtin University, Department of Environment, City of Canning and City of Gosnells will be requested. Monitoring program details such as parameters and sampling frequency have not been finalised.

Custodian South East Regional Centre for Urban Landcare

A desire has been expressed for a region wide water quality monitoring approach that includes ground water intrinsically with surface water. The objective of this approach would be to understand the influence of ground water on surface water nutrient loads and the effect this has on reaching nutrient targets (are the targets unrealistic in the face of ground water contribution to surface water nutrient loads?) Data to be shared with community, agencies, local government authorities and educational institutions.

Custodian Two Rivers Catchment Group (South East Regional Centre for Urban Landcare).

Two Rivers: understand algal blooms and their triggers, control algal bloom growth, identify how and where nutrients enter and cycle in river and minimise these inputs, reduce frequency and occurrence of algal blooms, 30% reduction in nitrogen, phosphorus and heavy metal inputs into the river by 2008.

Custodian Armadale-Gosnells Landcare Group (South East Regional Centre for Urban Landcare).

Armadale-Gosnells: publicise water quality targets and status of rivers and sub-catchments, continue to improve water quality entering the Canning and Southern Rivers. Monitoring of each sub-catchment. The Armadale-Gosnells Landcare Group would prefer to have monitoring provided by a state government body to ensure correct use of equipment and correct data management. Correct sampling procedures and appropriate data management has been difficult to achieve in the past using volunteers and Ribbons of Blue.

Custodian	Bayswater Integrated Catchment Group/Bennett Brook Catchment Group (North East Catchment Committee).

Modify and continue monitoring program in Bennett Brook catchment, research baseline monitoring for Bayswater Main Drain and Stirling drains.

Custodian	Claise Brook Catchment Group

The Claise Brook Catchment Group has proposed monitoring in Claise Brook drain (Royal Street), Royal Street drain, Plain Street municipal tip (opposite Queen's Gardens), Wellington Street drain (junctions near Milligan, William and Pier Streets), Lake Street drain, Beatty Park, Smith's Lake/Charles Veryard Reserve and Dog Swamp/Breckler Park. The proposed monitoring would be in response to a historical land use survey that highlighted a largely unrecorded pollution legacy in some soils and possibly ground waters of the catchment. A range of parameters including nutrients, heavy metals, organic acids, pathogens, pesticides and alkalis have been identified for incorporation into the proposed monitoring program.

Custodian	Two Rivers Catchment Group

No information provided.

Custodian	Ribbons of Blue / Waterwatch WA

No information provided.

RECOMMENDATIONS

With the development of the monitoring and evaluation framework for Natural Heritage Trust/National Action Plan co-funded regional strategy and new programs to be undertaken to meet the Riverplan requirements, there exists an excellent opportunity to integrate many of the existing and proposed monitoring programs, thus optimising the information gathered from monitoring expenditure.

- Develop an overall coordinated monitoring program that recognises the considerable overlap in objectives and needs of the various existing and proposed monitoring programs.

- Ensure all monitoring and reporting in the Swan-Canning river system is consistent and compatible with desired uses/outcomes such as local waterways management, communication of local waterways issues, State of Environment reporting, National Land and Water Resources Audit Reporting and natural resource management.

- Expand the estuary and catchment component of the Swan-Canning Cleanup Program to include contaminant (non-nutrient) and ecosystem health components;

- Enable comparison of results between similar monitoring programs by ensuring existing monitoring programs and proposed monitoring programs adopt consistent sampling and analysis methods. Ensure all data collected is on known quality. The Community Guideline to Surface Water Quality Investigations developed by the Department of Environment may be a useful tool in achieving consistency in water quality monitoring;

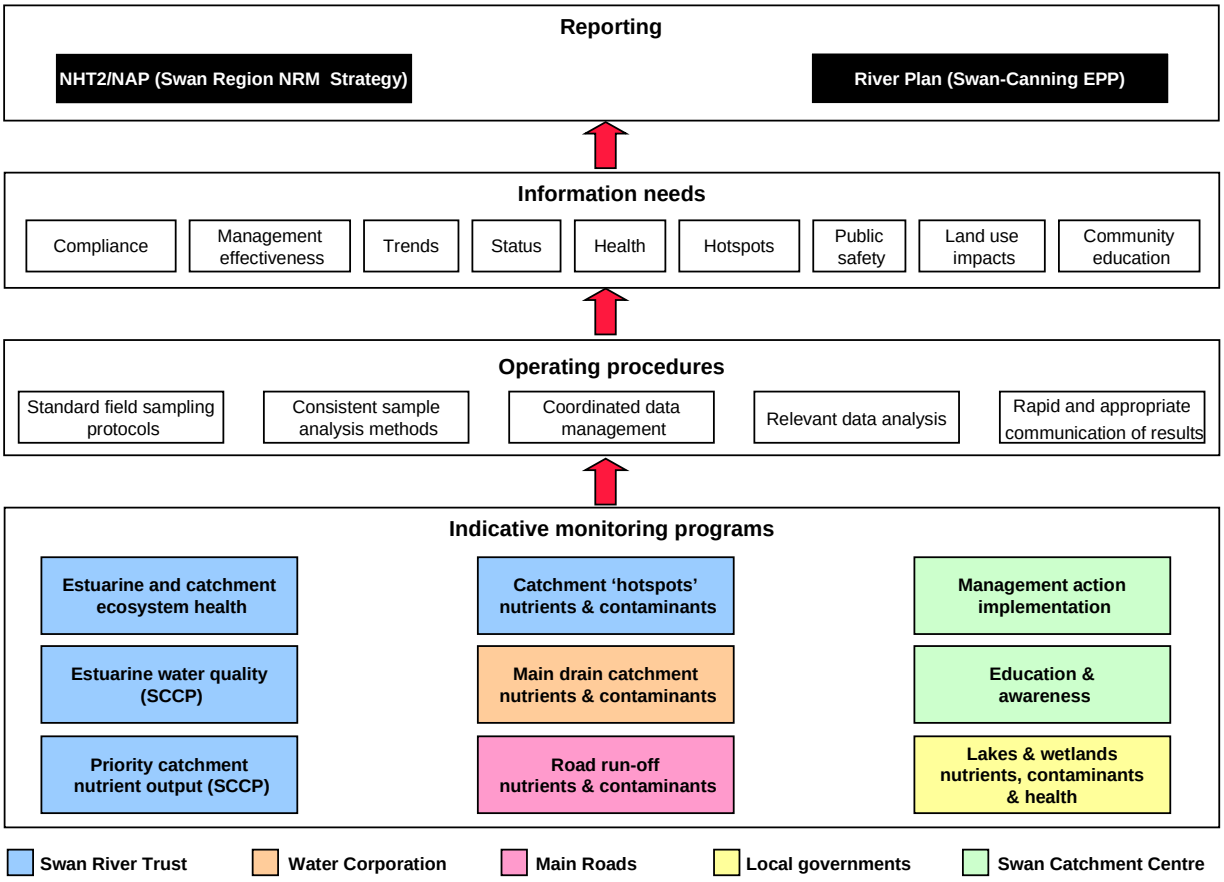
- Support access to monitoring data and information through use of consistent data management protocols such as storing all monitoring data in a single, publicly accessible database. The DoE WIN database has been specifically constructed for this purpose with a generalised data model to accommodate a range of environmental data;

- Monitoring in the Swan-Canning system needs to support local information needs as well as state and national reporting systems such as state of environment, national land and water resources audit and natural resource management (Natural Heritage Trust/National Action for Salinity and Water Quality).

- Promote the inclusion of appropriate and targeted communication strategies in all monitoring programs to maximise the benefit of the water quality information collected.

- Support the development of partnerships that are capable of reducing monitoring duplication and/or improving monitoring data quality and consistency in the Swan-Canning river system.

PROPOSED MONITORING AND REPORTING FRAMEWORK



CASE STUDIES

COCKBURN SOUND MANAGEMENT COUNCIL

The Cockburn Sound Management Council coordinates the Environmental Quality Monitoring Program in Cockburn Sound with support for the Department of Environment, Aquatic Science Branch. The Monitoring Program in Cockburn Sound comprises monitoring conducted by industry groups, local, state and federal government of many physical, chemical and biological indicators over a range of temporal and spatial intensities.

Standard Operating Procedures have been developed for Cockburn Sound to ensure existing and proposed monitoring programs adopt consistent sampling and analysis methods thus enabling the comparison of results between contributing monitoring programs.

Results from monitoring conducted by the Kwinana Industries Council, Fremantle Ports, Department of Defence, Department of Environment, Department of Health and the WA Mussel Producers Association are stored in a single, publicly accessible database. The Water Information Network (WIN) database managed by the Department of Environment was selected to store Cockburn Sound monitoring data and information.

Monitoring Program results are used by the Cockburn Sound Management Council to provide information on the health of Cockburn Sound marine environment to stakeholders and the community. A report card for each environmental value has been prepared every year since 2001. The Cockburn Sound report cards are derived through assessing the compliance of monitoring data with the environmental quality criteria. The management framework for Cockburn Sound is being formalised through the development of an Environmental Protection Policy. The environmental quality criteria provide quantitative benchmarks for measuring success in achieving environmental objectives. The draft Policy provides that where criteria are exceeded an investigation or adaptive management response is required to restore environmental quality within an agreed timeframe.

The Cockburn Sound report cards are presented to the community at an annual forum. A web reporting system was recently developed that builds on the existing annual report cards and uses report card maps to indicate specific locations of concern and areas requiring additional monitoring effort.

The Monitoring Program is being developed in partnership with stakeholders to provide information on the effectiveness of management recommendations promoted in the Interim Environmental Management Plan to protect and enhance the environmental values of Cockburn Sound.

For more information, visit the Cockburn Sound Management Council website at: http://www.wrc.wa.gov.au/region/csmc/

SWAN-CANNING CLEANUP PROGRAM

The Swan River Trust and Water and Rivers Commission (Department of Environment) have developed an extensive monitoring program to provide information on water quality in the Swan-Canning river system. The Swan-Canning Cleanup Program funds the program. The objectives of the monitoring program are to:

a) Provide chemical, physical and biological information on water quality and information on water quality trends in the estuary and coastal catchment;

b) assess whether SCCP water quality targets are being met;

c) provide information to help public health authorities assess hazards to public health and recreational use of the rivers associated with algal blooms; and

d) help establish environmental standards and assess trends in environmental quality.

The program measures water column nutrient concentrations at the bottom of 15 key catchments and physical, chemical and phytoplankton aspects of the water in the estuarine portion of the river system.

The program has been designed to provide information to support each of the 4 objectives specified above. For example, during periods of high phytoplankton activity, phytoplankton concentrations are determined at an increased number of locations to assist assessment of public health risks. This information also helps to refine our knowledge of algal blooms and assess the effectiveness of the SCCP implementation.

The monitoring program has been designed such that results can be used for assessing long-term water quality trends in addition to determining compliance against management water quality targets in addition to supporting the other information needs. The program supports a range of Science communication activities including weekly web reporting, the RiverScience newsletter series, technical reports and catchment report cards. The data are used by students and staff at all universities in the region and support process understanding in terms of system response and provide critical data for the calibration and validation of catchment and estuarine models.

For more information, visit the Swan River Trust (Swan-Canning Cleanup Program) website at: http://www.wrc.wa.gov.au/srt/index.html

MORETON BAY WATERWAYS AND CATCHMENT PARTNERSHIP

A strategy comprising a comprehensive and integrated program for the protection and restoration of the ecological health of South East Queensland's waterways and catchments has been developed. The Moreton Bay Waterways and Catchments Partnership, formed in 2001, brings together South East Queensland's Healthy Waterways Partners. State ministers, Council mayors, community, industry and Commonwealth Government representatives have made a commitment to provide the necessary resources and impetus to support the implementation of the Strategy and to deliver the Health Waterways Vision. The Strategy identifies management directives and provides a framework for the integrated and cooperative management actions necessary to protect the waterways of South East Queensland.

One of the hallmarks of the South East Queensland Regional Water Quality Management Strategy has been the development of a coordinated, integrated and cost-effective monitoring program for aquatic ecosystem health.

The aquatic ecosystem health of the major waterways in South East Queensland is monitored and assessed by a team of multi-disciplinary scientists as part of the Ecosystem Health Monitoring Program. This program, which commenced in January 2000, independently audits the effectiveness of community, council, state government and industry investments in improved waterways management to restore and protect the river estuaries and Moreton Bay.

The Ecosystem Health Monitoring Program is based on a conceptual model that integrates or current scientific understanding of the waterways with community-derived environmental values. The Monitoring Program includes a communication strategy that aims to deliver clear and informative accounts of monitoring activities, results and community benefits. The major elements of this strategy are an annual report card, regular newsletters and a comprehensive website. Each year a report card is presented to evaluate improvements or declines in ecosystem health across the Moreton region. Generation of this report card is based on integration of a range of physical, chemical and biological indicators.

Review is an integral component of the monitoring program. Quarterly reviews based on spatial and statistical analyses of results are conducted to provide regular quality control on data generated. A Monitoring Steering Committee represents stakeholder's interests, signs off on annual reports and approves modifications to the monitoring strategy.

The collaborative approach between all levels of government, community and industry is a key characteristic of the South East Queensland Study, the Moreton Bay Waterways and Catchment Partnership and the associated Healthy Waterways Campaign. Based on strong political leadership and advocacy, an effective, "whole of community" approach to prepare an action plan to protect and enhance water quality and ecological/economic sustainability in the region has been developed. A common vision, a regional approach, a staged set of tasks with close linkages between stakeholders and the science and management are essential elements of the success of the Partnership.

For more information on the Healthy Waterways Campaign visit the website at: http://www.healthywaterways.env.qld.gov.au/ and for more information on the Ecosystem Health Monitoring Program visit: http://www.coastal.crc.org.au/ehmp/index.html

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Ecosystem Health Monitoring Program website: http://www.coastal.crc.org.au/ehmp/index.html

APPENDIX A – Other Monitoring and/or Sampling Activities and Needs

The focus of drainage reform is on surface water quality monitoring in the Swan-Canning river system. Information has been provided as part of this task that is outside the scope of the drainage reform but relevant for other purposes such as natural resource management. Monitoring has not been included in the body of this report if classified as:

- Discrete sampling events (not ongoing monitoring);
- Outside Swan-Canning river system (monitoring in waterways that are not within the Swan-Canning river system);
- Mediums other than surface water (monitoring of groundwater, sediment etc not as part of a surface water monitoring program); and
- Other parameters (monitoring of parameters other than water quality parameters eg. macroinvertebrates, habitat etc not as part of a surface water monitoring program)

South Belmont Main Drain catchment 2003 (discrete sampling event)

On 20th May 2003 a one-off snapshot in South Belmont Main Drain was carried out at 7 sites (6 sites in the main drain & 1 site in the compensating lake) these sites were based on the City of Belmonts' (Kevin Davidsons') previous sampling. The sampling was for nutrients (totals and fractions), total heavy metals (arsenic, cadmium, chromium, copper, mercury, nickel, lead & zinc), total suspended solids and physical data (temperature, dissolved oxygen, conductivity & pH). Two sites (one upstream and one downstream of the riffle) at the Coolgardie Drain restoration site were also sampled as part of the South Belmont Main Drain snapshot.

Bayswater assessment 2003

An assessment of water, sediment and fish quality in the Bayswater drains and adjacent Swan River was conducted in April/May 2003. The assessment comprised one-off sampling of 16 drain and 10 river sites to determine the extent to which the drains and river were affected by industrial and other contaminants. The assessment involved the analysis of samples for physical properties, sulfate, fluoride (water only), nutrients (water and sediment) and metals. The monitoring data is stored on the Department of Environment – WIN database and has been published in a report titled Assessment of Water, Sediment and Fish Quality in the Bayswater drains and adjacent Swan River, April/May 2003.

City of Cockburn – Lakes

All current and proposed monitoring by City of Cockburn is directed towards the lakes (eg. North Lake, Bibra Lake). The lakes do not connect to the Swan-Canning river system.

Lake Joondalup Groundwater monitoring program

Current monitoring by the Yellagonga Catchment Group is directed towards (a) determining the load of nutrients entering Lake Joondalup via groundwater; (b) providing information on the water quality trends of the groundwater entering Lake Joondalup over time; (c) predicting/locating particularly contaminated areas and focusing further studies and/or management strategies on these highlighted areas; and (d) helping to establish environmental standards for the groundwater quality of the area. Lake Joondalup does not connect to the Swan-Canning river system.

Salinity, temperature, pH, and nitrate and filterable reactive phosphorus are sampled, at 4 bore sites along eastern edge of Lake Joondalup, as part of a monthly program that began in 2001. Volunteers

conduct sampling and analysis in accordance with the Ribbons of Blue sampling and analysis methods. All data is stored in a spreadsheet database and is also forwarded to the Ribbons of Blue regional office for collation into the Waterwatch Database.

The Yellagonga Catchment Group has proposed an extension of current groundwater monitoring program to include Lake Goollelal, Walluburnup and Beenyup Swamps to determine the contribution from Lake Goollelal and Walluburnup and Beenyup swamps to the total nutrient load in Lake Joondalup. All aspects of the proposed program extension would be consistent with the current program with the addition of sampling 5 bores along the eastern edge of Lake Goollelal, 1 bore between Walluburnup and Beenyup swamps.

Brockman Catchment Group monitoring.

Current and past monitoring has included a snapshot for salinity and pH (Sept 2003) at request of Swan/Avon catchment group, macroinvertebrate and fish monitoring at 10 sites (2000, repeated Oct 2001) and a foreshore assessment (2001). All monitoring in the Brockman Catchment has been performed in accordance with Ribbons of Blue guidelines.

The Brockman Catchment Group has identified a need to conduct water quality monitoring twice annually (rainfall event or first flush and spring flow) for at least one year to ascertain pH, conductivity, nutrients (total nitrogen & total phosphorus), chlorophyll a and suspended solids concentrations. Monitoring to determine salt and silt loads, water column heavy metal, herbicide and pesticide concentrations at the two gauging stations in the catchment has also been identified as a monitoring need. Annual macroinvertebrate and aquatic vertebrate monitoring, monitoring of water from suspected acid seepage sites and acid water sites for aluminium and iron concentrations and identification of algal bloom species would also be of value to the Brockman Catchment Group.

Salinity Management Scheme Program

The Wooroloo Brook Land Conservation District Committee monitors ground water temperature, conductivity and depth to groundwater quarterly at 10 sites within the Wooroloo Brook catchment to monitor changes in the water quality of Wooroloo Brook groundwater and assess the impact of catchment management projects. The monitoring data from this program is collected by the Wooroloo Brook Land Conservation District Committee Project Officer and forwarded to the Department of Environment – Northam Office.

Wooroloo Brook water quality monitoring.

The Wooroloo Brook Land Conservation District Committee (Eastern Hills Catchment Management Project) monitors changes in the water quality of Wooroloo brook and to assess the impact of catchment management projects (revegetation and protection of existing vegetation). Temperature, conductivity, pH and depth to ground water is monitored monthly at 7 sample sites being Chinganning Gully South (Woottating Rd), Chinganning Gully (Chinganning Rd), Muranine Gully, Coates Gully (Oyston Rd, two sites), Chinganning Gully (Great Eastern Hwy) and Coates Gully (junction of Great Eastern Hwy and Warin Rd. The monitoring data from this program is collected by the Wooroloo Brook Land Conservation District Committee Project Officer and forwarded to the Department of Environment – Northam Office.

Mosman Park Salinity Monitoring

The Town of Mosman Park currently undertakes monthly sampling at 24 bores to investigate salinity, for irrigation purposes. The program has been running for 10 years.

Confidential Draft

Improving Urban Drainage Water Quality

Options for resourcing improvements to urban drainage water quality on the Swan Coastal Plain

Prepared for the Swan-Canning Catchment Drainage Forum

March 2004



ACIL Tasman

Economics Policy Strategy

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ACIL Tasman Pty Ltd

ABN 68 102 652 148
Internet www.aciltasman.com.au

Melbourne office
Level 6, 224-236 Queen Street
Melbourne VIC 3000
Telephone (+61 3) 9600 3144
Facsimile (+61 3) 9600 3155
Email melbourne@aciltasman.com.au

Brisbane office
Level 15, 127 Creek Street
Brisbane QLD 4000
GPO Box 32
Brisbane QLD 4001
Telephone (+61 7) 3236 3966
Facsimile (+61 7) 3236 3499
Email brisbane@aciltasman.com.au

Perth office
Level 12, 191 St Georges Terrace
Perth WA 6000
PO Box 7035
Cloisters Square
Perth WA 6850
Telephone (+61 8) 9485 0300
Facsimile (+61 8) 9485 0500
Email perth@aciltasman.com.au

Canberra office
103-105 Northbourne Avenue
Turner ACT 2612
GPO Box 1322
Canberra ACT 2601
Telephone (+61 2) 6249 8055
Facsimile (+61 2) 6257 4170
(+61 2) 6249 7455
Email canberra@aciltasman.com.au

Darwin office
Suite 1/63 Marina Boulevard
Cullen Bay NT 0820
GPO Box 1000
Darwin NT 0801
Telephone (+61 8) 8981 2101
Facsimile (+61 8) 8981 2702
Email darwin@aciltasman.com.au

Sydney office
PO Box 170
Northbridge NSW 1560
Telephone (+61 2) 9958 6644
Facsimile (+61 2) 8080 8142
Email sydney@aciltasman.com.au

For information on this report

Please contact:

John Roberts
Telephone (08) 9485 0300
Mobile 0404 052 330
Email j.roberts@aciltasman.com.au

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Executive summary

The Swan-Canning Catchment Drainage Forum (the Forum) was recently established to develop recommendations for the future management of drainage and water quality on the Swan Coastal Plain. To inform its deliberations, the Forum commissioned a number of studies designed to fill existing gaps in knowledge of the drainage problem.

ACIL Tasman Pty Ltd was engaged as part of this process to develop options for resourcing the range of practices proposed to improve urban drainage water quality in the Swan-Canning Catchment.

ACIL Tasman identified a number of resourcing instruments that fall under the general heading of the market-based approach to environmental policy. Market-based instruments are gaining in prominence in environmental policy as an adjunct to or replacement for the traditional regulatory approach to environmental protection.

The three instruments identified are:

- Direct funding from the Consolidated Fund;
- An increase in the Water Corporation's Drainage Rate; and
- An environmental levy.

ACIL Tasman rated the three options against a number of criteria and given the current situation, concluded that the best option is an environmental levy.

1 Introduction

The Swan-Canning Catchment Drainage Forum (the Forum) was recently established to develop recommendations for the future management of drainage and water quality on the Swan Coastal Plain. To inform its deliberations the Forum commissioned a number of studies designed to fill existing gaps in knowledge of the drainage problem.

ACIL Tasman Pty Ltd (ACIL Tasman) was engaged as part of this process to develop options for resourcing the range of practices proposed to improve urban drainage water quality in the Swan-Canning Catchment.

A number of options are available to achieve this goal, ranging from direct funding by government through to 'polluter pays' or 'beneficiary pays' approaches. These options for funding fall under the general heading of the 'market-based approach' to environmental policy. This approach contrasts to the more widely known approach of direct regulation. With the exception of an occasional penalty for illegal discharges that have been identified, there has been little use of market-based instruments in managing water quality in the Swan-Canning Catchment.

Market-based instruments are seen as efficient, effective, incentive-based mechanisms for achieving complex environmental objectives in addition to raising revenue for environmental or other fiscal purposes.

This paper provides an overview of the alternative market-based approaches and makes recommendations as to the appropriate market-based instrument(s) to use to achieve the drainage water improvements desired for the Swan-Canning Catchment.

2 The market-based approach to environmental policy – an overview

There are situations in the economy where the interactions of firms and individuals are not adequately reflected in market prices. For example, a firm that pollutes a river with discharges high in phosphorus will negatively impact on the well-being of individuals who use the river for recreation. This impact or social cost is termed an externality[1] and it is not reflected in the price of the firm's products. In economic terms there is a divergence between the firm's private and social costs with the environmental costs being overlooked.

[1] Note that there can be positive externalities as a result of a firm's or individual's actions as well as negative impacts.

The presence of environmental externalities is an example of market failure and is considered a strong argument for government intervention in environmental protection. A regulatory approach has been the traditional form of government intervention in environmental matters, both in Australia and overseas. Regulation typically takes the form of explicit limits on allowable levels of emissions and mandated use of specified abatement techniques. Polluters must comply with prescribed regulations or face penalties. Examples of direct regulation include standards, licences and permits.

Direct regulations often suffer from inflexibility and high costs of administration and compliance. In addition, they have provided limited incentives for ongoing innovation to reduce pollution or other forms of environmental degradation (Industry Commission 1997).

More recently, environmental policy makers have shifted their focus to the market-based approach to environmental protection to support or replace direct regulation. The market-based approach came to prominence over the 1970s and 1980s and is founded on the theory of environmental policy developed over this period. It utilises a range of instruments such as environmental taxes and charges, marketable permits, subsidies and so on to achieve prescribed environmental objectives.

Unlike direct regulations, which place direct constraints on the polluter, market-based instruments provide economic signals or incentives to which the polluter responds.

A key concept underpinning the market-based approach is the 'polluter pays principle' (PPP). Under PPP the polluter bears the cost of carrying out pollution prevention and control. In this way they are encouraged to look for more effective ways of managing the environment to ensure a cost effective outcome.

Where it is either not possible or appropriate to apply PPP, the 'beneficiary pays principle' can be applied, whereby those who benefit from pollution control pay some or all of the costs of that control. Although this approach in theory can achieve the same environmental outcomes as PPP, it is generally viewed by the community as less acceptable than PPP. This may not hold if the community (the beneficiaries) accept that they are also the polluters. If they are aware that some household activities and cars contribute to the pollution problem then they may be prepared to pay an acceptable charge.

3 Market-based instruments in more detail

3.1 Types of market-based instruments

The OECD (1989) classified market-based instruments into five categories:

- Charges and taxes;
- Subsidies;
- Deposit refund systems;
- Market creation instruments; and
- Financial enforcement incentives.

3.1.1 Environmental taxes/charges

Environmental taxes/charges are perhaps the best known example of a market-based instrument. Under such a system the environmental regulator imposes a tax/charge on each unit of pollutant discharged. In its purest form, the tax/charge is set to reflect the damage done by the pollutant. A polluter who can reduce environmental damage at a lower cost than the rate of tax/charge will do so, while those that cannot will pay the tax/charge.

An environmental tax/charge represents a price to be paid by polluters for their use of the environment. It ensures that the polluter takes into account the environmental costs of its actions in an economically efficient way.

Taxes/charges can have both an incentive impact and a revenue raising impact. The cost and price changes brought about by the tax/charge can provide an incentive for the polluter to adopt new technologies or cleaner production processes.

Generally, taxes/charges are too low to have an incentive impact and they mainly serve to raise revenue. In some cases this revenue is 'earmarked' for the collective treatment of the environmental problem. More often, it becomes part of general government revenue.

Environmental taxes/charges are commonly classified into three categories:

- Emission taxes/charges are payments on direct discharges into the environment, based on pollutant characteristics and on the quantity of discharges.
- Product taxes/charges may be levied on products and services that involve pollution during production, consumption or at the disposal stage.
- User charges are payments for treatment and collection of effluent, such as sewage and solid waste.

3.1.2 Subsidies

Subsidies are forms of assistance paid to polluters as an incentive for them to alter their behaviour or at least comply with imposed standards. They also provide the polluter flexibility in the way in which it deals with pollution.

A problem with subsidies is that they can be perceived as rewarding poor environmental performers. They are also a net payment by government and therefore may distort the tax system.

Examples of subsidies include grants, tax allowances and soft loans.

3.1.3 Deposit-refund systems

In a deposit-refund system a surcharge is included in the price of a product, which has the potential to cause environmental damage when discarded. The surcharge is refunded when the product or its residuals are returned to a collection point.

Deposit-refund systems are typically used to enhance reuse or provide an incentive for recycling. Products covered by such systems include beverage containers, automobile batteries, tyres, aluminium cans, steel products and lubricating oil.

A weakness of deposit-refund systems is that the benefits may be achieved at high costs (additional handling, transport and storage costs) compared with alternative measures. These costs can also put the product at a competitive disadvantage compared with substitute products (Industry Commission 1997).

3.1.4 Market creation

Environmental problems generally arise where there are no clearly defined property rights for environmental resources. If property rights can be assigned a market for the resource can be created in which polluters can buy the rights for actual or potential pollution or where they can sell their pollution rights.

The two main forms of market creation are emissions trading and environmental liability insurance. Under emissions trading a limit on total pollution/emissions is established (a standard) and this is allocated amongst participants by way of individual emission or discharge permits. The total quantity of permitted discharges must add up to the maximum amount permitted, which is consistent with some predetermined goal.

No one without a permit is allowed to discharge the regulated pollutants. Permits are typically auctioned off to the highest bidders or distributed free of charge on some predetermined or random basis. Permit holders are able to

trade permits after the initial distribution. For example, a participant who releases less pollution than permitted, can trade the difference to another firm, which then has the right to release more pollution than its initial permit allows.

Emissions trading schemes provide an incentive to polluters with lower abatement costs to undertake pollution prevention measures and sell permits, while polluters with higher abatement costs have an incentive to buy permits. Thus, the overall cost of compliance is minimised and the information requirements of the regulator are reduced.

Environmental liability involves making polluters legally liable for environmental damage they cause. This may lead to the creation of a market in which risks for penalties relating to environmental damage are transferred to insurance companies (OECD 1989). Premiums will reflect the probable damage (penalty) or clean-up costs and the likelihood that damage will occur. The possibility of lower premiums acts as an incentive to polluters to modify their processes to lower emissions and reduce damages.

3.1.5 Financial enforcement incentives

Financial enforcement incentives such as performance bonds and non-compliance fees are designed to penalise non-compliance with a certain environmental standard or regulation (Industry Commission 1997).

Performance bonds are ex ante payments made to authorities for potential environmental damage, where the amount of payment generally varies with the level of potential damage. Refunding takes place when compliance has been achieved. Non-compliance fees are levied ex post on polluters when they do not comply with certain regulations.

Strictly speaking, these are not market-based instruments unless the penalty for non-compliance varies with the level of environmental damage.

3.2 Advantages of market-based instruments

Market-based instruments have several appealing properties that can improve the efficiency and effectiveness of environmental policy (Sprenger 2000). In summary, they are:

- Polluters are able to decide upon the best way to reduce pollution, given their particular economic circumstances (static efficiency);
- They provide continuous incentives for technological improvements in pollution abatement (dynamic efficiency);
- They provide flexibility by allowing polluters to pollute and pay for it or invest in pollution abatement or reduce pollution in some other cost effective way;

- They provide revenues, which can be used to reinforce the incentive effects or fund pollution abatement; and
- They promote resource conservation and transmission to future generations through appropriate resource pricing.

3.3 Experience with market-based instruments in managing water quality

The evaluation of the environmental effectiveness of market-based instruments has been limited. This has been mainly due to the methodological difficulties involved in conducting such studies and the lack of appropriate data over a sufficiently long time period. Examples of recent studies include those published by the OECD (1989, 1997); European Commission (1999); Andersen and Sprenger (2000); and Stavins (2000).

The main market-based instrument used in managing water pollution has been an environmental tax/charge. Subsidies have been used in certain circumstances, especially in the management of drainage water quality from irrigation areas. There has also been limited use of marketable permits, mainly in the United States, to manage the quality of large wastewater flows into significant water bodies such as dams and lakes.

Water pollution charges (emission charges or effluent charges) have played an increasing part in water quality policy around the world since the 1970s, usually in conjunction with direct regulation. Their use has been particularly strong in Europe, especially France, Germany, Italy and the Netherlands. They have also been used in the United States, although not to the same extent as in Europe.

The main focus of water pollution charges has been to fund measures for wastewater collection and treatment, mainly through cost recovery. They have also been used to fund other pollution abatement measures or to provide incentives to polluters to reduce their discharges. The structure of the charge, with the option of a rate reduction for individual discharges that meets specific pollution targets is designed to reduce pollutant discharge levels.

Experience has shown that assessment of the effectiveness of water pollution charges is not simple. Firstly, it is not always clear how effectiveness should be defined and measured, given that the charges may fulfil several functions simultaneously. Secondly, the close relationship between a system of charges and direct regulatory measures makes it difficult to isolate the impact of the charge. Thirdly, evidence can be hard to get since data are often lacking. This is particularly true when there has been insufficient time for a firm's decisions regarding pollution control to take effect.

In designing water pollution charges it is important to achieve a balance between efficiency and effectiveness. For example, a detailed charge base addressing all relevant pollutants with fine-tuned charge rates is effective, but can be inefficient due to administrative complexity and difficult enforcement.

Water pollution charges introduced to raise revenue to meet the costs of pollution abatement require administrative costs to be kept as low as possible.

3.4 Non-point source pollution

The economic instruments described in Section 3.1 apply mainly to point source (PS) pollution problems, where the source, the size and the distinctive characteristics of the discharges can be identified with sufficient accuracy at a reasonable cost. Point source pollution problems have traditionally been associated with discharges from industry and wastewater treatment plants.

Drainage water in the Swan-Canning Catchment is subject mainly to non-point source pollution (NPS) in that the pollutants arise from a diverse array of sources that are difficult to pinpoint. These include stormwater runoff from:

- roads (nutrients, metals, oils, greases and other organic compounds),
- agricultural areas (nutrients, organic matter, pesticides and herbicides, and silt), and
- industrial areas (a range of contaminants from industrial processes).

In addition to the difficulty of identifying specific sources of pollution and their contribution to ambient pollution, the dispersion of pollution through a receiving body such as a river or lake is greatly influenced by weather conditions. Monitoring of NPS pollution is therefore far more difficult than monitoring point source pollution (PS) discharges. The environmental regulator can only measure ambient pollution at specific receptor points, and is unable to attribute any part of the pollution to a specific polluter since the ambient levels are determined by the combined activities of many polluters as well as random factors, such as weather, over which the polluters have no control.

The variety of sources and pollutants means that a variety of pollution control and abatement technologies may be required. These may range from the interception, collection and treatment of runoff waters to remove pollutants through to changes in land use practices to prevent runoff or to prevent pollutants from being transported by normal runoff.

The informational problems (monitoring and measuring) associated with NPS pollution, especially the inability to observe NPS discharges with sufficient accuracy at a reasonable cost means that the market-based instruments described in Section 3.1 cannot be readily applied to NPS problems. The

inadequacy of these standard instruments has resulted in the development of other instruments to deal with NPS pollution. The two main instruments are:

- ambient pollution taxes, which are based on observed ambient pollution, and
- input-based schemes in which taxes are applied to observable polluting inputs (e.g. fertilisers).

Ambient pollution scheme

An ambient pollution tax/subsidy scheme should provide incentives for individual polluters to undertake appropriate pollution abatement measures. Each polluter (actual or potential) would be required to pay an ambient-based pollution tax (or receive a subsidy) equal to the full marginal social cost of the collective level of contamination. The tax would be applied uniformly, irrespective of discharges. Payment of the ambient tax by all polluters is triggered when measured ambient pollution levels at a receptor point exceed some desired or cut-off level. The tax is essentially a charge per unit deviation between a desired and a measured ambient concentration level. This gives ambient taxes the characteristic of a collective penalty.

In many areas the agriculture sector is believed to be the main contributor of nutrients (phosphorus and nitrogen) found in drainage water. One approach is to tax the observable inputs such as fertilisers and pesticides, providing growers with an incentive to reduce their use of the inputs concerned.

A higher level of complexity would be a scaled rate of tax on fertiliser depending on the speed of nutrient release.

Input based scheme

Input taxes suffer from the weakness that they may distort farm decisions as to the chosen input mix and lead to inappropriate input substitutions at the farm level rather than changes to farm practices such as frequency and timing of applications. A clear understanding of input substitution possibilities is critical if policies aimed at encouraging growers to reduce the use of certain inputs are proposed.

Subsidies have often been used in situations where other instruments are likely to lead to financial hardship when growers lack the financial capacity to engage in pollution abatement on-farm.

A problem with subsidies is that they may increase the rate of return to an industry, eventually leading to an expansion of the industry and an eventual increase in the overall level of pollution.

4 Potential for using market-based instruments in the Swan-Canning Catchment

4.1 The nature of the problem

The Swan and Canning Rivers have experienced an increasing number of ecological problems including algal blooms and fish kills over recent years. It is acknowledged that drainage water carrying high concentrations of nutrients and other contaminants is a significant contributor to these problems.

As discussed in Section 3.4 the problem with this type of pollution is that it is often a diffuse side effect of other activities such as agriculture rather than the result of direct discharges into the drainage system. This makes monitoring of the pollution and identification of individual polluters difficult and costly.

Parsons Brinckerhoff (PB) in its consultancy report entitled 'Review of Best Management Practices for Improvement of Urban Water Quality on the Swan Coastal Plan (2004)' has proposed a number of structural and non-structural best management practices (BMPs) to address drainage water quality issues in the Mill Street Catchment in the Shire of Canning. The up-front capital cost of the strategy was estimated by PB to be in the order of $4 million, with operating costs of $250,000 per annum to implement the strategy.

4.2 The role for market-based instruments

The Swan-Canning Catchment Drainage Forum has asked that ACIL Tasman provide options for resourcing the strategy proposed by PB. As mentioned in the introduction to the paper, ACIL Tasman recommends that the resourcing model be viewed within the framework of the market-based approach.

The non-point source nature of the drainage water pollution problem limits the range of market-based instruments that can be used. ACIL Tasman has identified three resourcing models. These are:

- Appropriations from the Consolidated Fund as part of the budgetary process of relevant government agencies;
- An increase in the Water Corporation's drainage rates. This model may also include a widening of the rating base to include those households and firms in the metropolitan area currently not subject to drainage rates; and
- Introduction of a special environmental tax/charge/levy. The base for this tax/charge/levy could be households or firms (including agricultural and horticultural enterprises in the immediate Swan-Canning Catchment). The

tax base could also be structured to reflect the nature of land use and likelihood of polluting activity.

4.3 Criteria for choosing an instrument

The Industry Commission (1997) sets out a number of criteria to be considered in selecting the best instrument(s) to use to address an environmental problem. These are:

Effectiveness - refers to how well an instrument achieves its objective(s). For example, a user charge may be appropriate for discharges at a point source, whereas a product charge may be more appropriate where the pollution is from diffuse points.

Dependability – refers to how reliable an instrument is in achieving its objectives.

Efficiency – relates to the relative net cost associated with using the instrument. The costs typically include administration, monitoring and compliance/enforcement. These costs are weighed up against the benefits of using the instrument, in particular, whether the environmental goal is achieved.

Equity – relates to the distribution of the benefits and costs of using the instrument across regions or firms and/or individuals within the economy.

Flexibility – takes into account the ability of an instrument to keep doing its job in the face of changing circumstances and the degree to which polluters may choose their own response within the context of the overall environmental goal.

Incentives – refers to the ability of the instrument to provide on-going incentives to reduce pollution.

Acceptability – relates to the acceptability of the instrument to politicians, the community and industry.

Informational requirements – refers to the availability and costliness of information required to implement and administer, and comply with, an instrument.

4.4 Which instrument to use?

Table 1 sets out an evaluation of the three market-based instruments proposed in Section 4.2 against the Industry Commission (1997) criteria.

Table 1 **Evaluation of market-based instruments**

Criteria	Consolidated Fund	Drainage Rate	Environmental Levy
Effectiveness	Discipline on request for funds to ensure budget allocation matches work program	Would require the revenue from the rate increase to be earmarked for specific purpose	Would require earmarking of revenue from levy for drainage purpose
Dependability	Could be subject to changing priorities at government and agency levels (e.g. infill sewerage program recently downgraded in priority in budget process)	Could be subject to changing budgetary priorities in the Water Corporation. Changes to the CSO policy may also impact on dependability. Program would need performance monitoring against key objectives Rating base not related to polluting activity	Specific purpose tax. Program would need performance monitoring against key objectives
Efficiency	Revenue comes from the existing tax base	Revenue raising system in place. May be subject to additional customer complaints. May be demarcation problems between Water Corporation and agencies responsible for program of works. Hypothecation of part of drainage revenue may be contrary to the Corporation's commercial objectives. May have to be done under ministerial direction	A new tax may involve higher costs of administration, monitoring and performance appraisal.
Equity	Community as a whole pays – more beneficiary pays than polluter pays	Community as a whole pays although people who do not pay Water Corporation drainage rates are excluded	In its basic form with a uniform rating base across the community it is beneficiary pays. By changing the rating base to reflect polluting activity it can be made more polluter pays. A flat tax may be viewed as inequitable.
Flexibility	Subject to sovereign risk – changes in government and agency priorities. Could meet urgent funding needs if required(e.g. in a very wet year).	May not be able to meet urgent needs because of lead time in annual rate setting	Could be adjusted to accommodate incentives. Rate could also be adjusted to reflect polluting activities and land uses.
Incentives	No incentive for polluters to change behaviour	Possible to develop incentives to reduce polluting activities. Could be done at a local catchment level but would result in differential rating and increased complexity and administrative difficulty plus increase monitoring requirements	Rate could be adjusted to reflect changes in ambient pollution levels resulting from changing polluter behaviour.
Acceptability	Community would accept as this is seen as what governments do	May be acceptable if carefully explained. Would need to ensure all people paid the rate. Would also depend on degree of earmarking of additional revenue from rate increase. Potential for a lack of transparency. May not be acceptable to the NCC if based on GRV.	A new tax unlikely to be acceptable to the community. The levy would be transparent.
Information Requirements	On-going monitoring at certain receptor points to gauge progress	More intensive measurements and monitoring if incentives built in	The information requirements would increase as the incentive mechanisms were made more complicated.

5 Recommendation

In theory, the choice of market-based instrument should be based on the overall costs and benefits of the options. That is, it will have the highest environmental and wider benefits for the lowest cost of implementation and compliance.

That said, given the information available to ACIL Tasman, it favours an environmental levy even though it would be the most challenging to implement. It offers a number of advantages over the other two models. In particular, it has the advantage of being able to be implemented in a simple form in the first instance, and then upgraded to offer incentives to polluters to change their behaviour as the community comes to understand and embrace the approach. However, its implementation would have to be weighed against the likely community acceptability of such a levy. This would need to be addressed in an accompanying communication strategy.

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Water Corporation



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Parsons Brinckerhoff Australia Pty Limited ACN 078 004 798 and
Parsons Brinckerhoff International (Australia) Pty Limited ACN 006 475 056
trading as Parsons Brinckerhoff ABN 84 797 323 433

589 Hay Street
Subiaco WA 6008
PO Box 1232
Subiaco WA 6904
Australia
Telephone +61 8 9489 9700
Facsimile +61 8 9380 4060
Email perth@pb.com.au

ABN 84 797 323 433
NCSI Certified Quality System ISO 9001

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Author: A Taylor, Dr Tony Wong, M Evangelisti, J Brosnan .....

Reviewer: M Evangelisti.....

Approved by: M Evangelisti.....

Signed: .....

Date: .....

Distribution: Water Corporation (1), PB (2), EE (1).....

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Executive Summary

Background

This report summarises the results of a desktop assessment of the relative values of best management practices for the improvement of urban drainage quality on the Swan Coastal Plain.

This study has used the Mills Street Catchment in the City of Canning region as a representative 'focus catchment'. The Mill Street Catchment is considered a good example of an urbanised catchment on the Swan Coastal Plain with a low ability to retain nutrients and which exports substantial quantities of nutrients to the Swan-Canning river system.

Discussions were undertaken with key representatives from the Department of the Environment, Water Corporation, and local consultants to clarify the specific water quality management goals in urban areas of the Swan Coastal Plain.

There was broad agreement that the high-level management goal for the Swan-Canning System should be to minimise the frequency and severity of harmful algal blooms, however there was not agreement amongst the primary water managers in the region as to how water quality management of urban drainage should be undertaken to meet this goal.

It is recommended that consensus amongst key stakeholders be sought on these issues as a matter of priority.

This project has sought to deliver an assessment that can address all views, by assessing the various merits of BMPs that reduce nutrients in baseflows/groundwater and storm flows using best available knowledge.

BMP Assessment

Structural and non-structural BMPs with potential for application on the Swan Coastal Plain were short-listed for assessment against sixteen criteria developed to address financial/economic, environmental/ecological, and social values.

Using the Mills Street Catchment as a 'focus catchment', estimates were undertaken of each BMP's ability to cost effectively reduce loads of nutrients (N and P) as expressed by a typical load reduction per unit cost. For structural BMPs, this required some pollutant export modelling work to be undertaken.

Results

BMP's recommended to be considered for the Mill Street catchment assuming a baseflow/groundwater management focus are as follows:

Non-structural BMP's

- *Point source regulation, education and enforcement*
- *Illegal discharge elimination programs*
- *Town planning controls*
- *'Master Gardener' style education/participation programs*
- *Water Management Strategies*
- *Financial incentives to lower the water table*

Structural BMP's

- *Groundwater re-use*
- *Bioretention system*
- *Constructed wetlands*

BMP's recommended to be considered for the Mill Street catchment assuming a stormwater management focus are as follows:

Non-structural BMP's

- *Point source regulation, education and enforcement*
- *Town planning controls*
- *'Master Gardener' style education/participation programs*
- *Water Management Strategies*
- *Illegal discharge elimination programs*

Structural BMP's

- *Bioretention system*
- *Constructed wetlands*
- *Urban Forestry*

Hydrologic Design Standards

Analysis of Perth rainfall records has shown that in excess of 90% of the mean annual runoff of an urban catchment in Perth is generated from storm events of average recurrence frequency more frequent than once every three months.

A plot of the cost per kg of additional pollutant removed and corresponding ARI indicates that the cost almost doubles between the 3 month and 6 month ARI and nearly triples between the 3 month and 1 year ARI when selecting hydrological design standards for stormwater quality BMP's.

It is recommended stormwater quality BMPs be designed for managing frequent events corresponding to the 3 month ARI discharge to achieve high levels of beneficial environmental outcomes.

Estimated Pollutant Removal

The estimated annual removal of TP and TN for a baseflow management strategy for Mill Street is approximately 1,000 kg and 7,200 kg respectively corresponding to 55% and 70% removal rates.

The estimated annual removal of TP and TN for a stormflow management strategy is approximately 1,400 kg and 8,200 kg respectively corresponding to an 80% removal rates for both TP and TN.

Cost Analysis

A cost analysis found that the up-front capital costs for the strategy for Mill Street is of the order of $4 million, or approximately $3,000/Ha/yr.

Life-cycle cost analysis found that an equivalent annual payment of approximately $250,000 will be necessary to implement the strategy, or approximately $200/Ha/yr in 2004 dollars, for built-up catchments like Mills Street.

Further Recommendations

1. It is recommended that a consensus be developed on specific objectives for the management of water quality in urban areas (e.g. whether the focus should be on minimising total loads of nutrients exported from urban areas, or targeting specific aspects of the urban water cycle such as the nutrient-rich summer baseflows).

2. It is recommended that water quality-related targets for the Swan-Canning system (specific and quantitative water quality targets) be developed and that the targets be suitable to undertake conceptual design and modeling work for all new development on the Swan Coastal Plain.

3. The assessment of structural and non-structural BMPs used in the short term to assist decisions on which BMPs to trial on the Swan Coastal Plain, be evaluated and refined using the principle of 'adaptive environmental management'.

4. The nutrient removal efficiency and costing information for BMPs that have potential application to the Mills Street Catchment be used to identify BMPs most worthy of implementation in this high priority location.

5. The costing information for BMPs that have potential application to the Mills Street Catchment be used as an indicator of 'order of magnitude' costs for applying water quality-related BMPs to built-up catchments containing large areas of medium density urban residential land use and unsewered industrial land use.

1. Introduction and Background

Despite past efforts to preserve the water quality of the Swan and Canning Rivers, there are increasing signs of ecological stress and reduced environmental values in the form of algal blooms, fish deaths and river closures since the early 1990's.

The algal blooms are fuelled by high concentrations of nutrients, particularly nitrogen and phosphorous. Drainage from urban areas is considered to be a significant source of pollutants entering the river system.

Currently there is considered to be critical gaps in knowledge on drainage and water quality management for the Swan Coastal Plain. Various Government agencies have been assigned responsibility for the coordination of a number of separate studies relating to drainage management, outcomes from each being required to fill knowledge gaps applicable to the entire Swan Coastal Plain.

This report represents the results of a desktop assessment of the relative values of best management practices for the improvement of urban drainage quality on the Swan Coastal Plain. The study evaluates these solutions in terms of sixteen assessment criteria to address the so-called 'triple bottom line', that is, financial/economic, environmental/ecological, and social values.

Whilst the study will have broader application to the Swan Coastal Plain there is a particular emphasis on the Mill Street Catchment. The Mill Street Catchment is considered a good example of an urbanised catchment on the Swan Coastal Plain with a low ability to retain nutrients and which exports substantial quantities of nutrients to the Swan-Canning river system.

2. Overview of Relevant Water Quality Issues

2.1 Introduction

The primary purpose of this chapter is to summarise the characteristics of water that typically drains from urban areas on the Swan Coastal Plain under baseflow and high-flow (storm-flow) conditions, as well as the 'management goals' for such water. This knowledge base is needed to enable the desk-top assessment of best management practices (BMPs) that potentially can be used to minimise water-borne pollutants from urban areas entering the Swan-Canning river system, as well as other valuable water bodies on the Swan Coastal Plain.

Particular emphasis has been given to understanding the nature of *nutrients* in drainage waters, given the current focus on the reduction of nitrogen and phosphorus loads entering the Swan-Canning river system. Pollutants of secondary importance (e.g. suspended sediments, heavy metals, pesticides, etc.) have also been addressed, albeit in less detail.

As suggested by the project brief, this study has used the Mills Street Catchment in the City of Canning region as a representative 'focus catchment'. Consequently, the bulk of water quality data that was reviewed related to this catchment. The quality of waters draining from the Mills Street Catchment has been well studied in comparison to other areas in Perth, with several detailed and relevant technical reports being available. The catchment also has the advantage of having a gauging station and an automatic water quality sampler, which enables some analysis to occur as to how pollutant concentrations relate to flow conditions.

Given the quantity of information on water quality characteristics that was identified from background reports and stakeholders, a brief summary section is provided in Chapter 2.3.2. More detail is available in Appendix A.

The review of background reports and data, as well as discussions with key stakeholders also revealed some significant findings with respect to management priorities and strategies which are summarised in Chapter 2.3.1.

2.2 Brief Background on the Mills Street Catchment and Swan Coastal Plain

The Mills Street Catchment in the City of Canning is approximately 12.3 km^2 in area, typically discharges 4.9 GL of surface water to the Canning River per year (via the Wilson Wetland), and is largely comprised of Bassendean Sands. It contains deeply incised open drains which intersect groundwater and typically produces a baseflow all year round.

The catchment hosts a shallow superficial aquifer (2-3 metres below the ground surface), large areas of residential land use, and the largest area of unsewered industrial land use in Western Australia.

The majority of the City of Canning's 1,780 developed industrial premises are located in this catchment. Of these, approximately 95% are effectively unregulated in terms of environmental management (City of Canning, 2001). This catchment characteristic is unusual (on a national basis) and needs to be kept in mind when water quality data is being interpreted. The table below is a breakup of landuse in the Mills Street Drain Catchment.

Table 2.1 Land Use in the Mill Street Catchment

Landuse	Area	%
Industrial and Hospital	572 Ha	47%
Residential	520 Ha	42%
Major Roads	101 Ha	8%
Parks & Railways	38 Ha	3%
Total	1231 Ha	

All drainage in the catchment is constructed, consisting of sub-soil drains, open drains, enclosed drains and 23 detention basins. The catchment also contains a significant area of major roads and potentially contaminated sites (see SRT, 2003a for more details).

The Mills Street Catchment represents a significant source of nutrients to the sensitive Swan-Canning Estuary, and one that is not easily managed through the use of traditional structural BMPs (e.g. constructed wetlands), as the catchment is largely developed.

The Swan Coastal Plain lies between the Indian Ocean to the West and the Gingin and Darling Scarps which rise 200-300m to the East. Its width varies from 23km in the South to 34km in the north. The drainage region covers an area of approximately 88,000 ha. It is estimated that approximately 10.0 tonnes of nitrogen and 1.73 tonnes of phosphorus drains from the catchment per year, with approximately 50% of these loads being as baseflow.[1]

The Swan Coastal Plain experiences a Mediterranean climate with warm to hot, dry summers and mild wet winters. This results in highly seasonal rainfall with approximately 90% of rainfall typically falling between April and October. The average annual rainfall is approximately 870mm.

Unlike most urban areas on the East Coast of Australia, the Swan Coastal Plain has large areas of highly permeable sands with a very low ability to retain phosphorus, significant aquifers, a shallow water table, and a low grade. In particular, in areas with highly permeable soils (e.g. Bassendean Sands), much of the rainwater (and pollutants) that falls on permeable surfaces and residential

[1] Based on recently acquired data from the Department of Environment, using load calculations over 1999 – 2001.

roofs will eventually reach receiving waters via groundwater, sub-soil drains and baseflow in open drains and creeks. This form of discharge occurs all year round in some urban catchments.

In areas where clay (e.g. Guildford Formation) underlies shallow sandy soils in urban areas on the Swan Coastal Plain, sub-soil drains slowly direct perched groundwater to the main drainage system. This can also generate a baseflow over summer.

2.3 Overview of Key Water Quality Issues and Characteristics

2.3.1 Water Quality Management Issues

In order to conduct the assessment phase of this project, the project team needed to clarify the specific water quality management goals in urban areas of the Swan Coastal Plain (with an emphasis on the Swan-Canning river system). As an initial step, background technical reports were reviewed and discussions were undertaken with key representatives from the Department of the Environment, Water Corporation, and local consultants (see Appendix A for a summary of this material).

This review process highlighted a significant water quality management issue. Namely, while there was *broad* agreement that the high-level management goal for the Swan-Canning System should be to minimise the frequency and severity of harmful algal blooms, there was not agreement amongst the primary water managers in the region as to how water quality management of *urban drainage* should be undertaken to meet this goal.

For example, some stakeholders believe the focus should be on reducing the total load of nitrogen and phosphorus entering the Swan-Canning system from urban areas, regardless of whether nutrients enter the system in baseflow or storm flow, or whether inputs occur in summer or winter, or what species the nutrients are in.

Other stakeholders believe in some areas, like upstream of the Kent Street Weir on the Canning River, the focus should be on managing nutrients (particularly phosphorus) in summer baseflows which contribute to blue-green algal blooms. While in the estuarine parts of the Swan-Canning system, the focus should be on managing nutrients (particularly nitrogen) in summer storm flows which are thought to trigger dinoflagellate blooms.

Other stakeholders question the fundamental premise of urban water quality management on the Swan Coastal Plain. That is, they question whether there currently is enough evidence to suggest that funds spent in the urban area will make a noticeable difference to the frequency and severity of algal blooms given the large input of nutrients from non-urban urban areas, available nutrient stores in sediments, and limitations of available best management practices.

This lack of consensus on such an important issue is a major concern. It is a recommendation of this project that consensus amongst key stakeholders be sought on these issues as a matter of priority.

To work within the current environment of dissenting views, this project has sought to deliver an assessment that can address all views, by assessing the various merits of BMPs that reduce nutrients in baseflows/groundwater and storm flows using best available knowledge.

2.3.2 Water Quality Characteristics of Urban Drainage

This chapter briefly summarises the physical water quality characteristics of urban drainage on the Swan Coastal Plain, with a particular emphasis on the Mills Street Catchment. The focus on Mills Street reflects the substantial quantity of data that is available for this catchment and it was included in the project brief as a focus catchment for BMP conceptual design and costing.

The Mills Street Catchment is a good example of an urbanised surface water catchment on the Swan Coastal Plain that is dominated by permeable soils with a low ability to retain nutrients and which exports substantial quantities of nutrients to the Swan-Canning river system. It is one of the highest priority catchments for nutrient management in the region.

Water quality investigations by the former Water and Rivers Commission over 2000-2002 found 84% and 100% of samples from the Mills Street Catchment failed to meet relevant water quality guidelines for total nitrogen (TN) and total phosphorus (TP), respectively. Concentrations of TN and TP are highly elevated in drainage water during low-flow (baseflow) *and* high-flow conditions. For example, the median concentrations of TN and TP during low flows (baseflow) were 1.9 mg/L and 0.28 mg/L, respectively. While the median concentrations of TN and TP during high-flows were 2.4 mg/L and 0.35 mg/L, respectively.

While nutrients are the primary concern, waters draining from the Mills Street Catchment also have elevated concentrations of heavy metals (Cu, Pb and Zn in particular), and occasionally elevated total suspended solid (TSS) concentrations. As a generalisation however, structural BMPs designed to minimise nutrient loads in the catchment during storm events would also significantly reduce secondary pollutants such as TSS, heavy metals and pesticides.

From the perspective of managing total nutrient loads in a catchment like Mills Street, 'high-flows' need to be managed (i.e. stormwater flows from frequent, small storm-events) as well as baseflow, as approximately 50% of the total nutrient load is thought to be associated with high-flows. Summer storms *may* also trigger dinoflagellate blooms in the estuary.

Significantly reducing the quantity of nutrients in *baseflow* may also be particularly important, due to the large loading of nutrients in baseflow, the high percentage of bioavailable phosphorous in baseflow, and the release of

nutrients during the summer, when the Swan-Canning system is particularly susceptible to eutrophication. This may be particularly important for poorly flushed areas, like upstream of the Kent Street Weir on the Canning River.[2]

Concentrations of TP and TSS in drainage waters from the Mills Street Catchment have also been seen to be elevated at the start of a runoff event, but not always. TN does not demonstrate this 'first flush' pattern.

In summer, the dominant nitrogen species in drainage waters is organic nitrogen, primarily as a result of plant material in the drain contributing to the nutrient load at this time. In winter however, dissolved inorganic nitrogen species dominate for most of the time.

The dominant phosphorous species during baseflow conditions over December to April is dissolved inorganic phosphorous (56%), which is thought to be primarily a result of nutrient-enriched groundwater, water from sub-soil drains, and illicit discharges from industry. In high-flow events however, phosphorous is primarily associated with particulate matter (73%).

Nutrient accumulation occurs in the drainage channel and in detention basins during low flows. These nutrients are cycled and flushed from the drainage network during high flows.

TSS concentrations are generally low during baseflow conditions (e.g. 82% of the Water and Rivers Commission's samples were less than 20 mg/L), and vary greatly during high flows (e.g. concentrations ranged from 2 mg/L to 150 mg/L in the Water and Rivers Commission's data set). Heavy metal concentrations are generally correlated with concentrations of particulate matter.

[2] A brief review of river flow data, rainfall data and the frequency and severity of blue-green algal booms and dinoflagellate booms on the Swan-Canning system (including both up-stream and down-stream of the Kent Street Weir) found no *direct* relationship between rainfall/run-off events and these types of harmful blooms. It is likely that bloom frequency and severity is a consequence of many factors (e.g. flows, salinity, light, temperature, flushing, nutrient release from sediments, presence of other species, ambient nutrient concentrations, etc.). This finding supports the need to focus more broadly on the manageable conditions that make the system susceptible to blooms (i.e. general nutrient enrichment of the water column and sediments), not specific bloom triggers.

3. Methodology

3.1 BMP Assessment for the Swan Coastal Plain

To undertake a desktop assessment of the potential value of a wide range of structural and non-structural BMPs, multi-criteria decision analysis was chosen as the primary assessment tool. This tool was chosen as it allows a wide range of assessment criteria to be considered in qualitative or quantitative form. It also does not require potential benefits that exists outside of a market to be expressed in monetary terms (unlike cost benefit analysis).

Multi-criteria decision analysis allows various options to be assessed against a range of criteria through the use of three elements:

- numerical *weightings* are allocated to each assessment criterion which reflects their relative importance;
- for each option (i.e. BMP) numerical *scores* are ascribed to each assessment criterion which reflect the extent to which each option satisfies the criterion; and
- a simple *utility function* converts the scores and weights to an overall "value score" for each option.

The "value score" can then be used to rank the BMP options to simply highlight those with the most potential overall value to urban areas of the Swan Coastal Plain.

To undertake this assessment, a brief review was undertaken of relevant reports and expert advice that related to water quality management in an urban drainage context on the Swan Coastal Plain. This review was necessary to clarify the *exact objectives* of the BMPs. For example, to assess a particular BMP, one needs to be clear about the nature of pollutants that are being targeted. A BMP that is effective at minimising baseflow and concentrations of dissolved phosphorus during the summer may not be very effective at minimising bioavailable nitrogen from stormwater runoff during small, frequent storm events.

As the local literature and expert opinion did not demonstrate a consensus on the specific approach to managing urban water quality on the Swan Coastal Plain (see Chapter 2.3.1), and the short timeframe of the project, the assessment process had to consider several contexts of assessment (i.e. scenarios). Each BMP could then be assessed against a set of assessment criteria within each context.

The primary contexts of assessment that were used to assess BMPs were:

- The management of flows and nutrients in *baseflow* (and therefore shallow groundwater), particularly during the summer months.

- The management of nutrient loads in small, frequent summer *storm events* that generate surface runoff.
- The management of urban drainage in areas experiencing *greenfield* development.
- The management of urban drainage in *built-up areas* (note however that these areas are assumed to have some level of redevelopment).

In addition, the assessment of structural BMPs had to consider the context of whether they would be used on Bassendean Sands (where subsoil drainage intercepts an unconfined superficial aquifer) or Guildford Formation clays (where subsoil drainage slowly drains a perched water table caused by a thin layer of sands overlying a relatively impermeable clay layer).

Sixteen (16) assessment criteria were developed in consultation with the client to address the so-called 'triple bottom line', that is, financial/economic, environmental/ecological, and social values. The resulting criteria are best described in Table 3.1.

Weights were allocated to each of these criteria to reflect their relative importance. Initially a weighting out of 10 was attributed to each criterion (with 10 being the most valuable weighting). Then, 33.3 weighting points were attributed to each of the three parts of the triple bottom line (i.e. financial, environmental and social parts). Within each of these parts, the criteria weightings out of 10 were used to allocate the 33.3 weighting points to each assessment criterion. The result being that equal weight is given to the three parts of the triple bottom line, but weightings vary for each criterion within each of the three parts depending on their relative importance. In total, 100 weighting points are allocated across all of the 16 assessment criteria. The resulting analysis is shown in Table 3.2.

Structural and non-structural BMPs that show promise for application on the Swan Coastal Plain were short-listed in consultation with the client. The short-listing process considered the context of assessment mentioned above. Tables 3.3 and 3.4 describe the short-listed BMPs and briefly explain how they are relevant to the management of baseflow/groundwater and stormwater, in both greenfield and built-up areas.

The short-listed BMPs were then assessed against each of the 16 assessment criteria. This assessment drew on available knowledge of how the BMPs operate, local management goals for the Swan Coastal Plain, and local characteristics of urban drainage water. It is however acknowledged that expert judgment needed to be applied in a number of areas due to the lack of high quality local performance data for several BMPs. To demonstrate transparency and accountability, scores with a very high degree of uncertainty were flagged as such. As all scores and weights have been individually reported, they can be subject to review by stakeholders.

For each BMP in each assessment context, a simple utility function was used to sum all the assessment scores after they were individually multiplied by the

relevant weighting. The resulting "value score" was used to rank the potential value of each BMP.

Finally, using the Mills Street Catchment as a 'focus catchment', estimates were undertaken of each BMP's ability to cost effectively reduce loads of nutrients (N and P) as expressed by a typical load reduction per unit cost. For structural BMPs, this required some pollutant export modelling work to be undertaken.

Life-cycle cost estimates for structural BMPs were based on recently developed regression equations that relate a BMP's size to cost elements (e.g. total acquisition cost, typical annual maintenance cost, etc.). These equations were generated from a national data set (i.e. data was obtained from all States) and represent a national average.

Table 3.1 Scoring Key for the Assessment Criteria

Criteria	Description of Each Score				
	5	4	3	2	1
Financial/economic:					
Total acquisition cost (i.e. cost of feasibility, design, construction/purchase and project/contract management).	Extremely low	Low	Moderate	High	Extremely high
Typical annual maintenance cost.	Extremely low	Low	Moderate	High	Extremely high
Life-cycle cost (i.e. the sum of all discounted BMP-related costs over the life span of the BMP). This type of cost would exclude land acquisition cost and tax.	Extremely low	Low	Moderate	High	Extremely high
Land acquisition cost.	Extremely low	Low	Moderate	High	Extremely high
Environmental:					
Pollutant reduction efficiencies - TN.	Extremely high (75-100%)	High (50-75%)	Moderate (30-50%)	Low (10-30%)	Very low (<10%)
Pollutant reduction efficiencies - TP.	Extremely high (75-100%)	High (50-75%)	Moderate (30-50%)	Low (10-30%)	Very low (<10%)
Pollutant reduction efficiencies - TSS (and by association, heavy metals, pesticides).	Extremely high (75-100%)	High (50-75%)	Moderate (30-50%)	Low (10-30%)	Very low (<10%)
Pollutant reduction for key nutrient species (e.g. FRP, NH_4^+, NOx).	Extremely high	High	Moderate	Low	Very low
Water re-use opportunities.	Extremely high	High	Moderate	Low	Very low
Social:					
Likely community acceptance.	Extremely high	High	Moderate	Low	Very low
Likely political acceptance.	Extremely high	High	Moderate	Low	Very low
Multiple use of the BMP/asset and/or area around asset (e.g. constructed wetlands with parkland features, or educational officers who also perform a water conservation role).	Extremely high	High	Moderate	Low	Very low
Safety hazards (e.g. health risks associated with mosquitoes or drowning).	Extremely low	Low	Moderate	High	Extremely high
Risk of BMP failure. This criteria covers issues such as the 'risk associated with BMPs that operate by changing people's behaviour', 'risks associated with unsustainable BMP funding', 'ease of BMP implementation', 'lack of sound local BMP performance data and design guidelines', etc.	Extremely low	Low	Moderate	High	Extremely high
Coverage of BMP (i.e. the spatial area of the BMP's effect).	Extremely broad (scale: regional, covering the Swan Coastal Plain)	Wide (scale: local government area to urban drainage sub-catchment)	Moderate (scale: estate/ subdivision)	Limited (scale: streetscape)	Little (scale: allotment/ site).
Timeliness of BMP implementation and the generation of positive results (e.g. positive environmental outcomes).	Very fast (operating within a year)	Fast (operating within 1-5 years)	Moderate (operating within 5-10 years)	Slow (operating within 10-50 years)	Very slow (operating after 50 years)

Notes:

Qualitative ratings (e.g. "moderate") are relative to other BMPs that treat drainage water from similar areas and operate at similar pollutant removal efficiencies.

Cost scores are made from the perspective of those paying for the implementation and maintenance of a BMP. For example a licensing program may be cost-neutral to the regulatory agency, so the BMP cost is considered to be "extremely low" from their perspective.

Table 3.2 BMP Assessment Criteria and Weights

Assessment Criteria*																Notes
Financial/ Economic				Environmental/ Ecological					Social							
Total acquisition cost	Typical annual maintenance cost	Life cycle cost	Land acquisition cost	Pollutant reduction efficiency - TN	Pollutant reduction efficiency - TP	Pollutant reduction efficiency - TSS	Pollutant reduction - key nutrient species	Water re-use opportunities	Community acceptance	Political acceptance	Multiple use of asset/BMP	Safety hazards	Risk of failure	Coverage of BMP	Timeliness of desired result	
9	7	10	6	10	10	5	8	6	10	10	7	8	8	5	7	Criteria weighting expressed as a simple score out of 10, where 10 indicates that the criteria is extremely important.
9.4	7.3	10.4	6.2	8.5	8.5	4.3	6.8	5.1	6.1	6.1	4.2	4.8	4.8	3.0	4.2	100 weighting points has been allocated across the 16 assessment criteria using the assumption that the 3 parts of the triple bottom line (i.e. financial, environment and social) should be initially given the same value (i.e. 33.3 points each), then the above weighting scores out of 10 for each criterion are used to distribute these points within each of the 3 parts of the triple bottom line.

* Note: The assessment criteria are described more fully in the scoring key accompanying Table 3.1.

Table 3.3 Short-listed Non-structural BMPs

Short-listed Non-structural BMPs	Applicability of BMPs			
	Used Where Baseflow/Groundwater is the Focus?		Used Where Storm-events are the Focus?	
	Greenfield areas	Built-up areas	Greenfield areas	Built-up areas
Soil amendment (e.g. use during development or retrofitting by government agencies in public open space)	✓	✓ (limited opportunities)	✓	✓ (limited opportunities)
Xeriscaping and water/nutrient management plans for public open space (e.g. use during development or retrofitting by government agencies in public open space)	✓	✓	✓	✓
Site-based Water Management Officer who performs a local, interactive, intensive and focussed education/participation role (ideally suited to large greenfield estates)	✓	✓ (limited opportunities)	✓	✓ (limited opportunities)
'Master Gardener' style education/participation programs (i.e. intensive local extension programs focussing on nutrient management in a residential garden context)	✓ (the 'Water Management Officer' BMP incorporates this element)	✓	✓ (the 'Water Management Officer' BMP incorporates this element)	✓
Town planning controls requiring water sensitive urban design and where appropriate, no baseflow in urban drains during summer months	✓	✓	✓	✓
Point source regulation, education and enforcement (e.g. involving small to medium sized commercial and industrial premises)	✓ (limited opportunities)	✓	✓ (limited opportunities)	✓
Maintenance regime for the urban drainage network (e.g. detention basins, infiltration pits, open channels). Includes maintaining the depth of open drains to minimise summer baseflows where relevant.	✓ (limited opportunities)	✓	✓ (limited opportunities)	✓
Erosion and sediment control programs (e.g. education, regulation and enforcement on construction and building sites)	Little value	Little value	✓	✓
Illegal discharge elimination programs (i.e. to identify and remove illegal discharges to stormwater and groundwater)	✓ (limited opportunities)	✓	✓ (limited opportunities)	✓
Water management strategies (for the catchment scale) that involve strategic planning and affect structure planning (where relevant) and town planning schemes	✓ (especially relevant to structure planning and town planning schemes)	✓	✓ (especially relevant to structure planning and town planning schemes)	✓
Financial incentives to lower the water table to prevent summer baseflows (i.e. use shallow groundwater for toilet flushing and irrigation)	Little value (better to use town planning controls)	✓	Little value (a groundwater control)	Little value (a groundwater control)
Financial incentives to retrofit the use of xeriscaping and/or soil amendment	Little value (better to use town planning controls)	✓	Little value (better to use town planning controls)	✓

Note: The short-listing process focussed on BMPs that could be directly applied to a site. Consequently, essential 'high level' non-structural BMPs such as sustainable funding mechanisms and institutional arrangements have not been assessed.

Table 3.4 Short-listed Structural BMPs

Short-listed Structural BMPs	Applicability of BMPs			
	Used Where Baseflow/Groundwater is the Focus?		Used Where Storm-events are the Focus?	
	Greenfield areas	Built-up areas	Greenfield areas	Built-up areas
FUNCTION – Removal of organic litter and sediment. Removal of coarse to medium size sediment is a necessary pre-treatment of stormwater prior to the use of wetlands, bioretention system or infiltration system for treatment of nutrients				
Gross Pollutant Traps	**Not Suitable** as this BMP does not target the pollutant or the source of the pollutant		Only **suitable** in commercial and industrial areas as a last resort.	**Suitable** but need to target catchment landuse – areas with high pedestrian traffic eg. commercial precinct. shopping precincts
Sedimentation Basin	**Not Suitable** as this BMP does not target the pollutant or the source of the pollutant		**Suitable** as a pre-treatment system for other treatment measures more effective in the removal of nutrients.	**Suitable** but limited by space constraints although existing retarding basins could be retrofitted
Buffer Strips Vegetated (often grassed) systems which serves as buffer for stormwater runoff to promote the removal of sediment in stormwater.	**Not Suitable** as this BMP does not target the pollutant or the source of the pollutant		**Suitable** for integration into the stormwater conveyance system for all impervious surfaces.	**Suitable** but limited by space constraint and existing kerb and channel road edging.
Roofwater Tanks Uses to promote the use of rainwater as an alternative source of water to that of potable (mains) water.	**Suitable** in so far as reducing the amount of rainwater discharging into the subsurface		**Suitable** in reducing stormwater runoff, especially for frequent events and thereby reducing the hydraulic loading of downstream stormwater treatment system for removal of nutrients in stormwater. Water management attributes include sediment removal and retardation of frequent flood retardation	
Vegetated Swales Uses to promote the removal of medium sized particulates and promote some degree of infiltration of stormwater	**Not Suitable** as this BMP does not target the pollutant or the source of the pollutant		**Suitable** for integration into the stormwater conveyance system for all impervious surfaces	**Generally Suitable** for retrofitting as part of the streetscape system providing a buffer of street runoff prior to their discharge into existing stormwater pipe system.

Table 3.5 Short-listed Structural BMPs (cont)

Short-listed Structural BMPs	Applicability of BMPs			
	Used Where Baseflow/Groundwater is the Focus?		Used Where Storm-events are the Focus?	
	Greenfield areas	Built-up areas	Greenfield areas	Built-up areas
FUNCTION – Removal of Nutrients, Metals and Pesticides				
Infiltration Systems Use to reduce runoff and thus pollutant discharge to the surface water system	**Generally Not Suitable** owing to the potential for increasing recharge into groundwater and thus increasing the rate of baseflow in catchments during the summer/autumn period. **Suitable only** if combined with sub-soil drainage to prevent recharge into groundwater – see bioretention system		**Suitable** – An effective means of reducing the volume of stormwater discharge to the receiving waters. Most effective usage is in the form of porous pavements, soakaway pits. If systems are kept ephemeral, significant benefit can be gained in trapping and biodegrading organic litter generated. **Most suitable** if combined with bioretention system to ensure that urban stormwater is treated and nutrient reduced prior to discharge to underlying aquifer.	
Bioretention Systems These systems take many different forms and are suited for the removal of fine and soluble pollutants. They also adde to the amenity of the streetscape and promote the retardation of frequent floods	**Generally Suitable** especially by locating bioretention systems at points of discharge to surface water system – integration with sub-soil drainage system. A different media could be used in the filtration trench to target specific pollutants, i.e. Phosphorus removal – crushed limestone, phoslock, ecomax Nitrogen removal – saw dust; sandy-loam and other high organic soils		**Most Suitable** by incorporating into streetscape for treatment of road runoff. Incorporate bioretention system planter boxes for treatment of roof runoff. A different media could be used in the filtration trench to target specific pollutants, i.e. Phosphorus removal – crushed limestone, phoslock, ecomax Nitrogen removal – saw dust; sandy-loam and other high organic soils Recover treated water for direct discharge into surface water system to prevent input to groundwater or delayed discharge to receiving water..	
Waterway Rehabilitation Initiative directed at rehabilitation of existing waterways (drains) to increase its environmental value and a valued community asset. Waterway rehabilitation works general include the re-establishment of aquatic habitats and riparian vegetation. In some instances, rehabilitation works could include the raising of its talweg to limit the extent of groundwater discharge during summer months.	**Most Suitable** by setting invert of rehabilitate channel above the groundwater table (at least above the summer watertable)	**Suitable only** if currently catchment drainage outfall allows waterway talweg to be raised.	**Suitable** with the emphasis of creating pool and riffle sequences to promote the reduction of sediment and associated pollutants .	

Short-listed Structural BMPs	Applicability of BMPs			
	Used Where Baseflow/Groundwater is the Focus?		Used Where Storm-events are the Focus?	
	Greenfield areas	Built-up areas	Greenfield areas	Built-up areas
Groundwater Reuse Uses to promote the use of groundwater derived from the superficial groundwater aquifer as an alternative source of water to that of potable (mains) water.	**Suitable** as groundwater extraction (say for garden and landscape watering would lower the local groundwater level in summer to below waterway talweg thus reducing groundwater outflow.		**Not Suitable** as this BMP does not target the pollutant or the source of the pollutant.	
Constructed Wetlands Constructed wetlands are well-established system for stormwater and wastewater quality improvement. Well-designed constructed wetlands are a community asset and provide wildlife habitats. They have the capacity to remove medium to fine particulate and some soluble pollutant through a combination of physical (eg. settling), chemical (ion adsorption) and biological (biofilm uptake) processes.	**Suitable** using either surface or sub-surface systems at points of discharge to surface water system – integration with sub-soil drainage system.		**Suitable** for integration into the stormwater conveyance system and the public open space	**Generally Suitable** with systems to be integrated into streetscape, malls and public open space,
Ponds Used for storage of stormwater for reuse and trapping of coarse to medium sediment. Well-designed ponds can serves as an important community asset, providing a focus for passive and active recreation activities as well as flood retarding.	**Not Suitable** as this BMP does not target the pollutant or the source of the pollutant. It is also not effective in reducing baseflow delivery of nutrients to the receiving water.		**Suitable** as a treatment system but could itself be potentially subjected to nutrient enrichment pressures.	**Generally Suitable** but limited by space constraints although existing retarding basins could be retrofitted.
Urban Forestry The establishment of urban forest to promote passive watering by stormwater and to potentially lower summer groundwater table. This BMP can be designed to provide a community asset through establishment of wildlife habitats.	**Most Suitable** when combined with waterway rehabilitation initiatives to create a riparian zone forest to control summer groundwater levels		**Suitable** as a focal point for stormwater discharge providing an avenue for passive watering and filtering of stormwater.	**Generally Suitable** but limited space constraints although existing parklands could be retrofitted.

3.2 Mills Street Drain Case Study

The project brief required that the Mills Street Catchment be used as a case study to attempt to 'retrofit' high-value BMPs (both structural and non-structural) and that they be costed.

This was undertaken for two assessment contexts:

- one assuming that the reduction of nutrients in shallow groundwater and baseflow (during summer) is the primary focus of water quality management; and
- the other assuming that the reduction of nutrients in small, frequent storms (particularly those in summer) is the primary focus of water quality management.

4. Results

4.1 Results of BMP Assessment for the Swan Coastal Plain

The 16 chosen assessment criteria and their relative weightings are shown in Table 3.2.

The BMPs that were short-listed for assessment are shown in Tables 3.3 and 3.4.

The scores allocated to each BMP in terms of how they perform against each of the 16 assessment criteria are shown in Table 4.1.

The resulting “value score” for each BMP is presented in Table 4.2 along with rankings. Note that the “value score” reflects the triple bottom line, incorporating key aspects such as cost, pollutant production efficiency, and social value.

Table 4.1 BMP 'Impact' Assessment

BMP NAME	Context of assessment		Assessment Criteria															
			Financial/ Economic				Environmental/ Ecological					Social						
	Baseflow (B) or storm flows(S)?	Greenfield (G) or built-up areas (B-U)?	Total acquisition cost	Typical annual maintenance cost	Life cycle cost	Land acquisition cost	Pollutant reduction efficiency - TN	Pollutant reduction efficiency - TP	Pollutant reduction efficiency - TSS	Pollutant reduction - target nutrient species	Water re-use opportunities	Community acceptance	Political acceptance	Multiple use of asset/BMP	Safety hazards	Risk of failure	Coverage	Timeliness of desired result
Non-structural BMPs																		
Soil amendment (e.g. use during development or retrofitting by government agencies in public open space)	B	G	3	5	4	N/A	2	5	N/A	5	4	5	5	4	4	4	3	3
	B	B-U limited	3	5	4	N/A	2	5	N/A	5	4	5	5	4	4	4	1	3
	S	G	3	5	4	N/A	1	5	1	4	1	5	5	4	4	3	3	5
	S	B-U limited	3	5	4	N/A	1	5	1	4	1	3	3	4	4	3	1	5
Xeriscaping and **water/nutrient management plans** for public open space (e.g. use during development or retrofitting by government agencies in public open space)	B	G	4	5	4	N/A	5	5	N/A	4	4	3	4	3	5	3	3	3
	B	B-U	4	5	4	N/A	5	5	N/A	4	4	2	3	3	5	4	1	3
	S	G	4	5	4	N/A	2	4	2	4	1	3	4	3	5	3	3	5
	S	B-U	4	5	4	N/A	2	4	2	4	1	2	3	3	5	4	1	5

BMP NAME	Context of assessment		Assessment Criteria															
			Financial/ Economic				Environmental/ Ecological					Social						
	Baseflow (B) or storm flows(S)?	Greenfield (G) or built-up areas (B-U)?	Total acquisition cost	Typical annual maintenance cost	Life cycle cost	Land acquisition cost	Pollutant reduction efficiency - TN	Pollutant reduction efficiency - TP	Pollutant reduction efficiency - TSS	Pollutant reduction - target nutrient species	Water re-use opportunities	Community acceptance	Political acceptance	Multiple use of asset/BMP	Safety hazards	Risk of failure	Coverage	Timeliness of desired result
Site-based Water Management Officer who performs a local, interactive, intensive and focussed education/participation role (ideally suited to large greenfield estates)	B	G	5	5	5	N/A	2	2	2	4	3	5	5	4	5	3	3	3
	B	B-U limited	5	5	5	N/A	2	2	2	4	3	5	5	4	5	2	1	3
	S	G	5	5	5	N/A	2	2	2	4	3	5	5	4	5	3	3	5
	S	B-U limited	5	5	5	N/A	2	2	2	4	3	5	5	4	5	2	1	5
'Master Gardener' style education/participation programs (i.e. intensive local extension programs focussing on nutrient management in a residential garden context)	B	G	5	5	5	N/A	2	2	2	4	3	5	5	2	5	3	3	3
	B	B-U	5	5	5	N/A	2	2	2	4	3	5	5	2	5	2	1	3
	S	G	5	5	5	N/A	2	2	2	4	3	5	5	2	5	2	3	5
	S	B-U	5	5	5	N/A	2	2	2	4	3	5	5	2	5	2	1	5

BMP NAME	Context of assessment		Assessment Criteria															
			Financial/ Economic				Environmental/ Ecological					Social						
	Baseflow (B) or storm flows(S)?	Greenfield (G) or built-up areas (B-U)?	Total acquisition cost	Typical annual maintenance cost	Life cycle cost	Land acquisition cost	Pollutant reduction efficiency - TN	Pollutant reduction efficiency - TP	Pollutant reduction efficiency - TSS	Pollutant reduction - target nutrient species	Water re-use opportunities	Community acceptance	Political acceptance	Multiple use of asset/BMP	Safety hazards	Risk of failure	Coverage	Timeliness of desired result
Town planning controls requiring water sensitive urban design and where appropriate, no baseflow in urban drains during summer months	B	G	5	5	5	N/A	4	4	N/A	4	5	3	3	3	5	4	5	3
	B	B-U	5	5	5	N/A	4	4	N/A	4	5	3	3	3	5	3	5	3
	S	G	5	5	5	N/A	3	3	3	3	5	4	4	5	3	4	5	5
	S	B-U	5	5	5	N/A	3	3	3	3	5	3	3	3	3	3	5	5
Point source regulation, education and enforcement (e.g. involving small to medium sized commercial and industrial premises)	B	G limited	5	5	5	N/A	4	4	N/A	4	3	5	4	3	5	4	5	3
	B	B-U	5	5	5	N/A	4	4	N/A	4	3	5	4	3	5	4	5	3
	S	G limited	5	5	5	N/A	2	3	3	3	3	5	4	3	5	4	5	5
	S	B-U	5	5	5	N/A	2	3	3	3	3	5	4	3	5	4	5	5

BMP NAME	Context of assessment		Assessment Criteria															
			Financial/ Economic				Environmental/ Ecological					Social						
	Baseflow (B) or storm flows(S)?	Greenfield (G) or built-up areas (B-U)?	Total acquisition cost	Typical annual maintenance cost	Life cycle cost	Land acquisition cost	Pollutant reduction efficiency - TN	Pollutant reduction efficiency - TP	Pollutant reduction efficiency - TSS	Pollutant reduction - target nutrient species	Water re-use opportunities	Community acceptance	Political acceptance	Multiple use of asset/BMP	Safety hazards	Risk of failure	Coverage	Timeliness of desired result
Maintenance regime for the urban drainage network (e.g. detention basins, infiltration pits, open channels)	B	G limited	4	2	2	N/A	2	1	1	1	1	4	4	3	5	4	5	5
	B	B-U	4	2	2	N/A	2	1	1	1	1	3	3	3	5	4	5	5
	S	G limited	4	2	2	N/A	1	1	2	1	1	4	4	3	5	4	5	5
	S	B-U	4	2	2	N/A	1	1	2	1	1	3	3	3	5	4	5	5
Erosion and sediment control programs (e.g. education, regulation and enforcement on construction and building sites)	B	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B	B-U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	S	G	5	4	5	N/A	1	2	3	1	2	5	5	3	4	4	4	5
	S	B-U	5	4	5	N/A	1	2	3	1	2	5	5	3	4	4	4	5
Illegal discharge elimination programs (i.e. to identify and remove illegal discharges to stormwater and groundwater)	B	G limited	4	4	4	N/A	2	2	N/A	3	1	3	3	1	4	5	4	3
	B	B-U	4	4	4	N/A	2	2	N/A	3	1	3	3	1	4	5	4	3
	S	G limited	4	4	4	N/A	1	1	1	3	1	3	3	1	4	5	4	5
	S	B-U	4	4	4	N/A	1	1	1	3	1	3	3	1	4	5	4	5

BMP NAME	Context of assessment		Assessment Criteria															
			Financial/ Economic				Environmental/ Ecological					Social						
	Baseflow (B) or storm flows(S)?	Greenfield (G) or built-up areas (B-U)?	Total acquisition cost	Typical annual maintenance cost	Life cycle cost	Land acquisition cost	Pollutant reduction efficiency - TN	Pollutant reduction efficiency - TP	Pollutant reduction efficiency - TSS	Pollutant reduction - target nutrient species	Water re-use opportunities	Community acceptance	Political acceptance	Multiple use of asset/BMP	Safety hazards	Risk of failure	Coverage	Timeliness of desired result
Water management strategies (for the catchment scale) that involve strategic planning and affect structure planning (where relevant) and town planning schemes	B	G	3	5	4	N/A	2	2	2	4	4	4	4	1	5	2	4	2
	B	B-U	3	5	4	N/A	2	2	2	4	4	4	4	1	5	2	4	2
	S	G	3	5	4	N/A	2	2	2	4	4	4	4	1	5	2	4	2
	S	B-U	3	5	4	N/A	2	2	2	4	4	4	4	1	5	2	4	2
Financial incentives to lower the water table to prevent summer baseflows (i.e. use shallow groundwater for toilet flushing and irrigation)	B	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B	B-U	3	3	3	N/A	2	2	N/A	5	5	4	4	1	4	3	5	3
	S	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	S	B-U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Financial incentives to retrofit the use of xeriscaping and/or soil amendment	B	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B	B-U	3	3	3	N/A	1	1	N/A	5	2	4	4	1	5	3	5	3
	S	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	S	B-U	3	3	3	N/A	1	1	1	2	2	4	4	1	5	3	5	5

BMP NAME	Context of assessment		Assessment Criteria															
			Financial/ Economic				Environmental/ Ecological					Social						
	Baseflow (B) or storm flows(S)?	Greenfield (G) or built-up areas (B-U)?	Total acquisition cost	Typical annual maintenance cost	Life cycle cost	Land acquisition cost	Pollutant reduction efficiency - TN	Pollutant reduction efficiency - TP	Pollutant reduction efficiency - TSS	Pollutant reduction - key target nutrient species	Water re-use opportunities	Community acceptance	Political acceptance	Multiple use of asset/BMP	Safety hazards	Risk of failure	Coverage	Timeliness of desired result
Structural BMPs																		
Gross Pollutant Traps	B	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B	B-U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	S	G	3	2	3	4	1	1	3	2	1	3	4	1	3	3	3	5
	S	B-U	3	2	3	3	1	1	3	2	1	3	4	1	3	3	3	5
Sedimentation Basin	B	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B	B-U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	S	G	3	4	4	4	3	3	4	3	3	3	3	2	2	5	3	5
	S	B-U	3	4	4	2	3	3	4	3	3	3	3	2	2	5	3	5
Buffer Strips Vegetated (often grassed) systems which serves as buffer for stormwater runoff to promote the removal of sediment in stormwater.	B	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B	B-U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	S	G	5	4	4	5	3	3	3	3	1	4	4	2	5	4	2	5
	S	B-U	5	4	4	5	3	3	3	3	1	4	4	2	5	4	2	5

BMP NAME	Context of assessment		Assessment Criteria															
			Financial/ Economic				Environmental/ Ecological					Social						
	Baseflow (B) or storm flows(S)?	Greenfield (G) or built-up areas (B-U)?	Total acquisition cost	Typical annual maintenance cost	Life cycle cost	Land acquisition cost	Pollutant reduction efficiency - TN	Pollutant reduction efficiency - TP	Pollutant reduction efficiency - TSS	Pollutant reduction - target nutrient species	Water re-use opportunities	Community acceptance	Political acceptance	Multiple use of asset/BMP	Safety hazards	Risk of failure	Coverage	Timeliness of desired result
Roofwater Tanks Uses to promote the use of rainwater as an alternative source of water to that of potable (mains) water.	B	G	4	5	5	4	3	3	2	3	5	5	3	1	5	4	1	3
	B	B-U	4	5	5	4	3	3	2	3	5	5	3	1	5	4	1	3
	S	G	4	5	5	4	2	2	2	2	5	5	3	1	5	4	1	4
	S	B-U	4	5	5	4	2	2	2	2	5	5	3	1	5	4	1	4
Vegetated Swales Uses to promote the removal of medium sized particulates and promote some degree of infiltration of stormwater.	B	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B	B-U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	S	G	4	4	4	4	2	3	4	2	1	4	3	1	5	4	2	4
	S	B-U	4	4	4	4	2	3	4	2	1	4	3	1	5	4	2	4
Infiltration Systems Use to reduce runoff and thus pollutant discharge to the surface water system.	B	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B	B-U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	S	G	4	4	4	4	3	3	4	3	1	4	3	1	5	3	3	4
	S	B-U	4	4	4	3	3	3	4	3	1	4	3	1	5	3	3	4

BMP NAME	Context of assessment		Assessment Criteria															
			Financial/ Economic				Environmental/ Ecological					Social						
	Baseflow (B) or storm flows(S)?	Greenfield (G) or built-up areas (B-U)?	Total acquisition cost	Typical annual maintenance cost	Life cycle cost	Land acquisition cost	Pollutant reduction efficiency - TN	Pollutant reduction efficiency - TP	Pollutant reduction efficiency - TSS	Pollutant reduction - target nutrient species	Water re-use opportunities	Community acceptance	Political acceptance	Multiple use of asset/BMP	Safety hazards	Risk of failure	Coverage	Timeliness of desired result
Bioretention Systems These systems take many different forms and are suited for the removal of fine and soluble pollutants. They also adde to the amenity of the streetscape and promote the retardation of frequent floods.	B	G	3	4	4	4	4	4	3	4	1	4	3	2	5	4	3	4
	B	B-U	3	4	4	3	4	4	3	4	1	4	3	2	5	4	3	4
	S	G	3	4	4	4	4	4	4	4	1	4	3	2	5	4	3	4
	S	B-U	3	4	4	3	3	3	4	3	1	4	3	2	5	4	3	4
Waterway Rehabilitation Initiative directed at rehabilitation of existing waterways (drains) to increase its environmental value and a valued community asset. Waterway rehabilitation works general include the re-establishment of aquatic habitats and riparian vegetation. In some instances, rehabilitation works could include the raising of its talweg to limit the extent of groundwater discharge during summer months.	B	G	2	4	3	4	4	4	4	4	2	5	5	4	4	4	3	4
	B	B-U	2	4	3	2	4	4	4	4	2	5	5	4	4	4	3	4
	S	G	2	4	3	4	2	2	3	2	1	5	5	4	4	3	3	3
	S	B-U	2	4	3	2	2	2	3	2	1	5	5	4	4	3	3	3

BMP NAME	Context of assessment		Assessment Criteria															
			Financial/ Economic				Environmental/ Ecological					Social						
	Baseflow (B) or storm flows(S)?	Greenfield (G) or built-up areas (B-U)?	Total acquisition cost	Typical annual maintenance cost	Life cycle cost	Land acquisition cost	Pollutant reduction efficiency - TN	Pollutant reduction efficiency - TP	Pollutant reduction efficiency - TSS	Pollutant reduction - target nutrient species	Water re-use opportunities	Community acceptance	Political acceptance	Multiple use of asset/BMP	Safety hazards	Risk of failure	Coverage	Timeliness of desired result
Groundwater Reuse Uses to promote the use of groundwater derived from the superficial groundwater aquifer as an alternative source of water to that of potable (mains) water.	B	G	5	4	4	5	4	4	4	4	5	5	5	1	5	5	4	4
	B	B-U	5	4	4	5	4	4	4	4	5	5	5	1	5	5	4	4
	S	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	S	B-U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Constructed Wetlands Constructed wetlands are well-established system for stormwater and wastewater quality improvement. Well-designed constructed wetlands are a community asset and provide wildlife habitats. They have the capacity to remove medium to fine particulate and some soluble pollutant through a combination of physical (eg. settling), chemical (ion adsorption) and biological (biofilm uptake) processes.	B	G	3	3	3	2	4	3	4	3	4	3	3	4	4	3	3	3
	B	B-U	3	3	3	1	4	3	4	3	4	3	3	4	4	3	3	3
	S	G	3	3	3	3	3	4	4	3	3	3	3	4	4	3	3	3
	S	B-U	3	3	3	1	3	3	3	3	3	3	3	4	4	3	3	3
Ponds Used for storage of stormwater for reuse and trapping of coarse to medium sediment. Well-designed ponds can serves as an important community asset, providing a focus for passive and active recreation activities as well as flood retarding.	B	G	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B	B-U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	S	G	3	3	3	3	2	3	4	2	3	3	3	4	2	3	3	3
	S	B-U	3	3	3	1	2	3	4	2	3	3	3	4	2	3	3	3

BMP NAME	Context of assessment		Assessment Criteria															
			Financial/ Economic				Environmental/ Ecological					Social						
	Baseflow (B) or storm flows(S)?	Greenfield (G) or built-up areas (B-U)?	Total acquisition cost	Typical annual maintenance cost	Life cycle cost	Land acquisition cost	Pollutant reduction efficiency - TN	Pollutant reduction efficiency - TP	Pollutant reduction efficiency - TSS	Pollutant reduction - target nutrient species	Water re-use opportunities	Community acceptance	Political acceptance	Multiple use of asset/BMP	Safety hazards	Risk of failure	Coverage	Timeliness of desired result
Urban Forestry The establishment of urban forest to promote passive watering by stormwater and to potentially lower summer groundwater table. This BMP can be designed to provide a community asset through establishment of wildlife habitats.	B	G	3	4	4	2	2	2	2	2	1	3	3	4	4	4	3	2
	B	B-U	3	4	4	1	2	2	2	2	1	3	3	4	4	4	3	2
	S	G	3	4	4	2	3	4	5	3	1	3	3	4	4	4	3	3
	S	B-U	3	4	4	1	3	4	5	3	1	3	3	4	4	4	3	3

* Note: Underlined entries (e.g. "3") indicate areas of high uncertainty.

Table 4.2 Calculated 'Value Scores' for Assessed BMPs

BMP NAME	CONTEXT OF ASSESSMENT	BMP "VALUE SCORE" (and ranking within each of the 4 assessment contexts)
Non-structural BMPs		
Soil amendment (e.g. use during development or retrofitting by government agencies in public open space)	Baseflow/groundwater focus – greenfield areas **(BG)**	340 (rank = 3/4 for the 'BG' assessment context)
	Baseflow/groundwater focus – built-up areas **(BB)**	334 (3 BB)
	Storm event focus – greenfield areas **(SG)**	317 (5 SG)
	Storm event focus – built-up areas **(SB)**	287 (7SB)
Xeriscaping and **water/nutrient management plans** for public open space (e.g. use during development or retrofitting by government agencies in public open space)	Baseflow/groundwater focus – greenfield areas	340 (3/4 BG)
	Baseflow/groundwater focus – built-up areas	326 (4 BB)
	Storm event focus – greenfield areas	307 (6 SG)
	Storm event focus – built-up areas	294 (6 SB)
Site-based Water Management Officer who performs a local, interactive, intensive and focussed education/participation role (ideally suited to large greenfield estates)	Baseflow/groundwater focus – greenfield areas	328 (5 BG)
	Baseflow/groundwater focus – built-up areas	318 (5 BB)
	Storm event focus – greenfield areas	337 (4 SG)
	Storm event focus – built-up areas	326 (3 SG)
'Master Gardener' style education/participation programs (i.e. intensive local extension programs focussing on nutrient management in a residential garden context)	Baseflow/groundwater focus – greenfield areas	320 (6 BG)
	Baseflow/groundwater focus – built-up areas	309 (6 BB)
	Storm event focus – greenfield areas	324 (3 SG)
	Storm event focus – built-up areas	318 (4 SB)
Town planning controls requiring water sensitive urban design and where appropriate, no baseflow in urban drains during summer months	Baseflow/groundwater focus – greenfield areas	346 (2 BG)
	Baseflow/groundwater focus – built-up areas	341 (2 BB)
	Storm event focus – greenfield areas	355 (1 SG)
	Storm event focus – built-up areas	329 (2 SB)

BMP NAME	CONTEXT OF ASSESSMENT	BMP "VALUE SCORE" (and ranking within each of the 4 assessment contexts)
Point source regulation, education and enforcement (e.g. involving small to medium sized commercial and industrial premises)	Baseflow/groundwater focus – greenfield areas	354 (1 BG)
	Baseflow/groundwater focus – built-up areas	354 (1 BB)
	Storm event focus – greenfield areas	344 (2 SG)
	Storm event focus – built-up areas	344 (1 SB)
Maintenance regime for the urban drainage network (e.g. detention basins, infiltration pits, open channels)	Baseflow/groundwater focus – greenfield areas	231 (9 BG)
	Baseflow/groundwater focus – built-up areas	219 (11 BB)
	Storm event focus – greenfield areas	227 (10 SG)
	Storm event focus – built-up areas	215 (11 SB)
Erosion and sediment control programs (e.g. education, regulation and enforcement on construction and building sites)	Baseflow/groundwater focus – greenfield areas	-
	Baseflow/groundwater focus – built-up areas	-
	Storm event focus – greenfield areas	299 (7 SG)
	Storm event focus – built-up areas	299 (5 SB)
Illegal discharge elimination programs (i.e. to identify and remove illegal discharges to stormwater and groundwater)	Baseflow/groundwater focus – greenfield areas	253 (8 BG)
	Baseflow/groundwater focus – built-up areas	253 (9 BB)
	Storm event focus – greenfield areas	248 (9 SG)
	Storm event focus – built-up areas	248 9 SB)
Water management strategies (for the catchment scale) that involve strategic planning and affect structure planning (where relevant) and town planning schemes	Baseflow/groundwater focus – greenfield areas	286 (7 BG)
	Baseflow/groundwater focus – built-up areas	286 (7 BB)
	Storm event focus – greenfield areas	286 (8 SG)
	Storm event focus – built-up areas	286 (8 SB)
Financial incentives to lower the water table to prevent summer baseflows (i.e. use shallow groundwater for toilet flushing and irrigation)	Baseflow/groundwater focus – greenfield areas	-
	Baseflow/groundwater focus – built-up areas	272 (8 BB)
	Storm event focus – greenfield areas	-
	Storm event focus – built-up areas	-

BMP NAME	CONTEXT OF ASSESSMENT	BMP "VALUE SCORE" (and ranking within each of the 4 assessment contexts)
Financial incentives to retrofit the use of xeriscaping and/or soil amendment	Baseflow/groundwater focus – greenfield areas	-
	Baseflow/groundwater focus – built-up areas	244 (10 BB)
	Storm event focus – greenfield areas	-
	Storm event focus – built-up areas	236 (10 SB)
Structural BMPs		
Gross Pollutant Traps	Baseflow/groundwater focus – greenfield areas	-
	Baseflow/groundwater focus – built-up areas	-
	Storm event focus – greenfield areas	235 (11 SG)
	Storm event focus – built-up areas	229 (11 SB)
Sedimentation Basin	Baseflow/groundwater focus – greenfield areas	-
	Baseflow/groundwater focus – built-up areas	-
	Storm event focus – greenfield areas	318 (4 SG)
	Storm event focus – built-up areas	306 (6 SB)
Buffer Strips	Baseflow/groundwater focus – greenfield areas	-
	Baseflow/groundwater focus – built-up areas	-
	Storm event focus – greenfield areas	336 (2 SG)
	Storm event focus – built-up areas	336 (1 SB)
Roofwater Tanks	Baseflow/groundwater focus – greenfield areas	344 (3 BG)
	Baseflow/groundwater focus – built-up areas	344 (2/3 BB)
	Storm event focus – greenfield areas	325 (3 SG)
	Storm event focus – built-up areas	325 (2 SB)
Vegetated Swales	Baseflow/groundwater focus – greenfield areas	-
	Baseflow/groundwater focus – built-up areas	-
	Storm event focus – greenfield areas	301 (8 SG)
	Storm event focus – built-up areas	301 (7 SB)
Infiltration Systems	Baseflow/groundwater focus – greenfield areas	-
	Baseflow/groundwater focus – built-up areas	-
	Storm event focus – greenfield areas	314 (5 SG)
	Storm event focus – built-up areas	308 (4 SB)
Bioretention Systems	Baseflow/groundwater focus – greenfield areas	339 (4 BG)
	Baseflow/groundwater focus – built-up areas	333 (4 BB)
	Storm event focus – greenfield areas	344 (1 SG)
	Storm event focus – built-up areas	313 (3 SB)

BMP NAME	CONTEXT OF ASSESSMENT	BMP "VALUE SCORE" (and ranking within each of the 4 assessment contexts)
Waterway Rehabilitation	Baseflow/groundwater focus – greenfield areas	357 (2 BG)
	Baseflow/groundwater focus – built-up areas	344 (2/3 BB)
	Storm event focus – greenfield areas	291 (9 SG)
	Storm event focus – built-up areas	278 (8/9 SB)
Groundwater Reuse	Baseflow/groundwater focus – greenfield areas	399 (1 BG)
	Baseflow/groundwater focus – built-up areas	399 (1 BB)
	Storm event focus – greenfield areas	-
	Storm event focus – built-up areas	-
Constructed Wetlands	Baseflow/groundwater focus – greenfield areas	302 (5 BG)
	Baseflow/groundwater focus – built-up areas	296 (5 BB)
	Storm event focus – greenfield areas	303 (7 SG)
	Storm event focus – built-up areas	278 (8/9 SB)
Ponds	Baseflow/groundwater focus – greenfield areas	-
	Baseflow/groundwater focus – built-up areas	-
	Storm event focus – greenfield areas	270 (10 SG)
	Storm event focus – built-up areas	257 (10 SB)
Urban Forestry	Baseflow/groundwater focus – greenfield areas	264 (6 BG)
	Baseflow/groundwater focus – built-up areas	258 (6 BB)
	Storm event focus – greenfield areas	313 (6 SG)
	Storm event focus – built-up areas	307 (5 SB)

Note:

Non-structural and Structural BMPs have been ranked separately. "1" is the highest rank (i.e. most value).

4.2 Results of the Mills Street Drain Case Study

4.2.1 Nutrient Contributions from Baseflow and Storm Flow

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was used to predict the relative contribution of nutrients into the Mill Street Drain. Figure 4.1 shows the layout of the model established, representing the Mill Street catchment with 9 sub-catchments. Groundwater inflows are also modelled with a seasonal pattern, peaking in the winter months. Figures 4.2 and 4.3 shows the resulting groundwater flow and storm flow hydrographs respectively for the period January 1999 to July 2001.

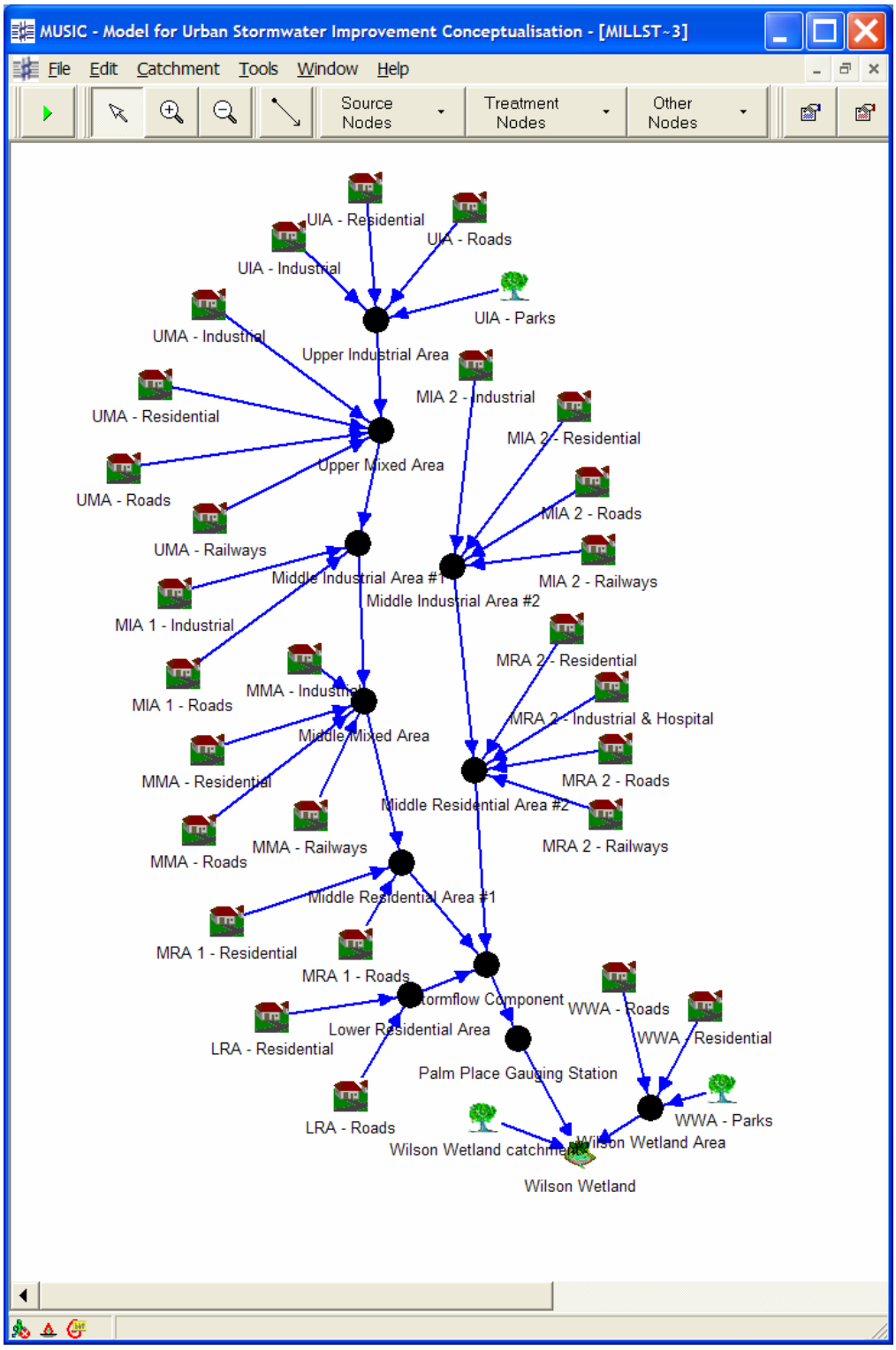


Figure 4.1 Layout of MUSIC model established for the Mills Street Catchment

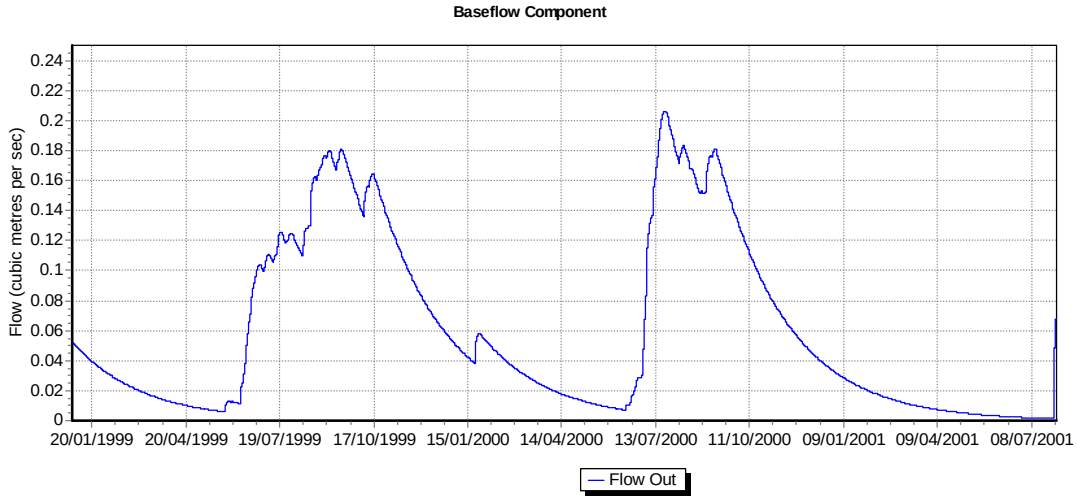


Figure 4.2 Seasonal Groundwater Inflows (Jan 1999 to July 2001)

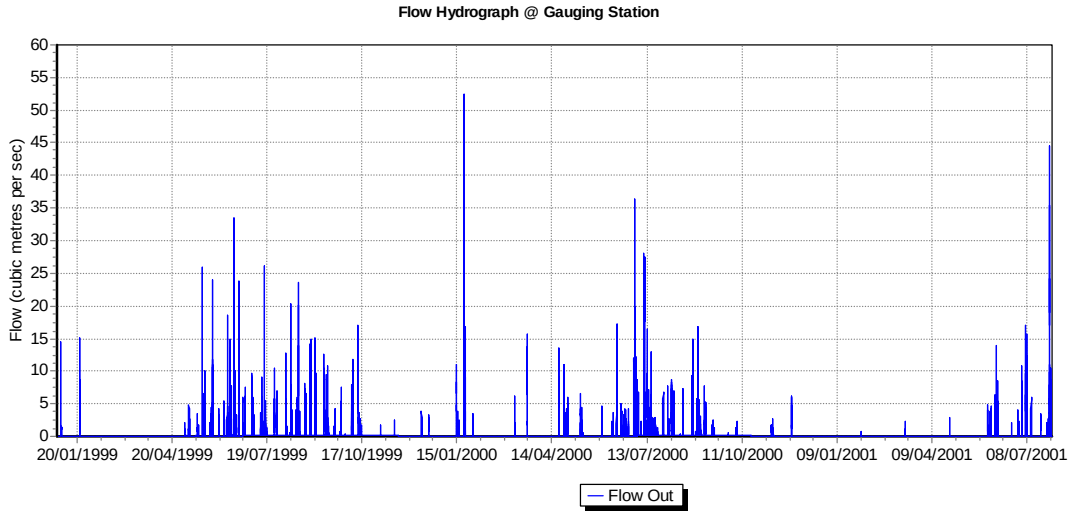


Figure 4.3 Predicted Flow at Palm Place Gauging Station (Jan 1999 to July 2001)

Preliminary simulations with the model for the period January 1999 to July 2001 (mean annual rainfall of 674 mm) indicates that storm flows account for 3.0 GL (resulting in a volumetric runoff coefficient of 0.36) or approximately 60% of the estimated 4.9 GL of mean annual flow from the catchment. In relation to nutrient loads, storm flows account for approximately 70% of the predicted total load from the catchment. These figures are at variance with the observations made by the Department of Environment which suggest that storm flows generate approximately 50% of the total nutrient loads. There may be a number of possible reasons for this related to model calibration to available data, the frequency of water quality sampling undertaken by the Department and understanding the basis by which the interpretation of observed data was made. The influence of sampling frequency can be expected to having the highest influence on the estimation of nutrient loads generated from storm events while groundwater nutrient concentrations are likely to be more uniform and seasonal groundwater flow rates varying less stochastically. Furthermore,

the present model has not taken into account the influence of the 23 compensating basins on nutrients reductions of loads derived from storm events.

The following is a summary of the relative flow and nutrient contributions from storm flows and groundwater flows.

Parameters	Groundwater Flows	Storm Flows	Total	DoE Estimates (1999-2001)
Annual Flow Volume	1.88 GL	3.01 GL	4.89 GL	4.90 GL
Annual TP	500 kg	1,260 kg	1,760 kg	1,730 kg
Annual TN	3,700 kg	8,000 kg	11,700 kg	10,027 kg

4.2.2 Baseflow Management Scenario

The aim of this chapter is to select, assess and cost some BMPs that have a high over-all "value score" for the Swan Coastal Plain (for use in built-up areas) and could be applied in the Mills Street Catchment assuming the management of nutrients in *baseflow/groundwater* is the focus. Approximate nutrient load reductions and BMP costings have also been provided. The size of the structural BMPs were determined based on what could be reasonably expected to be implemented in a built-up catchment with significant space constraints.

Table 4.3 lists all the possible BMPs from Chapter 3.0, the *approximate* load reductions for TP and TN that would occur in a typical year if they were applied in the Mills Street Catchment, and relevant BMP costing information. The approximate load reductions for TP and TN were estimated using MUSIC with appropriate parameters for the various BMPs adjusted to account for possible lower nutrient removal efficiencies due to the fact that nutrients, especially phosphorus, generated in Perth urban catchments are significantly different in characteristics from that typical of urban catchments in the eastern States of Australia, for which many of these parameters have been calibrated. At present, there is not data on urban stormwater quality and performance of BMPs in nutrient reduction for urban areas in the Perth region to allow the adjustments applied to be validated.

Table 4.3 also highlights (with an asterisk) those BMPs that are recommended for application in the Mills Street Catchment based on their potential nutrient reduction efficiency (i.e. the approximate cost to remove a kg of TN and TP using each BMP) and other elements of the triple bottom line.

In order to undertake pollutant removal estimates for many of the *non-structural BMPs*, a high degree of professional judgment was needed, often drawing upon limited case study information and published research. While many of these estimates are open to debate, it was understood from the client that a 'ball park' estimation process was necessary to help focus management priorities in the short term. Such estimates, albeit inaccurate are needed now to assist decisions on which BMPs to trial, evaluate and refine using the principle of 'adaptive environmental management'.

Figures 4.4 to 4.5 plot the relative rankings of the non-structural and structural BMPs according to nutrient reduction and load remove per dollar investment.

Table 4.3 Load Reduction and Costing Estimates for BMPs Applied to the Mills Street Catchment (Assuming a Baseflow/Groundwater Management Focus)

BMPs	Approx. TP reduction (kg/yr)	Approx. TN reduction (kg/yr)	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Decommissioning cost ($2004)	Life span (years)	Life Cycle cost (LCC) ($2004)	Equivalent annual payment cost ($2004)	TP load reduction efficiency (g/$)	TN load reduction efficiency (g/$)
Non-structural BMPs										
1. Point source regulation, education and enforcement* (e.g. involving small to medium sized commercial and industrial premises)	PRE (pollutant removal efficiency): 60% Area: 40% (approx. % of catchment to which the BMP could apply) K (kilograms of potentially captured p.a.) = 208	PRE: 50% Area: 40% K = 1,003	$200,000 (set up costs)	$0 (Licence fees structured to be cost neutral. Actual costs ~$480 per premises for ~$1,500 premises.)	$0 (on-going BMP)	Ongoing (for the purposes of life cycle costing, 30 years shall be used for all on-going BMPs)	$200,000	$7,000	31	151
2. Illegal discharge elimination programs* (i.e. to identify and remove illegal discharges to stormwater and groundwater)	PRE: 20% Area: 80% K = 139	PRE: 20% Area: 80% K = 802	$100,000 (annual cost)	$100,000	$0 (on-going BMP)	Ongoing	$1,134,000	$38,000	3.7	21
3. Soil amendment (e.g. use during development or retrofitting by government agencies in public open space)	PRE: 75% Area: 1% (very limited opportunities) K = 7	PRE: 10% Area: 1% K = 6	$2,300,000	$0	$0 (on-going BMP)	Ongoing	$2,300,000	$77,000	0.09	0.07

BMPs	Approx. TP reduction (kg/yr)	Approx. TN reduction (kg/yr)	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Decommissioning cost ($2004)	Life span (years)	Life Cycle cost (LCC) ($2004)	Equivalent annual payment cost ($2004)	TP load reduction efficiency (g/$)	TN load reduction efficiency (g/$)
4. Town planning controls* requiring water sensitive urban design and where appropriate, no baseflow in urban drains during summer months	PRE: 50% Area: 20% (assuming 20% of the catchment is re-developed over the BMP costing horizon of 30 years at 0.67% of the catchment p.a.) K = 45 (average over the 30 years as the area develops)	PRE: 50% Area: 20% (making the same assumptions as for TP) K = 260 (average over the 30 years as the area develops)	$100,000	$60,000 (includes the cost of additional development assessment)	$0 (on-going BMP)	Ongoing	$720,000	$24,000	1.9 (NB. benefit: cost ratio increases with time as the catchment develops)	11 (NB. benefit: cost ratio increases with time as the catchment develops)
5. Xeriscaping and water/nutrient management plans* for public open space (e.g. use during development or retrofitting by government agencies in public open space) [NB: very little relevant literature/case studies were available to support PRE estimates]	PRE: 75% Area: 1% (limited opportunities) K = 7	PRE: 75% Area: 1% K = 38	$160,000	$0 (no *additional* costs)	$0 (on-going BMP)	Ongoing	$160,000	$5,000	12	7
6. Site-based Water Management Officer who performs a local, interactive, intensive and focussed education/participation role (ideally suited to large greenfield estates)	(This BMP is best suited to large *developments* – therefore the 'Master Gardener' style program below would be a more applicable BMP for Mills Street, perhaps with an additional water conservation element)									

BMPs	Approx. TP reduction (kg/yr)	Approx. TN reduction (kg/yr)	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Decommissioning cost ($2004)	Life span (years)	Life Cycle cost (LCC) ($2004)	Equivalent annual payment cost ($2004)	TP load reduction efficiency (g/$)	TN load reduction efficiency (g/$)
7. 'Master Gardener' style education/participation programs* (i.e. intensive local extension programs focussing on nutrient management in a residential garden context)	PRE: 20% Area: 40% (urban residential area) K = 69	PRE: 20% Area: 40% K = 401	$100,000	$20,000	$0 (on-going BMP)	Ongoing	$307,000	$10,000	7	39
8. Water management strategies* (for the catchment scale) that involve strategic planning and affect structure planning (where relevant) and town planning schemes	PRE: 15% Area: 100% K = 130 (note that this PRE reflects the over-all effectiveness of a city/catchment wide management program with *many* BMPs)	PRE: 20% Area: 100% K = 1,003 (note that this PRE reflects the over-all effectiveness of a city/ catchment wide management program with *many* BMPs)	$100,000 (planning) + $100,000 (annual implement-ation costs)	$10,000 (maintenance of plan/ strategy) + $100,000 (annual implement-ation costs)	$0 (on-going BMP)	Ongoing	Total (planning plus implement-ation) = $1,336,905	$45,000 (planning plus implement-ation)	2.9 (planning plus implement-ation)	23 (planning plus implement-ation)
9. Financial incentives to lower the water table* to prevent summer baseflows (i.e. use shallow groundwater for toilet flushing and irrigation) [NB: relevant literature/case studies were not available to support estimates for this BMP]	Assume baseflow is stopped for 3 months a year, reducing the baseflow nutrient load by ~25% K = 217	K = 1,254	$254,000 (assumes 2 bores are needed very 50m of open drain and incentive = $1,000 per bore)	$5,000	$0	Incentive = 1-2 years, but assume BMP is on-going as there will be maintenance /compliance costs involved	$306,000	$10,000	21	123
10. Financial incentives to retrofit the use of xeriscaping and/or soil amendment [NB: relevant literature/case studies were not available to support estimates for this BMP]	PRE: 7.5% (75% x 10% uptake of incentive) Area: 40% K = 26	PRE: 5% (50% x 10% uptake of incentive) Area: 40% K = 101	$250,000 (assume 2,500 premises participate and an incentive of $1,000 per premises)	$10,000	$0	Incentive = 1-2 years, but assume BMP is on-going as there will be maintenance /compliance costs involved	$353,000	$12,000	2.2	9

BMPs	Approx. TP reduction (kg/yr)	Approx. TN reduction (kg/yr)	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Decommissioning cost ($2004)	Life span (years)	Life Cycle cost (LCC) ($2004)	Equivalent annual payment cost ($2004)	TP load reduction efficiency (g/$)	TN load reduction efficiency (g/$)
11. Maintenance regime for the urban drainage network (e.g. detention basins, infiltration pits, open channels)	PRE: 0% Area: 100% K = 0	PRE: 10% Area: 100% K = 502	$500,000 (set up and first year cost)	$500,000	$0 (ongoing)	Ongoing.	$5,668,000	$189,000	0	2.7
12. Erosion and sediment control programs (e.g. education, regulation and enforcement on construction and building sites)	N/A (BMP has no significant affect on *baseflow* nutrient loads)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Structural BMPs										
Groundwater Reuse for landscape watering of Canning River Regional Park* (pumping scheme to use superficial groundwater as an alternative source of water for landscape watering of the Canning River Regional Park in spring and summer months (~20 Ha; ~260 ML).	PRE = 100% - Area = 100% of catchment – extract spring and summer baseflow from storage upstream of Wilson Wetland. K = 80 kg	PRE = 100% Area = 100% of catchment – extract spring and summer baseflow from storage upstream of Wilson Wetland. 780 kg	$100,000	$5,000	$0 (assume the BMP is on-going for the purposes of this exercise)	Ongoing (for the purposes of life cycle costing, 30 years shall be used for all on-going BMPs)	$152,000	$5,000	16	154
Roofwater Tank For harvesting of stormwater and prevention of infiltration into groundwater	PRE = 10% Area = 25% of residential dwellings (~1500 dwellings; 5.2 km^2 residential area of which 30% is roof area ~ 1.6 km^2) = 0.39 km^2 K = 2 kg reduction of TP discharged from baseflow. K = 5 kg reduction of TP discharged from stormflow	PRE = 10% Area = 25% of residential dwellings (~1500 dwellings; 5.2 km^2 residential area of which 30% is roof area ~ 1.6 km^2) = 0.39 km^2 K = 20 kg reduction of TN discharged from baseflow. K = 158 kg reduction of TN discharged from stormflow	$3,000,000	$150,000	$300,000 ($200 per tank)	25 (above ground, metal)	$4,517,000	$181,000	0.011 (baseflow); and 0.028 (storm flow)	0.11 (baseflow); and 0.88 (storm flow)

BMPs	Approx. TP reduction (kg/yr)	Approx. TN reduction (kg/yr)	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Decommissioning cost ($2004)	Life span (years)	Life Cycle cost (LCC) ($2004)	Equivalent annual payment cost ($2004)	TP load reduction efficiency (g/$)	TN load reduction efficiency (g/$)
Waterway Rehabilitation* approximately 3 km of open drains with the rest being underground pipes	PRE = 30% Area = 100% - K = 80 kg	PRE = 30% Area = 100% - K = 780 kg	$750,000	$7,000 (incl. weed management)	$0	Ongoing	$822,000	$27,000	2.9	28
Bioretention System* Approximately 3 km of open drains with the rest being underground pipes requiring 6000 m^2 area of bioretention system	PRE = 45% Area = 100% - K = 225 kg	PRE = 30% Area = 100% - K =1110 kg	$77,000	$30,000	Assume systems are 're-set' every 25 years and effectively on-going. Re-setting cost = $37,410.	Effectively on-going (assumed 30 for the LCC'ing exercise)	$393,000	$16,000	14	71
Constructed Wetlands* retrofit parkland around Wilson Wetland for nutrient reduction (~ 5 Ha)	PRE = 30% Area = 100% - K = 150 kg	PRE = 30% Area = 100% - K = 1110 kg	$2,018,000	$78,000	Assume systems are 're-set' every 20 years and effectively on-going. Re-setting cost = $209,900.	Effectively on-going (assumed 30 for the LCC'ing exercise)	$2,858,000	$95,000	1.6	12

Notes:

BMPs within the non-structural and structural sections have been ranked in order of the relative value using the calculated "value scores" (i.e. BMPs with the highest scores are listed first).

Nutrient reduction estimates for non-structural BMPs are based on *very limited information* and should be regarded only as 'order of magnitude' estimates. They also assume that approximately 10,027 kg of TN and 1,730 kg of TP are exported from the Mills Street Drainage Catchment every year (based on recently calculated DoE data). Based on this data it is also assumed that ~50% of the TN and TP load occurs as baseflow (which currently occurs 12 months a year). Reductions of TN and TP loads in groundwater that enters receiving waters *directly* (i.e. without intersecting the catchment's drains and detention basins) has *not* been included in this assessment.

The estimates of pollutant removal efficiency (PRE) for the non-structural BMPs assume each BMP is used *in isolation* to manage water quality. If BMPs are used in combination, the cumulative load reduction would be less that the sum of individual load reductions when BMPs are considered in isolation. To estimate cumulative load reductions, pollutant export modelling would have to be undertaken.

For non-structural BMPs, the known load of TN and TP from baseflow is assumed to be derived from all areas of the catchment on an equal basis for the purposes of roughly approximating possible load reductions in the absence of pollutant export modelling.

Those BMPs marked with an asterisk (*) are those recommended to be considered for use in the Mills Street catchment.

PRE = pollutant removal efficiency, assuming the BMP is used in isolation.

K = tonnes removed per year by the BMP.

For life-cycle costing, the real discount rate is assumed to be 8%. Where BMPs have an indefinite life span the life-cycle has been assumed to be 30 years (the effect of discounting on the life-cycle cost allows this assumption to be safely made without significantly affecting the life-cycle cost).

The life-cycle cost (LCC) is the sum of all discounted costs over the life span of the BMP as defined in AS 4536:1999 (Australian Standards, 1999). Equivalent to the 'net present value' *plus* all initial acquisition costs for the BMP in the first year.

The EAP is the LCC divided by the life span of the BMP.

Costs are *relative to the agency implementing the BMP*, so some BMPs can be cost-neutral if there is a source of revenue to balance expenditure.

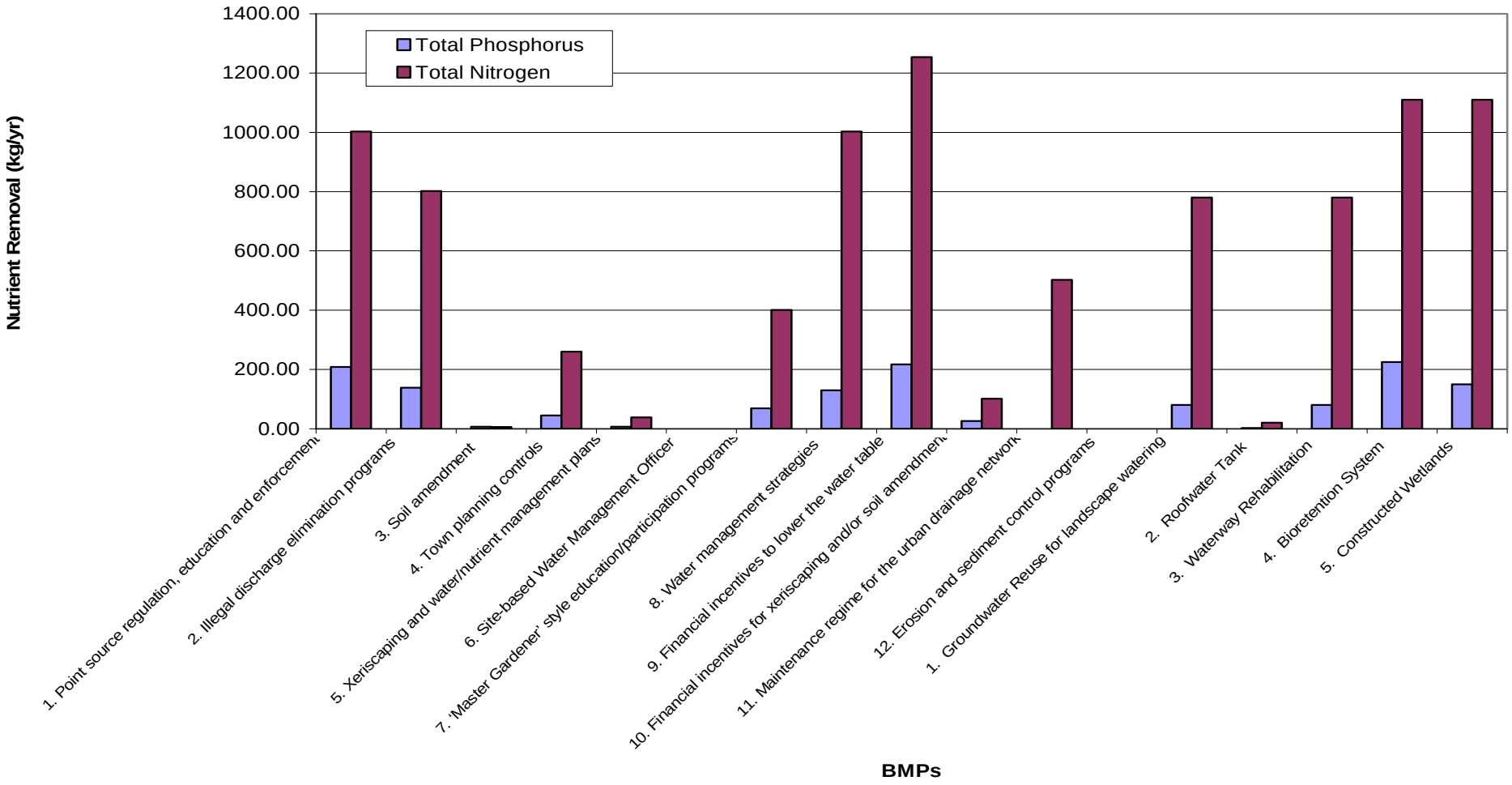


Figure 4.4 Plot of Mean Annual Nutrient Removal for Short-listed BMPs for Mills Street Catchment (Groundwater Flow Management)

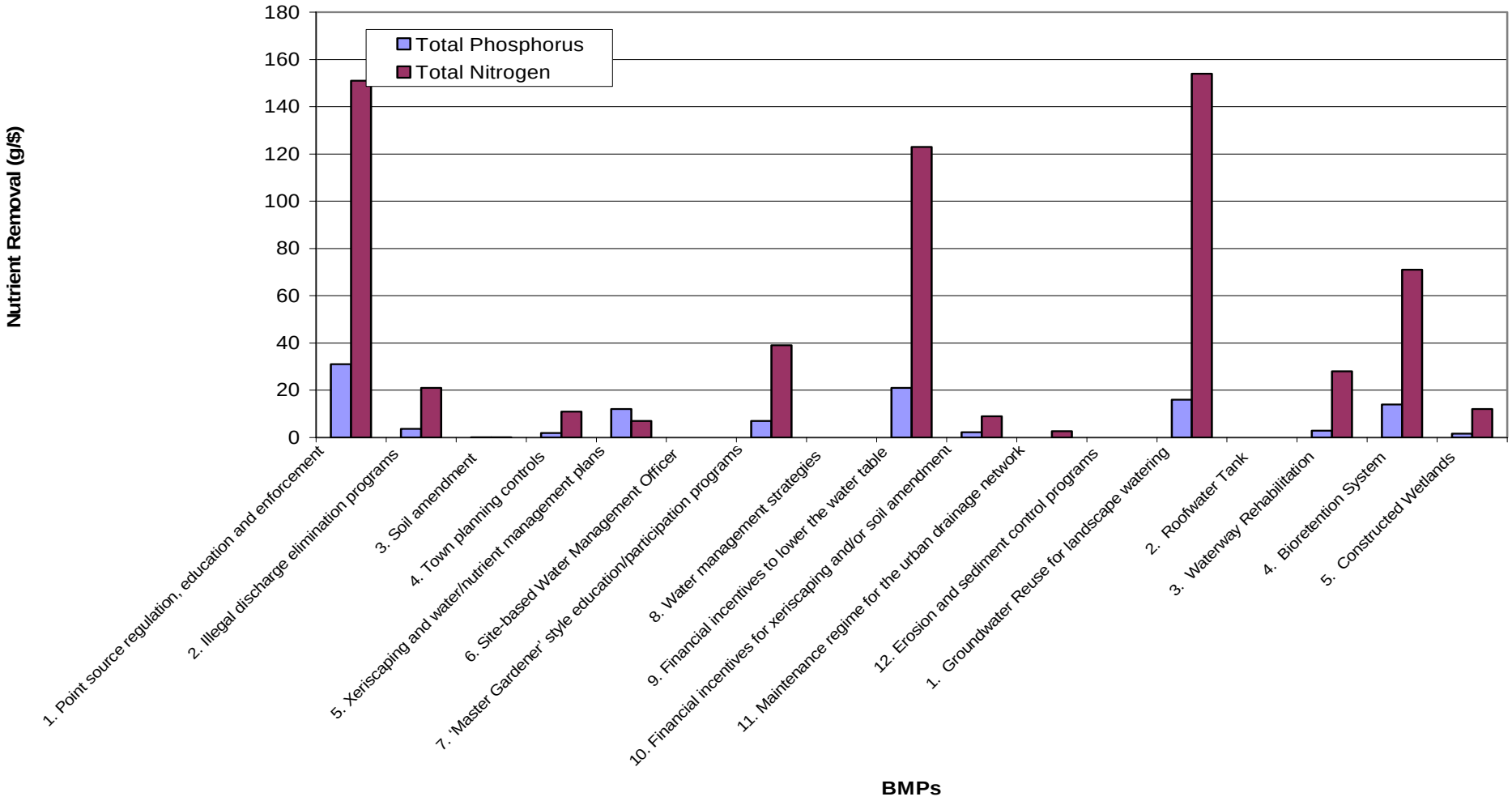


Figure 4.5 Plot of Annual Nutrient Removal per unit $ expenditure for Short-listed BMPs for Mills Street Catchment (Groundwater Flow Management)

4.2.3 Storm Event Management Scenario

Table 4.4 assesses the merits of short-listed BMPs for application in the Mills Street catchment assuming the reduction of nutrients in *small, frequent storm events* (i.e. stormwater) is the focus. Those BMPs that have high potential nutrient removal efficiencies are highlighted with an asterisk (*) and are recommended for use in the catchment. The size of the structural BMPs were determined based on what could be reasonably expected to be implemented in a built-up catchment with significant space constraints.

Once again approximate BMP costing and nutrient load reduction information is provided for each relevant BMP. The approximate load reductions for TP and TN were estimated using MUSIC with appropriate parameters for the various BMPs adjusted to account for possible lower nutrient removal efficiencies due to the fact that nutrients, especially phosphorus, generated in Perth urban catchments are significantly different in characteristics from that typical of urban catchments in the eastern States of Australia, for which many of these parameters have been calibrated. At present, there is not data on urban stormwater quality and performance of BMPs in nutrient reduction for urban areas in the Perth region to allow the adjustments applied to be validated.

Figures 4.6 to 4.7 plot the relative rankings of the non-structural and structural BMPs according to nutrient reduction, load remove per dollar investment.

Table 4.4 Load Reduction and Costing Estimates for BMPs Applied to the Mills Street Catchment (Assuming a Stormwater Management Focus)

BMPs	Approx. TP reduction (kg/yr)	Approx. TN reduction (kg/yr)	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Decommissioning cost ($2004)	Life span (years)	Life Cycle cost (LCC) ($2004)	Equivalent annual payment cost ($2004)	TP load reduction efficiency (g/$)	TN load reduction efficiency (g/$)
Non-structural BMPs										
1. Point source regulation, education and enforcement* (e.g. involving small to medium sized commercial and industrial premises)	PRE: 55% Area: 40% K = 191	PRE: 45% Area: 40% K = 903	$200,000 (set up costs)	$0 (Licence fees structured to be cost neutral. Actual costs ~$480 per premises for ~$1,500 premises.)	$0 (on-going BMP)	Ongoing (for the purposes of life cycle costing, 30 years shall be used for all on-going BMPs)	$200,000	$7,000	29	136
2. Town planning controls* requiring water sensitive urban design and where appropriate, no baseflow in urban drains during summer months	PRE: 50% Area: 20% (assuming 20% of the catchment is re-developed over the BMP costing horizon of 30 years at 0.67% of the catchment p.a.) K = 45 (average over the 30 years as the area develops)	PRE: 50% Area: 20% (making the same assumptions as for TP) K = 260 (average over the 30 years as the area develops)	$100,000	$60,000 (includes the cost of additional development assessment)	$0 (on-going BMP)	Ongoing	$720,000	$24,000	1.9 (NB. benefit: cost ratio increases with time as the catchment develops)	11 (NB. benefit: cost ratio increases with time as the catchment develops)

BMPs	Approx. TP reduction (kg/yr)	Approx. TN reduction (kg/yr)	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Decommissioning cost ($2004)	Life span (years)	Life Cycle cost (LCC) ($2004)	Equivalent annual payment cost ($2004)	TP load reduction efficiency (g/$)	TN load reduction efficiency (g/$)
3. Site-based Water Management Officer who performs a local, interactive, intensive and focussed education/participation role (ideally suited to large greenfield estates)	(This BMP is best suited to large *developments* – therefore the 'Master Gardener' style program below would be a more applicable BMP for Mills Street, perhaps with an additional water conservation element)									
4. 'Master Gardener' style education/participation programs* (i.e. intensive local extension programs focussing on nutrient management in a residential garden context)	PRE: 20% Area: 40% (urban residential area) K = 69	PRE: 20% Area: 40% K = 401	$100,000	$20,000	$0 (on-going BMP)	Ongoing	$307,000	$10,000	7	39
5. Erosion and sediment control programs (e.g. education, regulation and enforcement on construction and building sites)	PRE: 20% Area: 2.5% (assume 5% re-developed area per year, which is subject to the BMP for 6 months) K = 4	PRE: 10% Area: 2.5% K = 13	$50,000	$0 (cost-neutral due to income from fines)	$0 (on-going BMP)	Ongoing	$50,000	$2,000	2.1	8

BMPs	Approx. TP reduction (kg/yr)	Approx. TN reduction (kg/yr)	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Decommissioning cost ($2004)	Life span (years)	Life Cycle cost (LCC) ($2004)	Equivalent annual payment cost ($2004)	TP load reduction efficiency (g/$)	TN load reduction efficiency (g/$)
6. Xeriscaping and water/nutrient management plans for public open space (e.g. use during development or retrofitting by government agencies in public open space) [NB: very little relevant literature/case studies were available to support PRE estimates]	PRE: 50% Area: 1% (limited opportunities) K = 5	PRE: 20% Area: 1% K = 10	$160,000	$0 (no *additional* costs)	$0 (on-going BMP)	Ongoing	$160,000	$5,000	0.9	1.9
7. Soil amendment (e.g. use during development or retrofitting by government agencies in public open space)	PRE: 75% Area: 1% (very limited opportunities) K = 7	PRE: 10% Area: 1% K = 5	$2,300,300	$0	$0 (on-going BMP)	Ongoing	$2,300,000	$77,000	0.09	0.07
8. Water management strategies* (for the catchment scale) that involve strategic planning and affect structure planning (where relevant) and town planning schemes	PRE: 20% Area: 100% K = 173 (note that this PRE reflects the over-all effectiveness of a city/catchment wide management program with *many* BMPs)	PRE: 20% Area: 100% K = 1,003 (note that this PRE reflects the over-all effectiveness of a city/ catchment wide management program with *many* BMPs)	$100,000 (planning) + $100,000 (annual implement-ation costs)	$10,000 (mainten-ance of plan/ strategy) + $100,000 (annual implement-ation costs)	$0 (on-going BMP)	Ongoing	Total (planning plus implement-ation) = $1,336,905	$45,000 (planning plus implement-ation)	3.9 (planning plus implement-ation)	23 (planning plus implement-ation)
9. Illegal discharge elimination programs* (i.e. to identify and remove illegal discharges to stormwater and groundwater)	PRE: 10% Area: 80% K = 69	PRE: 10% Area: 80% K = 401	$100,000 (annual cost)	$100,000	$0 (on-going BMP)	Ongoing	$1,134,000	$38,000	1.9	11

BMPs	Approx. TP reduction (kg/yr)	Approx. TN reduction (kg/yr)	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Decommissioning cost ($2004)	Life span (years)	Life Cycle cost (LCC) ($2004)	Equivalent annual payment cost ($2004)	TP load reduction efficiency (g/$)	TN load reduction efficiency (g/$)
10. Financial incentives to retrofit the use of xeriscaping and/or soil amendment [NB: relevant literature/case studies were not available to support estimates]	PRE: 6% (60% x 10% uptake of incentive) Area: 40% K = 21	PRE: 1.5% (15% x 10% uptake of incentive) Area: 40% K = 30	$250,000 (assume 2,500 premises participate and an incentive of $1,000 per premises)	$10,000	$0	Incentive = 1-2 years, but assume BMP is on-going as there will be maintenance /compliance costs involved	$353,000	$12,000	1.8	2.6
11. Maintenance regime for the urban drainage network (e.g. detention basins, infiltration pits, open channels)	PRE: 10% Area: 100% K = 87	PRE: 10% Area: 100% K = 502	$500,000 (set up and first year cost)	$500,000	$0 (ongoing)	Ongoing.	$5,668,000	$189,000	0.46	2.7
12. Financial incentives to lower the water table to prevent summer baseflows (i.e. use shallow groundwater for toilet flushing and irrigation) [NB: relevant literature/case studies were not available to support estimates]	N/A (BMP has no significant affect on nutrient loads in *stormwater*)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Structural BMPs										
Buffer Strips Buffer strips for 25% of roads (total area of buffer strips ~ 11,000 m^2)	PRE: 46% Area: 9% of directly connected impervious areas K = 50 kg	PRE: 29% Area: 9% of directly connected impervious areas K = 210 kg	$122,000 (assumes cost elements are similar to swales)	$53,000 (relatively high estimate for buffer strips)	Ongoing ($0)	Ongoing – assume 30 for the LCC'ing exercise	$672,000	$27,000	1.9	7.8

BMPs	Approx. TP reduction (kg/yr)	Approx. TN reduction (kg/yr)	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Decommissioning cost ($2004)	Life span (years)	Life Cycle cost (LCC) ($2004)	Equivalent annual payment cost ($2004)	TP load reduction efficiency (g/$)	TN load reduction efficiency (g/$)
Roofwater Tank harvesting of stormwater and prevention of infiltration into groundwater	PRE = 10% Area = 25% of residential dwellings (~1500 dwellings; 5.2 km^2 residential area of which 30% is roof area ~ 1.6 km^2) = 0.39 km^2 K = 2 kg reduction of TP discharged from baseflow. K = 5 kg reduction of TP discharged from stormflow	PRE = 10% Area = 25% of residential dwellings (~1500 dwellings; 5.2 km^2 residential area of which 30% is roof area ~ 1.6 km^2) = 0.39 km^2 K = 20 kg reduction of TN discharged from baseflow. K = 158 kg reduction of TN discharged from stormflow	$3,000,000	$150,000	$300,000 ($200 per tank)	25 (above ground, metal)	$4,517,000	$181,000	0.011 (baseflow); and 0.028 (storm flow)	0.11 (baseflow); and 0.88 (storm flow)
Bioretention System * Total bioretention area to treat 25% of the impervious areas in the catchment is 15,000 m^2	PRE: 65% Area: 25% K = 210 kg	PRE: 57% Area: 25% K = 1100 kg	$155,000	$72,000	Assume systems are 're-set' every 25 years and effectively on-going. Re-setting cost = $76,000.	Effectively on-going (assumed 30 for the LCC'ing exercise)	$904,000	$36,000	5.8	30
Constructed Wetlands* Retrofit parkland around Wilson Wetland for nutrient reduction (~ 5 Ha)	PRE = 52% Area = 100% - K = 660 kg	PRE = 34% Area = 100% - K = 2720 kg	$2,018,000	$78,000	Assume systems are 're-set' every 20 years and effectively on-going. Re-setting cost = $210,000.	Effectively on-going (assumed 30 for the LCC'ing exercise)	$2,858,000	$95,000	6.9	29

BMPs	Approx. TP reduction (kg/yr)	Approx. TN reduction (kg/yr)	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Decommissioning cost ($2004)	Life span (years)	Life Cycle cost (LCC) ($2004)	Equivalent annual payment cost ($2004)	TP load reduction efficiency (g/$)	TN load reduction efficiency (g/$)
Urban Forestry* Retrofit parkland around Wilson Wetland into urban forest for nutrient reduction (~ 5 Ha)	PRE = 33% Area = 100% - K = 420 kg	PRE = 26% Area = 100% - K = 2080 kg	$208,000 (using urban rehabilitation cost estimates)	$131 (using US estimates for maintenance *once BMP is established*)	$0 (ongoing)	Effectively on-going (assumed 30 for the LCC'ing exercise)	$215,000	$7,000	59	290

Notes:

Notes provided for Table 4.3 are also relevant to this table.

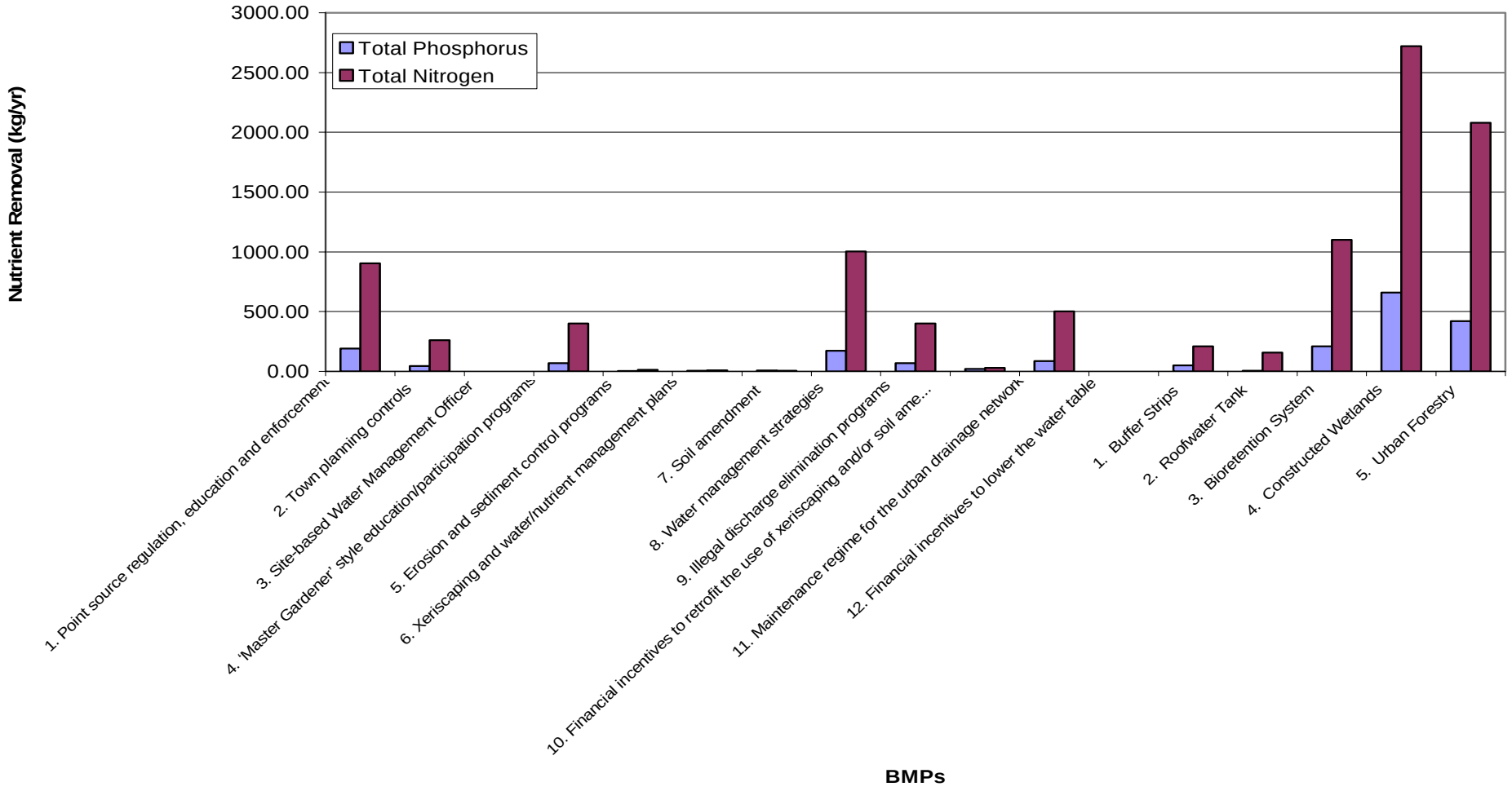


Figure 4.6 Plot of Mean Annual Nutrient Removal for Short-listed BMPs for Mills Street Catchment (Storm Flow Management)

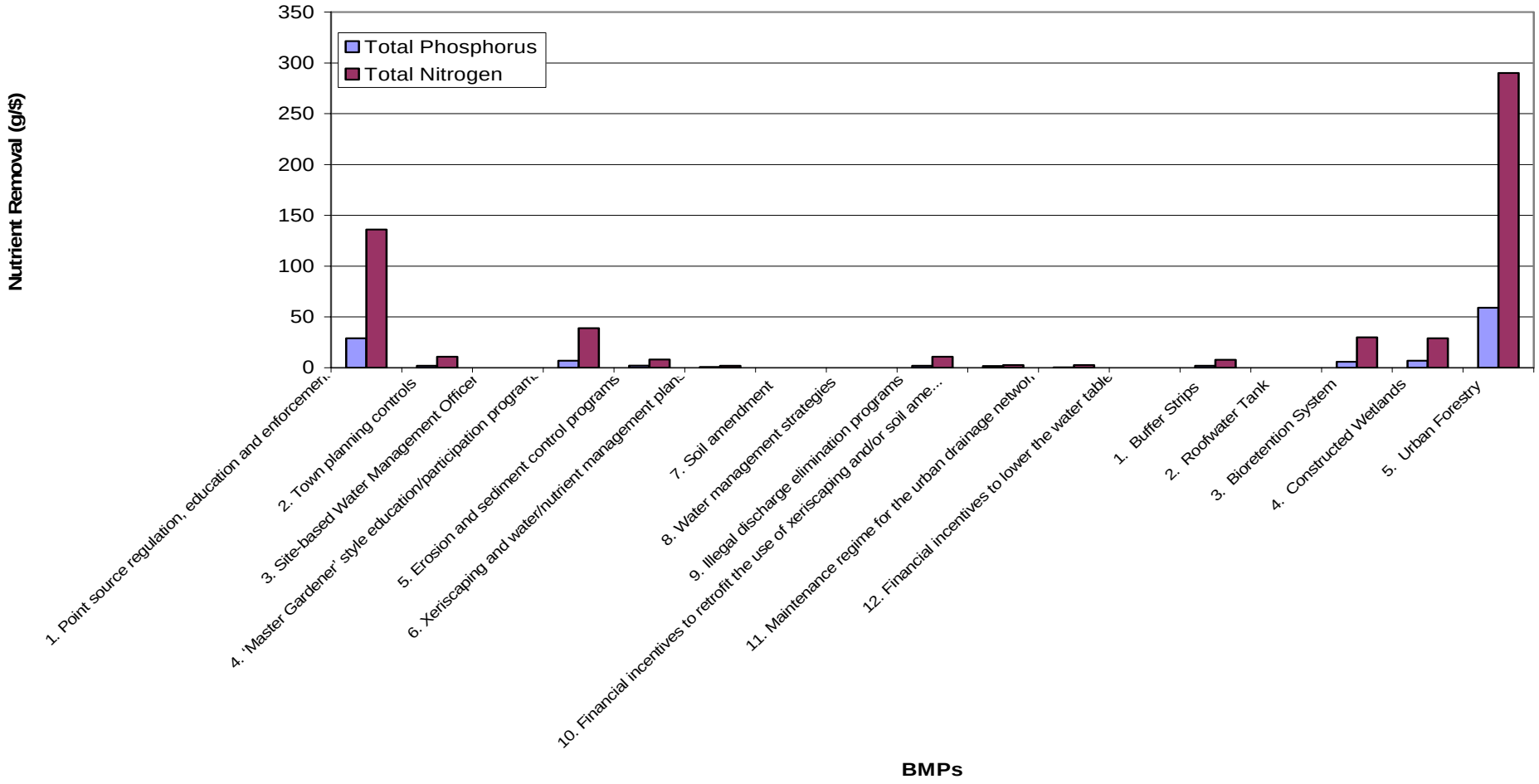


Figure 4.7 Plot of Annual Nutrient Removal per unit $ expenditure for Short-listed BMPs for Mills Street Catchment (Groundwater Flow Management)

5. Hydrologic Design Standards and Cost Analysis

5.1 Hydrologic Design Standards

Urban pollutants, whether in particulate or soluble forms, are conveyed by stormwater frequently, almost every time a storm event occurs. Studies in urban areas have shown that there is no general trend of increased concentrations of such contaminants as nutrients and metals with increasing storm sizes (instead, the trend could be reversed with a higher "dilution" associated with larger storms. It follows that stormwater treatment should be directed at treating all storm events and that the percentage of the total catchment runoff treated is a reasonable representation of the treatment effectiveness of the selected BMP. Thus the hydrologic design standard for stormwater treatment facilities should be directed at achieving the target percentage of mean annual runoff treated rather than an individual storm magnitude. Analysis of Perth rainfall records has shown that in excess of 90% of the mean annual runoff of an urban catchment in Perth is generated from storm events of average recurrence frequency more frequent than once every three months. This is illustrated in Figure 5.1 below.

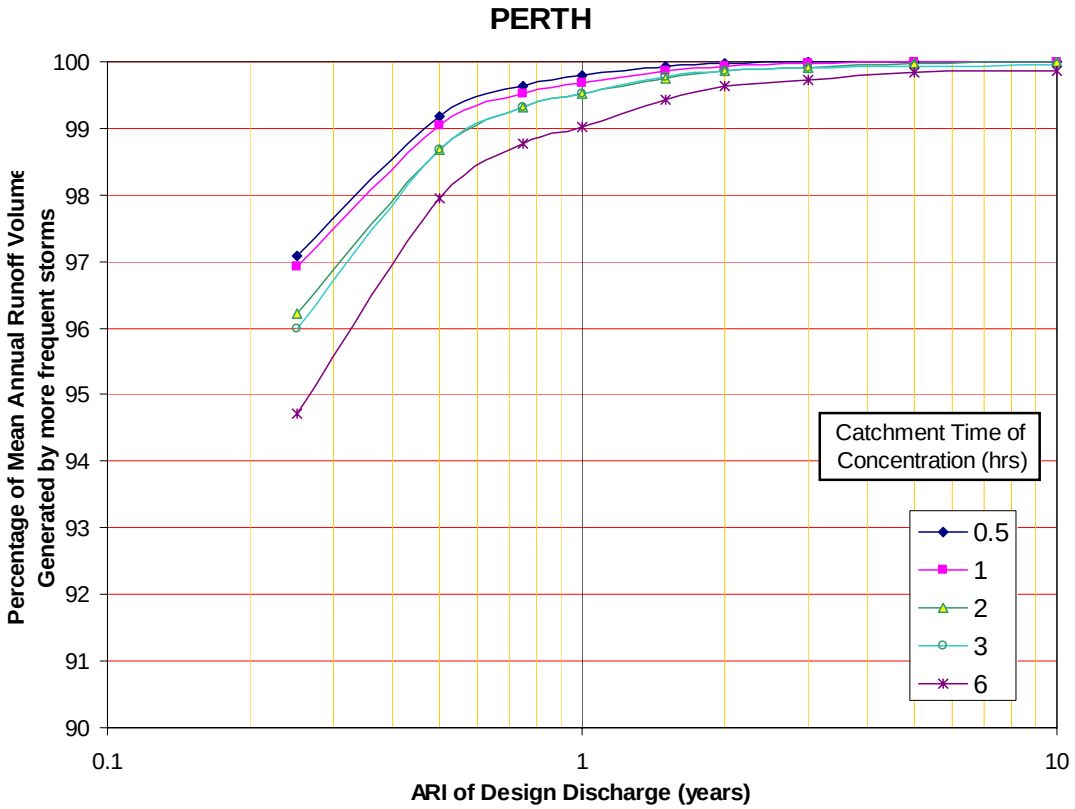


Figure 5.1 Percentage of Stormwater Volume treated by BMPs designed for various ARI discharges

The significance of the information contained in Figure 5.1 above is that stormwater BMPs do not need to be designed for storm events of high ARI to achieve high *hydrologic effectiveness* (a term commonly used to express the percentage of mean annual runoff volume subjected to treatment). With stormwater pollutant concentrations not following any trend associated with the magnitude of the storm event, pollutant loads generated from an urban catchment is directly associated with stormwater runoff volume. The notion of selecting a probabilistic storm design frequency for sizing detention systems is inappropriate as their performance is dependent on antecedent conditions (ie. the state of the inundation in the system at the commencement of a storm event). Thus the selection of a probabilistic design storm for stormwater detention system such as constructed wetlands and bioretention systems can be misleading. They are nevertheless useful in provide some context on the selection of an appropriate design standard for such BMPs. Their "equivalent design ARI" can be used to compare the design standard for stormwater BMPs with that for flood mitigation measures.

Unlike flood mitigation measures, stormwater quality BMPs need only be designed for managing frequent events to achieve a high level of beneficial environmental outcomes. It is common practice to select hydrologic design standards corresponding to the 3 month or 6 month ARI discharge (ie. with the BMP operating under above design conditions on average 2 to 4 times every year).

Figure 5.2 plots the incremental acquisition costs of a constructed wetland (ie. $ per additional kg of phosphorus removed) with increasing hydrologic effectiveness as expressed as an equivalent Average Recurrence Interval design standard (see Figure 5.1). As evident, there is a trend of increasing incremental cost for increasing equivalent ARI design standard with the trend increasing significantly for equivalent design standards exceeding 1 year ARI.

Using Figure 5.2, Table 5.1, summarises the indicative cost per kg of additional pollutant removed and corresponding ARI. Table 5.1 also shows the corresponding hydrological effectiveness and percentage cost difference when selecting higher ARI's for stormwater quality.

This summary indicates that the cost almost doubles between the 3 month and 6 month ARI and nearly triples between the 3 month and 1 year ARI when selecting hydrological design standards for stormwater quality BMP's.

Table 5.1: Indicative Cost per kg of Additional Pollutant Removed and Corresponding ARI

Cost per kg of Additional Pollutant Removed	ARI	Hydrological Effectiveness	% Cost Difference
$10,000	3 Month	95%	
$18,000	6 Month	98%	80%
$22,000	9 Month	99%	120%
$28,000	1 Year	99.5%	180%
$250,000	10 Year	99.9%	2,400%

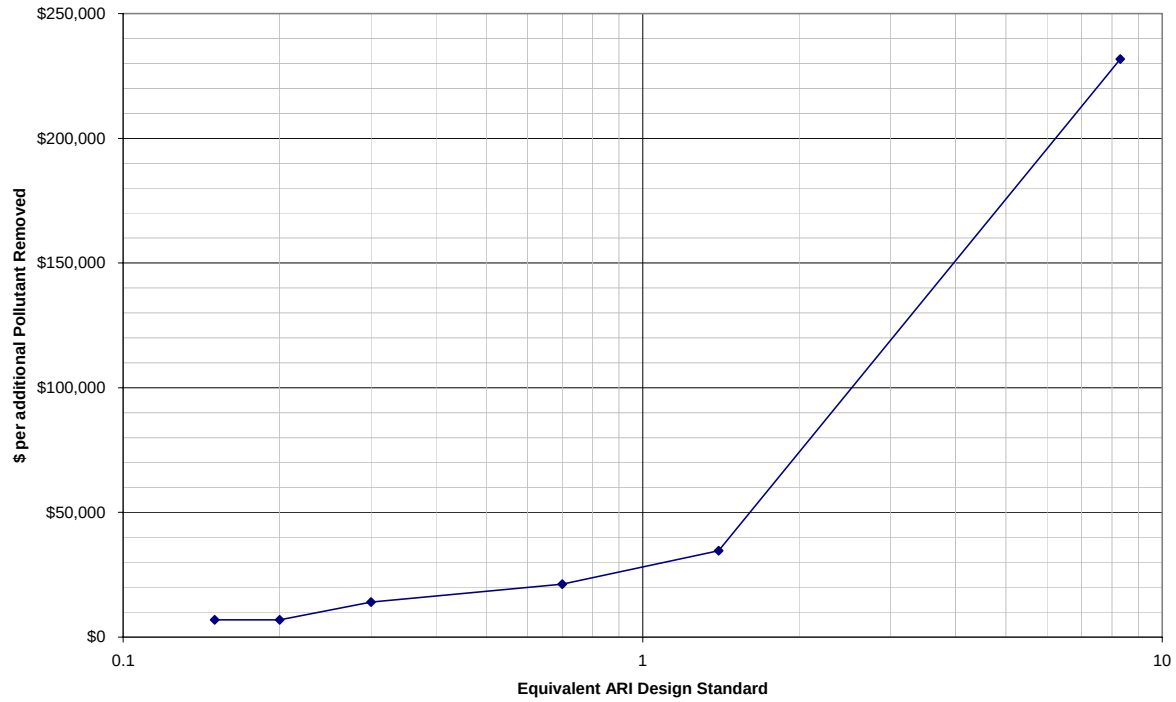


Figure 5.2 Indicative Incremental Acquisition Cost ($ per additional kg of pollutant removed) for a range of Equivalent ARI Design Standard for Constructed Wetlands

5.2 Cost Analysis

Stormwater quality treatment operates non-linearly owing to the intermittent loading of stormwater and pollutants such that one can reach a point of diminishing return as the size of BMPs is increased in terms of the incremental reduction in pollutant load achieved. This is illustrated in Figures 5.3 and 5.4 showing the treatment performances of a constructed wetland and a bioretention system respectively in nutrient reduction in Perth catchments. The corresponding comparisons against total acquisition costs are shown in Figures 5.5 and 5.6.

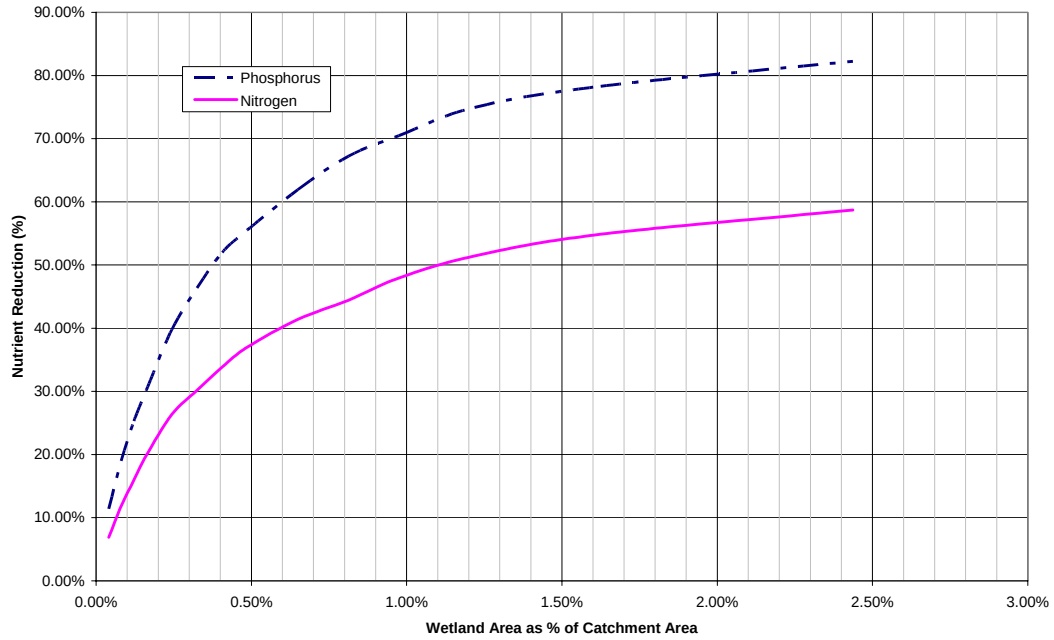


Figure 5.3 Nutrient Reduction Performance Curve for Constructed Wetlands in Perth

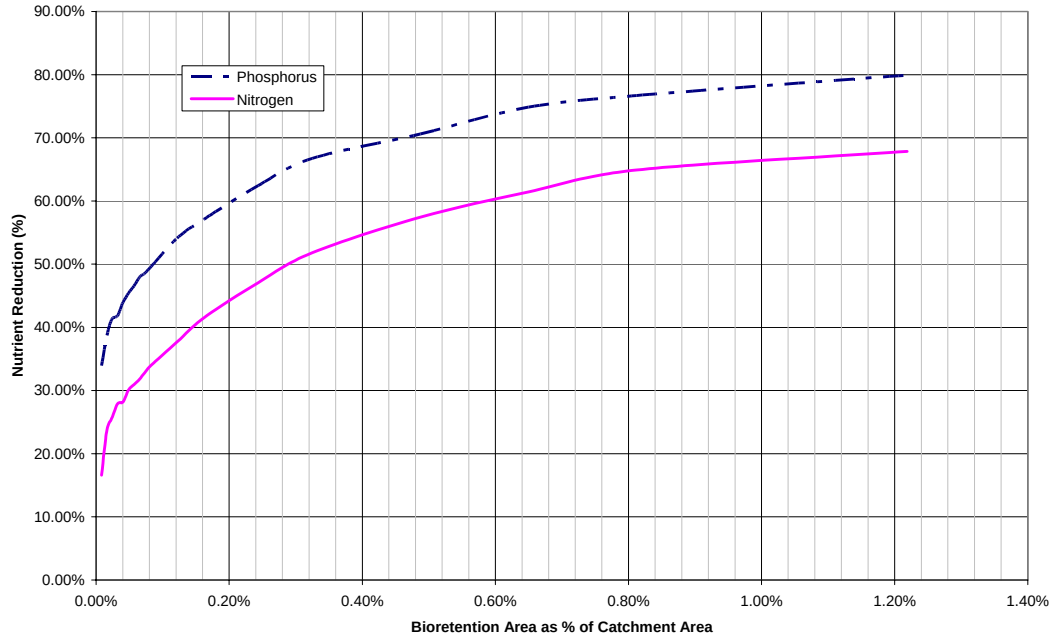


Figure 5.4 Nutrient Reduction Performance Curve for Bioretention Systems in Perth

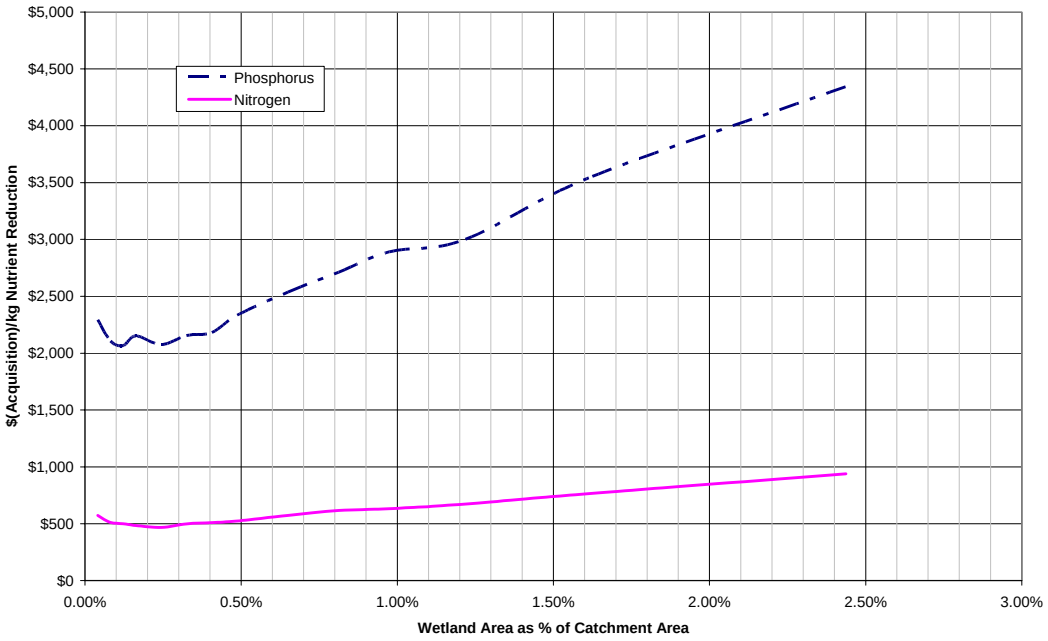


Figure 5.5 Acquisition Cost/kg Nutrient removed for Constructed Wetlands in Perth

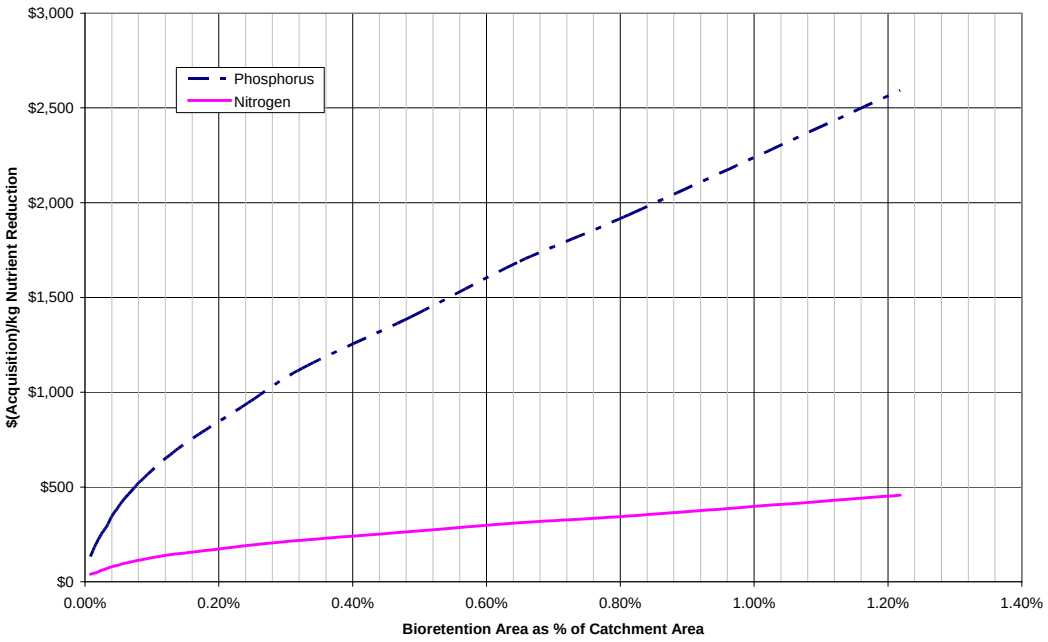


Figure 5.6 Acquisition Cost/kg Nutrient removed for Bioretention Systems in Perth

5.3 Order of magnitude costs for BMP implementation

A request was made by the Water Corporation to select high value structural and non-structural BMPs for application in the Mills Street Catchment, and to summarise approximate costs associated with these BMPs. In determining an indicative cost for the BMPs, the sizes of the BMPs selected were based on what could be reasonably be expected to be implemented in a built-up catchment with significant space constraint and they are not a refection of what is required to fully control the nutrient problems currently experienced in the Canning River. A number of BMPs have been combined into a suite of measures which may have some inherent redundancies. These are considered necessary at this stage of the investigation to provide a conservative estimate of the expected cost of works to optimise the potential for nutrient reduction in the Canning River.

Tables 5.2 and 5.3 below provide this information, drawing upon the analysis undertaken in Chapter 4. Once again, it is emphasized that many of these cost estimates are based on limited information, and accordingly, the total costs should only be seen as *order of magnitude* estimates.

The estimated annual removals of TP and TN for the baseflow management strategy are approximately 1,000 kg and 7,200 kg respectively. This represents removal rates of about 55% and 70% for TP and TN respectively based on estimated catchment inputs of 1,730 kg and 10,000 kg (refer Section 2.2).

The corresponding annual removal rates for the stormflow management strategy are 1,400 kg and 8,200 kg respectively. This represents removal rates of about 80% for both TP and TN based on the estimated catchment inputs mentioned above.

As an over-all statement on indicative cost, it is suggested that *approximately* a quarter of a million dollars (in 2004 dollars) would be needed per year to implement and maintain a high-value set of BMPs in the Mills Street Catchment, with up-front capital costs being of the order of $4million. The estimated equivalent annual payment of approximately $250,000 equates to approximately $200/Ha/per year in 2004 dollars for built-up catchments like the Mills Street catchment.

Table 5.2 Costing Estimates for BMPs Recommended for the Mills Street Catchment (Assuming a *Groundwater/Baseflow* Management Focus)

Recommended BMPs	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Life cycle cost ($2004)	Equivalent annual payment cost ($2004)
Non-structural BMPs				
Point source regulation, education and enforcement (e.g. involving small to medium sized commercial and industrial premises)	$200,000 (set up costs)	$0 (Licence fees structured to be cost neutral. Actual costs ~$480 per premises for ~$1,500 premises.)	$200,000	$7,000
Illegal discharge elimination programs (i.e. to identify and remove illegal discharges to stormwater and groundwater)	$100,000	$100,000	$1,134,000	$38,000
Town planning controls requiring water sensitive urban design and where appropriate, no baseflow in urban drains during summer months	$100,000	$60,000 (includes the cost of additional development assessment)	$720,000	$24,000
Xeriscaping and **water/nutrient management plans** for public open space (e.g. use during development or retrofitting by government agencies in public open space)	$160,000	$0 (no *additional* costs)	$160,000	$5,000
'Master Gardener' style education/participation programs (i.e. intensive local extension programs focusing on nutrient management in a residential garden context)	$100,000	$20,000	$307,000	$10,000
Water management strategies (for the catchment scale) that involve strategic planning and affect structure planning (where relevant) and town planning schemes	$100,000 (planning) + $100,000 (annual implementation costs)	$10,000 (maintenance of plan/ strategy) + $100,000 (annual implementation costs)	Total (planning plus implementation) = $1,336,905	$45,000 (planning plus implementation)
Structural BMPs				
Groundwater reuse for landscape watering of Canning River Regional Park (pumping scheme to use superficial groundwater as an alternative source of water for landscape watering of the Canning River Regional Park in spring and summer months (~20 Ha; ~260 ML).	$100,000	$5,000	$152,000	$5,000
Waterway rehabilitation – Involving approximately 3 km of open drains.	$750,000	$7,000 (incl. weed management)	$822,000	$27,000
Bioretention system - Approximately 3 km of open drains with the rest being underground pipes requiring a 6,000 m^2 area of bioretention systems.	$77,000	$30,000	$393,000	$16,000

Recommended BMPs	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Life cycle cost ($2004)	Equivalent annual payment cost ($2004)
Constructed wetlands – Retrofit parkland around Wilson Wetland for nutrient reduction (~ 5 Ha).	$2,018,000	$78,000	$2,858,000	$95,000
TOTAL COST (order of magnitude estimates only)	~$3,805,000	~$410,000	~$8,083,000	~$242,000

Notes:

For life-cycle costing, the real discount rate is assumed to be 8%. Where BMPs have an indefinite life span the life-cycle has been assumed to be 30 years (the effect of discounting on the life-cycle cost allows this assumption to be safely made without significantly affecting the life-cycle cost).

The life-cycle cost is the sum of all discounted costs over the life span of the BMP as defined in AS 4536:1999 (Australian Standards, 1999). Equivalent to the 'net present value' *plus* all initial acquisition costs for the BMP in the first year.

The equivalent annual payment cost is the life-cycle cost divided by the life span of the BMP.

Costs are *relative to the agency implementing the BMP*, so some BMPs can be cost-neutral if there is a source of revenue to balance expenditure.

Table 5.3 Costing Estimates for BMPs Recommended for the Mills Street Catchment (Assuming a *Stormwater* Management Focus)

Recommended BMPs	Total acquisition cost ($2004)	Typical annual maintenance cost ($2004)	Life cycle cost ($2004)	Equivalent annual payment cost ($2004)
Non-structural BMPs				
Point source regulation, education and enforcement (e.g. involving small to medium sized commercial and industrial premises)	$200,000 (set up costs)	$0 (Licence fees structured to be cost neutral. Actual costs ~$480 per premises for ~$1,500 premises.)	$200,000	$7,000
Town planning controls requiring water sensitive urban design and where appropriate, no baseflow in urban drains during summer months	$100,000	$60,000 (includes the cost of additional development assessment)	$720,000	$24,000
'Master Gardener' style education/participation programs (i.e. intensive local extension programs focusing on nutrient management in a residential garden context)	$100,000	$20,000	$307,000	$10,000
Water management strategies (for the catchment scale) that involve strategic planning and affect structure planning (where relevant) and town planning schemes	$100,000 (planning) + $100,000 (annual implementation costs)	$10,000 (maintenance of plan/ strategy) + $100,000 (annual implementation costs)	Total (planning plus implementation) = $1,336,905	$45,000 (planning plus implementation)
Illegal discharge elimination programs (i.e. to identify and remove illegal discharges to stormwater and groundwater)	$100,000 (annual cost)	$100,000	$1,134,000	$38,000
Structural BMPs				
Bioretention system - Total bioretention area to treat 25% of the impervious areas in the catchment is 15,000 m^2.	$155,000	$72,000	$904,000	$36,000
Constructed wetlands - Retrofit parkland around Wilson Wetland for nutrient reduction (~ 5 Ha).	$2,018,000	$78,000	$2,858,000	$95,000
Urban forestry - Retrofit parkland around Wilson Wetland into urban forest for nutrient reduction (~ 5 Ha).	$208,000 (using urban waterway rehabilitation cost estimates – may be a little low)	$131 (using US estimates for maintenance *once BMP is established* – maintenance costs over the establishment phase may be much greater)	$215,000	$7,000
TOTAL COST (order of magnitude estimates only)	~$3,081,000	~$340,000	~$7,675,000	~$226,000

Note:

Notes provided for Table 5.2 are also relevant to this table.

6. Recommendations

1. Key experts and opinion leaders within the Water Corporation, Department of Environment and local consultancies currently do not share a consensus on the specific objectives for the management of water quality in *urban areas* (e.g. whether the focus should be on minimising total loads of nutrients exported from urban areas, or targeting specific aspects of the urban water cycle such as the nutrient-rich summer baseflows). It is strongly recommended that such a consensus be developed, as without agreement on *specific* management objectives, meaningful progress on urban water quality management will be significantly impeded.

2. The approach taken during this project was to rank various BMPs in terms of their over-all value, which reflects a range of potential benefits and costs. Ideally, specific and quantitative water quality targets (e.g. concentration *and* load based targets) would be available for nutrients leaving urban drains that allow water managers to model the catchment and selectively apply high value BMPs until the targets have been met. Existing water quality-related targets for the Swan-Canning system are not sufficient for this process to occur. It is recommended that such targets be developed as a priority, and that the targets also be suitable for those undertaking conceptual design and modelling work for all new development on the Swan Coastal Plain.

3. The "value scores" for structural and non-structural BMPs be used in the short term to assist decisions on which BMPs to trial on the Swan Coastal Plain, evaluate and refine using the principle of 'adaptive environmental management'. Future BMP evaluation data from such trials should be used to refine the 'ball park' estimates that were necessarily undertaken during this project due to very limited BMP performance data.

   Stormwater BMPs do not need to be designed for storm events of high ARI to achieve high *hydrologic effectiveness.* It is common practice to select hydrologic design standards corresponding to the 3 month or 6 month ARI discharge

4. The nutrient removal efficiency and costing information for BMPs that have potential application to the Mills Street Catchment be used (along with the Canning Plain Catchment Management Plan which is in preparation) to identify BMPs most worthy of implementation in this high priority location.

5. The costing information for BMPs that have potential application to the Mills Street Catchment be used as an indicator of 'order of magnitude' costs for applying water quality-related BMPs to built-up catchments containing large areas of medium density urban residential land use and unsewered industrial land use.

   a. The analysis found that the up-front capital costs for the strategy is of the order of $4 million, or approximately $3,000/Ha/yr with the estimated removal of approximately 1000 kg/yr of TP and 7000 kg/yr of TN corresponding to removal efficiency rates of 55% and 70% of estimated catchment inputs.

   b. Life-cycle cost analysis found that an equivalent annual payment of approximately $250,000 will be necessary to implement the strategy, or

approximately $200/Ha/yr in 2004 dollars, for built-up catchments like Mills Street.

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Appendix A

Summary of Relevant Water Quality Information from Relevant Reports and Conversations with Local Experts

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Summary of Relevant Water Quality Information from Relevant Reports and Conversations with Local Experts

Verbal Advice from Department of Environment Technical Staff (31 January 2004)

The primary 'management goal' for water quality improvement in urban areas in the Swan Canning region is to minimise the frequency severity of related algal blooms in receiving waters.

Two types of hazardous algal blooms are thought to be related to drainage from urban areas in the Swan-Canning region:

- Blue-green algal blooms occur in places like upstream of the Kent Street Weir in the middle Canning River. These blooms occur in summer and are not triggered by storm events. The river system here in summer is fresh, warm, clear and has ample supply of phosphorous. Blue-green algae out-compete others species by fixing nitrogen from the atmosphere under these conditions (i.e. it is a N-limited system). If a storm occurs which introduces additional nitrogen, a different type of algal bloom may eventuate (i.e. a type of less concern to water scientists).

  The primary goal of urban water managers in these regions should be to minimise the concentration and load of nutrients (especially bioavailable phosphorous species) entering the river as baseflow and groundwater during the warm summer months (e.g. December to April).

- Dinoflagellate blooms occur in the tidal section of the Swan Canning river system after storm events. These blooms also generally occur in summer. It is thought that nitrogen from stormwater draining from urban areas is one of the triggers for these blooms.

  The primary goal of urban water managers in these regions should be to minimise the concentration and load of nutrients (especially bioavailable nitrogen species) entering the river during summer storm events.

Verbal Advice from Acacia Springs Environmental (3 February 2004)

Dr Dave Deeley agreed with the view that the primary 'management goal' for water quality improvement in urban areas in the Swan-Canning region should be to minimise the frequency severity of related algal blooms in receiving waters. However, he is of the view that the primary goal of *urban* water quality management should be to reduce *all nutrients sources*: summer inputs, winter inputs, and accumulations within the system.

The rationale for this view is that the Swan-Canning system has become highly enriched with nutrients so that sediment regeneration mechanisms have become a major source of nutrient availability in the water column. Without high ambient concentrations of nutrients, bloom species would not be able to maintain a presence in the system and to bloom if conditions become favourable.

While blooms above the Kent Street Weir may not be *directly* triggered by storm events, they are indirectly.

Concern was raised over the scientific basis for the 'nitrogen limitation theory' for the Canning River upstream of the Kent Street Weir.

Dr Deeley suggested that focusing only on nutrient reduction in baseflow or storm flows is focusing too much of the detail and losing track of the big picture. "A whole range of opportunistic species and trigger mechanisms can be observed in highly enriched systems. The Peel-Harvey went from epiphyte dominated 'weeds' in the 1960s, macroalgal dominated 'weeds' in the 1970s, and green and blue-green 'weeds' in the 1980s. The current fine scale patterns in the Swan-Canning may change rapidly over the next decade as different trigger mechanisms/species mixes establish themselves. The main aim of the Swan Program should be to significantly reduce all [nutrient] inputs and accumulations."

Dr Deeley also stressed the need for improved catchment management, BMP-implementation scenario testing using an adaptive environmental management philosophy, and the use of cost-neutral policies to reduce nutrient inputs and storages.

Verbal Advice from Water Corporation (3 February 2004)

The Water Corporation's environmental management staff generally agreed with the views of Dr Dave Deeley (see above). They stressed the need to be cognisant of nutrient stores (e.g. in sediment and biomass) and well as all inputs (e.g. groundwater, baseflow, storm flow). For example, focussing on managing bloom triggers ignores the fact that the maintenance of blooms and peak biomass reached during a bloom will be largely determined by nutrients already stored within the system, particularly in the sediments.

Dr Bob Humphries and David Luketina collectively suggested the following steps need to be taken for the Swan-Canning system:

- Determine (preferably in quantitative terms) the specific management objectives for each reach or zone of the estuary (e.g. Karlodinium blooms to occur not more than one summer in 10).
- Determine the sustainable concentrations of bioavailable nutrients in the water column for various parts of the Swan-Canning system.
- Estimate the magnitude of nutrient load reductions needed to achieve the management objectives for each sector of the estuary.
- Assess the environmental and social consequences of reducing nutrient loads - for example, excessive load reduction in the Canning River may reduce desirable primary and secondary production downstream.
- Estimate the magnitude of the sources of nutrients driving the problem, and technically assess the options for managing them (i.e. BMPs).
- Decide if meaningful management control of the problem is possible, or whether people need to be informed that they will just have to live with blooms from time to time.

Draft Nutrient and Contaminant Assessment for the Mills Street Main Drain Catchment (SRT, 2003a)

This document provides background technical information to support the prioritisation and development of improvement options to address water and sediment quality concerns in the Mills Street Catchment. It also provides:

- a snapshot of the quality of water and sediment in the Mills Street Catchment; and
- a review of background information relating to water quality in the catchment.

Significantly however, it does not provide information of the percentage of *pollutant loads* associated with baseflow and high-flow events.[3]

Nutrient flushing during summer thunderstorms and late autumn/early winter rainfall events create substantial risks of algal blooms in the Swan-Canning Estuary. These risks primarily occur because the discharge from urban drains results in slugs of nutrient-rich, relatively fresh water being retained in the estuary with little immediate mixing or flushing. This occurs because summer thunderstorms and late autumn/early winter rainfall events result in flows from drains but are not sufficient to result in flows from the larger tributaries (e.g. the Canning River) which would flush nutrients out to sea. Consequently, the focus of this document was on the summer-autumn low flow periods.

Water quality samples were taken over a range of flow conditions. Total nitrogen (TN) in drainage water was elevated throughout the drainage system, with the highest concentrations generally being detected in the lower catchment areas. Occasional extreme concentrations of TN were measured at some sites in the upper catchment.

Eight-four percent (84%) of all of the water samples were above the relevant ANZECC and ARMCANZ (2000) water quality guideline for TN and freshwater ecosystem protection (i.e. 1.2 mg/L). The median TN concentration was 1.9 mg/L during baseflow events and 2.4 mg/L during the high flows.

Organic N was the dominant form of nitrogen in drainage waters, with a median value (across all sites) of 76%. The equivalent concentration for ammonium was 8%. Oxidisable nitrogen species (NOx) concentrations were generally low except in August.

Elevated levels of total phosphorus (TP) and soluble phosphorus (FRP) generally occurred in the mid to upper parts of the catchment, particularly during the summer and autumn sampling events. FRP often exceeded 60% of the TP fraction at sites during the summer and autumn sampling events, however during high flows TP mainly consisted of particulate material. The high FRP is probably associated with shallow groundwater and sub-soil drainage producing phosphorus-rich baseflow during the drier months.

One hundred percent (100%) of water samples exceeded the relevant ANZECC and ARMCANZ (2000) water quality guideline for TP and freshwater ecosystem protection (i.e. 0.065 mg/L). Seventy seven percent (77%) of these samples exceeded 0.2 mg/L TP. Water quality samples from the gauging station at the bottom of the catchment indicated that TP had no observable seasonal variation. TP concentrations were however highest during storm events.

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[3] Based on limited information it is estimated that approximately 50% of the catchment's *loads* of TP and TN would be associated with storm-related flows, even though concentrations of nutrient species can be as high during baseflow conditions.

The authors concluded that the consistently high TP concentrations with little seasonal variation indicate a broad regional pattern of groundwater contamination with phosphate. This is most likely due to a combination of historic and current phosphate leaching from gardens, lawns and septic tanks (prevalent in the residential part of the catchment before the 1980s and still in existence in much of the unsewered industrial area).

The median TP concentration for all sites was 0.34 mg/L (baseflow = 0.28 mg/L and high flow = 0.35 mg/L). The equivalent percentage for FRP was 44% (baseflow = 56% and high flow = 27%).

Nutrient accumulation occurs within the drainage system during low flow conditions in summer and autumn (e.g. in sediment and plant material). These nutrients may be flushed from the network during high flows (e.g. as organic nitrogen and particulate phosphorus).

Nutrient discharge from the drainage system during low flow periods are thought to be from a combination of groundwater discharge, sub-soil drainage discharge, illicit industrial discharges and nutrient release from the organic-rich sediments, algae and annual weeds.

100%, 74% and 66% of water samples exceeded the ANZECC and ARMCANZ (2000) water quality guideline levels for zinc, copper and lead respectively. Concentrations of copper, chromium, nickel, zinc and lead were frequently much greater during high flows than low flows, probably because of the association between these metals and particulate matter. Concentrations of lead and chromium were generally greater at the sites in the lower catchment, whereas zinc, copper and nickel concentrations were generally elevated throughout the catchment. Major roads were thought to be the main source of lead and chromium in high flows. The spatial patterns of zinc, copper and nickel concentrations in high flows may be due to more widespread sources consisting of roads, roofs, storage yards and parking areas.

Total suspended solid (TSS) concentrations were low during baseflow (e.g. 82% of samples were < 20 mg/L). TSS concentrations during high flow events were highly variable (e.g. from 2 to 150 mg/L).

Chronic hydrocarbons contamination was not found to occur in the catchment, however there may be acute contamination incidences occurring from isolated sources and/or associated with stormwater runoff events.

Surfactants, pesticides and solvents were, in general, not found to be a major threat to the health of receiving waters. A wide spatial variability in the types and concentrations of solvents and pesticides were detected across the catchment. No obvious trends could be identified from the data.

Results for pesticides indicated that one third of the sites had no detectable levels of pesticides. Where levels were detected, they were generally low.

Water temperature varied significantly over the sampling program, ranging from 16.5 to 33.4^{o}C. The high percentage of impervious area within the catchment and the lack of shading in the drainage corridor would contribute to high fluctuations in water temperature.

The report concluded that: "There is no evidence that any of the compensation [detention] basins act as *effective* sediment basins, particularly since there are pathways by which flows could short-circuit through many basins". Concerns were also raised about the maintenance regime of these assets with respect to nutrient removal.

The detention basins appear to be concentration points for heavy metals in the drainage system. The detention basins at Charles Street, Ewing Street and Mills Street were all found to contain sediments with high concentrations of heavy metals, hydrocarbons and nutrients.

Recommendations of the report include retrofitting the main drain to implement the concepts of water sensitive urban design, living streams, and multiple use corridors. The report also recommended a review of the existing sediment maintenance program (undertaken by the Water Corporation) involving detention basins to ensure they do not release trapped pollutants.

The report concluded that there is evidence of both regional and 'hotspot' contamination of groundwater. This may account for isolated but extreme TN and TP concentrations in baseflows.

The report stressed the need to treat both the baseflow and the first flush of storm events (as *some* events showed elevated concentrations and loads of TSS and TP only during the early stages of the runoff event).

Draft Water Quality Improvement Framework for the Mills Street Main Drain Catchment (SRT, 2003b)

This draft report builds on the abovementioned Nutrient and Contamination Assessment Report. The document divides the Mills Street Catchment into nine management precincts based on existing Water Corporation drainage sub-catchments and land use zoning. Recommendations are made on management measures that could be implemented, particularly in relation to retro-fitting the existing stormwater drainage network in accordance with the principles of water sensitive urban design.

The philosophy of the document is to focus on treating baseflows in the drain, rather than high flows. This is largely because of the timing of baseflow releases to the estuary, the high concentrations of nutrients in baseflow, and the cost-effectiveness of baseflow treatment (cf. high flow treatment). However the relative *loads* of nutrients in baseflow and high flow have not been established in this report or the preceding assessment report.

Identified industries with the potential to pollute stormwater in the area include printers, chemical blenders and suppliers, electroplaters, animal feed producers and automotive industries (e.g. panel beaters, depots, workshops and engine reconditioning workshops). In addition to these industries there are several main arterial roads such as the Leach Highway, Albany Highway, Orrong Road, Welshpool Road, Kewdale Road, Abernethy Road and Manning Road.

Other potential polluting sources include runoff from roads, runoff from paved industrial areas, illegal discharges into the stormwater system, and illegal dumping into and around the drain. Chemical and nutrient spills and leakage from septic tanks also pose a significant risk to groundwater quality.

Nutrients in Tributaries of the Swan-Canning Estuarine System (1987 – 2000) – Seasonal and Flow Variation (Swan-Canning Cleanup Program, 2002)

Net recharge to aquifers below urban areas on the Swan Coastal Plain is thought to be increasing, causing a rise in water tables in the metropolitan area and an increase in the baseflow component of the urban drainage network.

Total N: Of 6 urban catchments that were sampled (these included the Mills Street Main Drain), median concentrations ranged from 0.65 mg/L to 2.5 mg/L.

NOx: A low and high concentration group were identified. The low group had a median concentration of less than 0.25 mg/L, while the high group (which included the Mills Street Main Drain) had a median concentration of greater than 0.45 mg/L.

Ammonium: Median concentrations ranged from 0.04 mg/L to 0.88 mg/L (i.e. the Mills Street Main Drain).

TP: Median concentrations ranged from 0.07 mg/L to 0.23 mg/L (i.e. the Mills Street Main Drain).

Dissolved inorganic phosphorus: Median concentrations were generally above 0.02 mg/L. The Mills Street Main Drain had a median of 0.1 mg/L.

Dissolved organic carbon: Median concentrations ranged from 12 mg/L to 47 mg/L.

TSS: Median concentrations ranged from 5 mg/L to 34 mg/L.

For Mills Street Main Drain the composition of nitrogen species (sampled from regular grab sampling) was typically: 49% organic N, 30% NH_4^+, and 21% NOx. The composition of phosphorous species was typically: 54% particulate and 46% dissolved inorganic.

As flows increased in the Mills Street Main Drain, typically:

- Organic N and NH_4^+ concentrations reduced;
- TP concentrations did not change;
- Dissolved inorganic phosphorous concentrations decreased (slightly);
- Dissolved organic carbon concentrations decreased significantly; and
- TSS concentrations increased.

Posters Summarising the Water Quality of the Mills Street Drain (Department of Environment, 2003)

Plots of typical seasonal flows and nutrient concentrations in the Mills Street drain over the 1987 to 2001 period broadly indicate that the distribution of TN and TP loads is ~50% storm flow and 50% baseflow.

Nitrogen concentrations in drainage water do not show a distinctive seasonal pattern. It is thought that the dominant transport mechanism in the catchment is groundwater

flow/baseflow. Organic nitrogen is lowest in winter and highest in summer as a result of in-stream sources of particulate N such as algae and bacteria. Surface and subsurface flow following rain events transports all forms of nitrogen to the drain, particularly NOx, which increases slightly in spring to autumn compared to summer.

There is a slight but distinctive seasonal pattern of phosphorous concentrations, which is expressed as a small rise in summer. Groundwater plays an important role in transporting dissolved phosphorus to the drain, while illegal dumping and industrial waste could also be important sources. Particulate phosphorous is predominantly in the form of algae and bacteria which grow in the drains and compensation basins over summer.

Base flow (i.e. intercepted groundwater) dominates the hydrology of the drain from December to April.

Fact Sheet on the Swan Canning River System (Government of Western Australia, 2003)

The coastal plain catchment of the Swan Canning estuary is approximately 2,117 square kilometres. Over summer, surface flows are reduced and groundwater discharge makes up the majority of river flows.

Drainage water is thought to be made up of approximately 50% surface water runoff (includes stormwater and baseflow) and 50% groundwater.

In winter, the inflowing nitrogen, phosphorus and silica stimulate natural, largely harmless blooms of phytoplankton, particularly diatoms.

In spring and summer, a thin layer of freshwater from urban drains sits over the dense saltwater. The freshwater 'blanket' helps to reduce the transfer of oxygen to deeper waters, stimulating nutrient release from sediments. This release helps to fuel summer phytoplankton blooms.

Canning River Drain Study (Swan-Canning Cleanup Program, 2003)

This study examined water quality in five urban drains in the Canning region (i.e. drains at Wharf Street, Cockram Street, Liege Street, Lacey Street and Menzies Road). Grab sampling was undertaken, with some samples taken during baseflow and high-flow conditions. The authors concluded that "water quality did not appear [to be] closely related to rainfall".

Median concentrations of TP ranged from 0.06 mg/L to 0.3 mg/L, with 64% of all samples exceeding the target of 0.1 mg/L. Overall, the samples had a median of 0.14 mg/L.

Under baseflow conditions, 60% of the TP was in dissolved form (i.e. FRP). This percentage was 53% during high-flow, and 56% overall.

Median concentrations of TN ranged from 0.7 mg/L to 1.6 mg/L, with 54% of all samples exceeding the target of 1.0 mg/L. Overall, the samples had a median of 1.2 mg/L.

Under baseflow conditions, 37% of the TN was dissolved inorganic nitrogen (DIN). This percentage was 39% during high-flow, and 37% overall.

Under baseflow conditions, 63% of the TN was organic nitrogen (ON). This percentage was 62% during high-flow, and 63% overall.

Concentrations of TP and TRP in storm events appeared to decrease over winter (i.e. during successive storm events).

Intense and/or prolonged storms could cause septic tanks to overflow, creating a spike in TP/FRP concentrations.

Concentrations of toxicants (including heavy metals) were generally low, albeit with some exceptions. Copper and zinc were of the most concern (i.e. the median values for Zn and Cu data from all sites exceeded relevant guidelines).

Some extremely high levels of faecal coliforms were detected in all drains. Seventy-five percent (75%) of samples failed to meet relevant guideline levels for faecal coliforms.

Total suspended solid concentrations varied greatly with location, time and flow. Surprisingly, some high-flow events produced low concentrations of TSS.

Information on pollutant loads was not provided.

Canning Urban Drainage Study (Swan River Trust & City of Canning, 1994)

This study examined water quality in drains immediately to the south-east of the Mills Street Catchment.

The study found a correlation between high phosphorus concentrations in drainage waters and unsewered catchments. This correlation was not observed for nitrogen.

A summary of water quality data collected by the study is given below.

Summary of Water Quality Data – Surface Water in Drains (1993)

Catchment in City of Canning	Area (ha)	% Sewered (circa 1993)	Median TP in 1993 (mg/L)*	Median TN in 1993 (mg/L)**
River Road	14.7	10	0.3	1.2
Cockram	515	15	0.44	1.5
Council Depot	44.1	98	0.13	1.1
Bywater	21.4	100	0.05	1.1
Adenia	100.7	100	0.05	0.65
Champlin	95.8	100	0.05	1.1
Wharf Street	118	80	0.16	1.15

Notes:

* A concentration >0.065 mg/L would normally be of concern when discharging into freshwater aquatic ecosystems.

** A concentration >1.2 mg/L would normally be of concern when discharging into freshwater aquatic ecosystems.

Trace metal concentrations (particularly chromium, copper and zinc) were elevated in the Council Depot, Cockram, and Wharf Street catchments. This was attributed to runoff from industrial and commercial areas.

A correlation was observed between concentrations of copper in drainage waters and unsewered catchments. This was attributed to copper piping associated with septic disposal systems.

Levels of zinc and chromium in drainage waters were thought to be associated with industrial pollution.

Concentrations of nutrients and pathogens increased following rainfall events, suggesting that these pollutants were being flushed mainly via surface drainage (cf. groundwater discharges). This was interpreted to mean that a significant number of septic systems may have had leach drains that were fully saturated prior to the rainfall event, with groundwater levels intersecting the ground surface.

The primary sources of pollution identified in the report were failing and poorly sited septic systems (from residential areas and premises that house animals) and stormwater pollution from industrial activities. It is understood however, that Perth's in-fill sewerage program has significantly increased the proportion of residential areas that are now sewered.

Mills Street Main Drain Study (GHD, 1999)

This study briefly summarised the state of the drain in 1999 in terms of water quality. It concluded that phosphorus and nitrogen concentrations in baseflows were high (i.e. exceeded the relevant ANZECC water quality guidelines that were current at that time). Heavy metal concentrations, including copper, zinc and chromium were also reported as being above relevant water quality guidelines.

Reported threats to stormwater quality included septic tanks and unsewered areas, illegal discharges to stormwater, illegal dumping of wastes, stormwater runoff from roads and industrial pavements, diffuse pollution sources, spills, and the design of drains and detention basins.

The report concluded that nitrogen concentrations in the drain's baseflow increased during the 1990s (although the raw data appeared to be inconclusive). Median concentrations of TN varied from 1.6 mg/L to 3.4 mg/L (with NO_X being 19% - 35% of TN and NH_3 being 18% - 30% of TN), while TP from 1987 to 1996 varied from 0.2 mg/L to 0.29 mg/L (with FRP being 42% - 55% of TP).

Canning - Integrated Local Area Planning Study (Mouritz Environmental Services, 1995)

This study involved the Mills Street Main Drain, as well as the Cockram Street Main Drain and the Wharf Street Main Drain.

The report noted that while the permeable sands of the Bassendean Dunes allow rapid infiltration of stormwater, a substantial part of the region is underlain with a semi

permeable barrier (referred to as “coffee rock”) and intrusions of clay. Thus in low-lying areas, where these retarding layers occur, there is seasonal waterlogging.

Identified threats to groundwater and stormwater quality included: septic tank leakage, lawn fertiliser, runoff from roads, pesticides from homes and gardens, leakage from tanks containing hydrocarbons, spills and leakage from automotive business.

Swan-Canning Cleanup Program Action Plan (SRT, 1999)

This comprehensive report contains background information on the science relating to the health of the Swan-Canning river system. Key and relevant findings of the report are summarised below.

The report concludes that the management of *both* phosphorus and nitrogen is needed to sustain a healthy Swan-Canning river system.

The overall contribution of nutrients from *groundwater* reaching the Swan-Canning river system is estimated to be less than 16% of the total nutrients entering the estuary.

Nine (9) catchments were seen as major nutrient contributors to the Swan-Canning river system of which the Mills Street Main Drain was one.

Median concentrations of total nitrogen from 1995 to 1997 in the Mills Street Main Drain was in the 'high' range (i.e. 2.0 mg/L - 3.0 mg/L). The equivalent for total phosphorus was also 'high' (i.e. 0.2 mg/L - 0.3 mg/L). This data represents baseflow conditions.

In residential areas, nutrient sources include pollution from vehicles, septic tanks, domestic animals, atmospheric fallout, garden fertiliser runoff and accidental spills from material stored in sheds and garages. In particular, management of lawn fertiliser, excessive watering, discharge from septic tanks, and nutrients from pet faeces are priorities for management.

In commercial areas, pollution sources include retail establishments, car yards, nurseries, medical and business offices, churches, government offices and museums.

In light industrial areas, pollution sources include a wide variety of small businesses and shops including motor vehicle repairers, printers, food processors, service stations and radiator repairers.

The action plan flags the risk associated with waste disposal sites as an important source of nutrients and other components. In particular, older waste disposal sites including landfills and rubbish tips (particularly those older than 10 to 15 years) are thought to pose a greater potential environmental threat than newer facilities.

The action plan sets water quality targets for tributaries of the Swan-Canning river system. Short-term targets relate to a timeframe of five years (2005), while long-term targets relate to a 20 year timeframe (2020). Relevant targets for the Mills Street Main Drain are:

- By 2005: TP = 0.2 mg/L and TN = 2.0 mg/L (median values) – this represents the low range of observed values in the mid 1990s; and
- By 2020: TP = 0.1 mg/L and TN = 1.0 mg/L (median values).

To reach the 20 year targets above, *substantial* improvement in the water quality will be required for the Mills Street Main Drain.

Estimated Nutrient Loads Discharged into the Swan-Canning Estuary from Groundwater (Appleyard, 1992)

This report is a preliminary estimate of the groundwater fluxes of nutrients to the Swan-Canning Estuary. Given the close association between stormwater and shallow groundwater on the permeable soils of the Swan Coastal Plain, this information is relevant to the overall understanding of water and nutrient movement. Note however, that the scope of this report includes urban and non-urban land use, as well as the entire estuary.

The report estimates a maximum of 160 tonnes of nitrogen and 5 tonnes of phosphorus could be discharged *directly* from groundwater to the Swan-Canning Estuary each year. These loadings are small compared to those from surface water (i.e. 500 and 60 tonnes per year for TN and TP, respectively). Note however that some of the "surface load" includes baseflow from urban drains that intercept shallow groundwater.

Concentrations of phosphorus in groundwater entering the estuary were found to be generally very low, probably as a result of absorption in the unsaturated zone. Nitrogen concentrations were variable but generally much less than concentrations anticipated from current application rates of fertiliser. This anomaly is explained by denitrification in the shallow groundwater.

There was evidence in 1992 when the report was written that concentrations of nutrients in groundwater were increasing throughout the Swan Canning Plain.

Groundwater flow rates in the superficial aquifer near Perth were thought to vary from 30 to 90 metres per year. However, this flow rate may be less than 10 metres per year in some parts of the metropolitan area, particularly where there are large amounts of clay in the aquifer.

The main sources of nutrients in groundwater near the Swan-Canning Estuary are septic tanks, as well as fertiliser use on parks and domestic gardens. Disused landfill sites were also highlighted as a potential source, although the total load of nitrogen discharged into the Swan Canning Estuary from this source is estimated to be relatively low and decreasing with time.

Although concentrations of phosphorus in groundwater were found to be typically low, the report warns that these concentrations could significantly rise if soil absorption capacities are exceeded.

Gross Pollutant Trap Installations - Mills Street Main Drain (PPK, 2000)

This report is a review of potential locations and installation options for gross pollutant traps in the Mills Street Catchment.

Heavy traffic was noted in the locations of Orrong Road, Kewdale Road, Welshpool Road, Albany Highway, Cannington Highway and Leach Highway. These areas represent potential 'hotspots' for litter generation.

Loads of TSS were thought to be high around the following roads: Kewdale Road - Orrong Road intersection near Welshpool Road, downstream of Orrong Road, Welshpool Road, and Abernethy Road.

The locations that were highlighted as priorities for the installation of gross pollutant traps were at Kewdale Road, Orrong Road and Abernethy Road.

Evaluation of Constructed Wetlands in Perth (Water and Rivers Commission, 1997)

This report noted that for a Mediterranean climate, like Perth, pollutant concentrations are generally greatest in the early stages of winter runoff (or during infrequent summer storms). In Perth, the 'first flush effect' is often compounded by soil with non-wetting properties, which may behave like an impermeable surface during the beginning of the first rainfall event after an extended dry period.

Design of a Constructed Wetland to Remove Nutrients from Ellen Brook, Western Australia – Workshop Proceedings (Water and Rivers Commission and CSIRO, 1999)

These proceedings noted that superficial groundwater on the Swan Coastal Plain is often dark due to high levels of the brown fraction of total organic carbon, called gilvin. The presence of gilvin has significant ramifications for treatment efficiencies of BMPs like constructed wetlands.

SETTING TARGETS FOR THE SWAN-CANNING

Context, existing targets and future directions



Prepared for: **Drainage Reform Forum**

Prepared by: **Aquatic Science Branch, Department of Environment**

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INTRODUCTION

The purpose of the Swan Canning Drainage Forum is to discuss and develop governance models for drainage including both natural and engineered streams. Within the governance model eventually implemented will lie the responsibility to set and perform against a range of targets. This discussion paper is not meant to be an exhaustive analysis of all the different target types and mechanisms to set them, but rather an introduction to the target setting environment for the Swan Canning. Setting of targets will depend somewhat on the adopted governance model and the powers and responsibilities assigned and will take some time as explained below. We will consider the forum successful if all of the stakeholder target needs are identified so that target setting methodologies can be developed.

In the last two years much has been written and talked about targets as a consequence of the NAP/NHT2 requirements for the Monitoring and Evaluation Framework and other documents on NRM issues. Much confusion now exists on the nature of targets and their usage. This confusion is not helped by the regulatory language of license conditions and the WA EPA terminology of Environmental Quality Objectives and Criteria. Planners, environmental scientists, engineers, water utility managers, environmental regulators and the informed community all use different target languages and have a wide range of needs and expectation of targets.

Target setting in the Swan Canning for environmental managers will be governed by two main frameworks: the Swan Canning Environmental Protection Policy (SCEPP) now known as Riverplan; and the NAP/NHT2 derived Monitoring and Evaluation Framework target setting in the regional strategy of the Swan Catchment Council. These frameworks do not preclude other forms of targets setting for individual groups and organisations.

This paper examines briefly these two frameworks and explains in detail the existing environmental performance targets for the Swan Canning Cleanup Program (SCCP) as a case study in target setting. Comments on the requirements of measuring against targets and recommendation for future activity in this area are also made and should be read in combination with the companion paper on Monitoring and Reporting.

What is a target

A target is simply something to aim for and therefore can take a number of forms. Milestones and benchmarks constitute targets, for example. Targets by their very nature require some form of measurement of performance against that target, otherwise the setting of a target has little practical purpose. Performance against targets or milestones provides the tools to evaluate success or otherwise of the activity or programs.

In a natural resource management (NRM) program, such as the Swan-Canning Cleanup Program (SCCP), a target may be a numerical measure of a management objective. The adoption of targets can strengthen the objectives of the program from broad statements of intent to numerical measures of progress. ‘Compliance’ with a target means that a desirable condition has been attained. Non-compliance with (or breach of) a target indicates that resource quality is inconsistent with the management objective and action needs to be taken to improve the system. The adoption of water quality targets has been an integral component of SCCP, and precedes current Commonwealth recommendations.

Language 1: NAP/NHT II

The recently developed Monitoring and Evaluation Framework for the National Action Plan for Salinity and Water Quality (NAP) and the Natural Heritage Trust II requires target setting as a basis for determining management actions that can be linked to environmental outcomes. This framework refers to 3 types of targets, which are relevant on different timescales:

1. **Aspirational targets** (>50 years), which are vision statements of the overall goals or outcomes of the management program. Aspirational targets are broadly equivalent to the objectives of the Swan-Canning Cleanup Program (SCCP), which are outlined in the SCCP Action Plan.

2. **Resource condition targets** (10-20 years), which are quantifiable outcome-based targets relating to desired changes in natural resource condition. These are the equivalent of the SCCP water quality targets explained in this paper. Resource condition targets must be achievable, measurable and time-bound.

3. **Management action targets**, or milestones (0-5 years), which are targets linked to specific actions, such as the number of kilometres of riparian zone revegetated, or the proportion of development in a catchment incorporating water sensitive urban design. These targets are yet to be developed for the SCCP.

Measuring progress against resource condition targets is more difficult than for management action targets. In the latter case, measuring the attainment of the target (compliance) is a relatively straightforward process. For instance if the goal of a community revegetation project is to replant 10 kilometres of streambank then once this amount has been achieved the target has been successfully attained. However, where a numerical target relating to an indicator of environmental condition is used, a sampling program based on sound statistical reasoning is required to ensure comparisons with the target are meaningful and consistent over time.

The chosen measures of success are known as *indicators*, and a *target* is the chosen value of the indicator that is consistent with the management objective. Indicators need to be readily measurable, scientifically valid for assessing resource quality, and provide relevant information for management decision making. For example, indicators could include numbers of faecal bacteria in recreational waters, the concentration of pollutants in a stormwater drain, or the heavy metal content of shellfish in the vicinity of an industrial area. Because these indicators can be quantified it is possible to assign to each of them target values which represent the desired outcome of the management program. Environmental indicators are often highly variable, and respond to a range of factors in addition to any implemented management actions. For this reason an approach incorporating a well-designed sampling program (when, where, how often, and how you sample), and appropriate data analysis and use of statistical techniques is necessary to set targets and measure against them.

Setting numerical resource condition targets using indicators also requires sufficient understanding of the physical or ecological processes occurring in the ecosystem in question which will be based on some years of data collection prior to the target setting exercise. At the very least a conceptual model of how the ecosystem functions will need to be formulated and modified in time as new knowledge becomes available. This timescale is recognised by the NAP/NHT2 Framework which allows up to three years to collect data on specific indicators before resource condition targets need to be set.

Another challenge it to understand how achievement of the Management Action Target will contribute to the achievement of the Resource Condition Target. In addition to a conceptual model there is a need to quantify the changes made by any management action in terms of appropriate indicators so that the impact of these actions on meeting both the resource condition and aspirational targets can be evaluated.

The actions and targets in the regional strategy cover the whole range of environmental and socio-economic issues of which water quality is an important but only one component. Most of the Swan Canning catchment excluding the Avon is recognised as an NHT region but is excluded from the NAP rules, meaning that the main source of funds for environmental improvement will come from NHT2. Through the offices of the Swan Catchment Council the regional strategy is being finalised for public comment. The first cut of aspirational, resource condition and management targets are included in this draft.

In summary NRM targets are developed through consensus within the regional strategy partnership, are not based on blame, are non statutory and in general reflect measures of improvement from the current condition.

Language 2: Riverplan

The Environmental Management Framework embodied in Riverplan follows the procedure for the development of Environmental Protection Policies in the Environmental Protection Act (1986) and as such approaches target setting from the statutory point of view. In other words measures established

under Riverplan set a minimum standard and will have a legal basis to require actions to be implemented to meet these measures. The language is quite different to that used in NAP:

1. **'Environmental Values** (EV)are particular values or uses that are conducive to a healthy ecosystem and also provide public benefit' . The explicit assumption is that 'management of the human of the human oriented uses will be achieved by protecting the ecologically based values.'

2. **'Environmental Quality Objectives' (EQO)**are the 'goals which, when achieved, will allow the environmental values to be supported'

3. **'Environmental Quality Criteria (EQC)** represent the nominated acceptable levels for a specific indicator. They are nearly always numerical and represent a nominated level that has yet to be met for an environmental objective to be achieved'.

The development of Environmental Values and associated objectives and criteria are part of the current work load of the Swan River Trust Riverplan Implementation team. An interim set of EVs, EQO's and indicators have been proposed in the current Riverplan document..

Although broad similarities between the Riverplan terms and the NAP terms can be drawn, they are not directly equivalent since the Riverplan objectives and criteria have a legal and therefore statutory basis in which organisation or individuals can be held accountable. This type of language is reflected in the National Water Quality Management Strategy (NWQMS). In both, trigger values (often risk based) are used to indicate when management action is required. Guidelines and trigger values are often used as defacto targets although the ANZECC documents frequently state that these values should not be used for targets and that site specific values should be determined.

In the case of the NAP target process achievement or failure to meet targets does not have legal implications although management action targets may be construed as contract performance measures. The State Monitoring and Evaluation Framework Discussion Paper No 1 in the State of the Environment Reporting series attempts to show equivalence between these terminologies which in our view is incorrect and unwarranted especially since the meaning of these terms is subject to change and redefinition.

In summary these types of targets are not consensus (with the possible exception of EV's), are statutory, often risk based in derivation (EQC's), and could be considered to be based on measures of deterioration rather than improvement.

The Language of Regulation

We have already identified above two target languages. In a discussion of this sort we need to mention a third language, the regulatory language of conditions and license conditions. Both the NRM type of targets and the statutory EPP types of targets operate in areas where multiple stressors lead to environmental decline. In situations where individuals or organisations can be held accountable then legally enforceable license conditions may be used. In the context of this discussion paper license conditions are not defined as targets.

License conditions clearly have a role to play in environmental improvement and the numerical values of these may be computed from either of the target languages we have already described. They often have to take into account what is theoretically achievable through best management practice or codes of practice. It is our view that license conditions should only be applied in situations where the licensee has control or influence over the inputs, such as the end of pipe to a factory. It is not appropriate to set license conditions on the drainage operator in the case of urban drainage when that operator has little or no control over the discharges to the drainage.

In the case of this debate and the Swan Canning, license conditions for main drains should not be set on the Water Corporation and made enforceable since they have little control over both groundwater, industrial discharges and stormwater runoff. It <u>is</u> appropriate to set targets for urban main drains which are in essence system wide and can be achieved by multiple partners working together where each partner is accountable for instituting management practices under their control. It is also appropriate to set legally enforceable license conditions on point source generators to achieve these

system wide targets. The establishment and enforcement of these conditions is the responsibility of the regulatory agency, in this case the Department of Environmental Protection.

Other Target Languages

As noted above there are number of other target languages in use. The context described above requires measurement against targets and reporting back to both government and the community.

Gunningham and Sinclair
As part of the drainage reform review a recent discussion paper from Neil Gunnigham and Darren Sinclair explores targets and incentives where a number of different target concepts are used and discussed. The interested reader is referred to that document for a more detail discussion. Disappointingly their discussion does not make reference to or allowance of the NAP/NHT2 process and the EPP requirements but does provide an interesting analysis of the effectiveness of incentives.

The Gunningham discussion paper does make a case for the establishment of firm and practical policy targets so that effectiveness of policy can be evaluated; a key threshold related to algal bloom occurrence. The existing SCCP targets meet that requirement. They then go on to discuss effectiveness indicators and performance standards by which they mean something equivalent to a license condition and then process standards; these measures should not be confused with target as set system wide. All of these measures are useful at an industry or organisation level.

Australian Runoff QualityGuidelines
The draft Australian Runoff Quality (ARQ) provides a very confusing rehash of the ANZECC and NWQMS discussion of guidelines and trigger values and then goes on to discuss the need for design or performance criteria. That is, some guidance to engineers to develop performance criteria for engineered stormwater management devices. Clearly there is a need for this sort of information, but these are not targets since they are often notional and mostly not measured against.

In the case of the Swan Canning especially in the monitored streams notional estimates reduction of loads can be provided based on existing data. However it is not possible to say with precision how the achievement of these reductions would effect the activity of algal blooms due to the multiplicity of triggers to algal blooms. We can only say that algal activity will be reduced. In smaller waterbodies such as urban lakes and ponds we make more definitive statements. In the parallel project for this forum in which BMP's for Mills St drain are costed we could run a number of cost/benefit scenarios based on a range of notional reductions. The term notional is used in the sense that it is our best estimate derived from our conceptual or numerical models.

In a development approval context design criteria or design objectives may be developed so that system wide environmental targets can be achieved and are considered by some as constituting targets in of themselves. In some cases, terms such as performance indicators or environmental performance indicators are used interchangeably for targets and in other cases so are goals and objectives.

Decision Support Models
In the Swan Canning as in other areas, various types of catchment models are used to determine, say, nutrient generation rates based on land use and incorporating to various degrees process understanding. These models are then used as decision support tools to identify focus areas for management action or to determine the effect and feasibility of various management approaches. Notional targets may be set to run various model scenarios. The extent to which these notional targets can be used as performance targets will depend on the real data available from that catchment and the degree to which the efficacy of the selected management practice can be quantified. In fact in determining cost/benefit factors for WSUD measures particularly in established areas there is a critical need for performance data for engineered solutions and even the non-structural approaches.

DEVELOPING TARGETS FOR THE SWAN-CANNING CLEANUP PROGRAM

Water quality targets for the Swan-Canning Cleanup Program

The Swan-Canning Cleanup Program was instigated in 1994 in response to nuisance phytoplankton blooms and fish deaths which focused community attention on the deteriorating health of the Swan-Canning river system. The Cleanup Program aims to improve the health of the river system, which has become degraded through loss of habitat and increased supply of nutrients (especially nitrogen and phosphorus) and organic material from urban and agricultural lands.

The Swan River Trust (SRT) has made it a priority to measure and report on the progress of the Cleanup Program to the community. To assess performance the SRT is comparing the quality of both freshwater tributaries in the Swan-Canning catchment, and the estuary, with water quality targets. The SRT developed targets for nutrient levels in the rivers and drains that discharge to the Swan and Canning rivers and for nutrients, phytoplankton biomass and oxygen in the estuary. These targets allow managers to evaluate the appropriateness and effectiveness of the tasks undertaken in the Cleanup Program against specified objectives.

Developing the targets

In developing water quality targets for the Cleanup Program there were five major tasks:

1. Selecting a list of water quality indicators measuring environmental characteristics that will be influenced by the proposed management initiatives;

2. Choosing the target levels for each of the indicators;

3. Designing and implementing a monitoring program to compare the quality of the test systems with the targets;

4. Developing data analysis techniques so that monitoring data is interpreted consistently when making compliance decisions; and

5. Developing and gaining agreement on the reporting format to the Trust and the wider community.

Water quality indicators chosen for the Cleanup Program

Selecting an appropriate set of water quality indicators for natural systems can be a complex and difficult task. However, in the case of the SCCP, it was relatively straightforward because it is a highly focused management program and a good system understanding and therefore conceptual model had been developed from pre-Action Plan studies. The overall goals of the SCCP relate to community aspirations for the Swan-Canning river system. These include keeping algal blooms to a level where there is no threat to public health and amenity and they are not a nuisance to the community; keeping toxic algal blooms to a minimum; and ensuring that water quality in the Swan-Canning river system is suitable for maintaining a healthy ecosystem, such that people can swim or catch fish at any time.

Specific management objectives linked to these goals are to decrease nutrient discharges to the rivers from the catchment, reduce the frequency and duration of nuisance phytoplankton blooms in the river system, and limit the occurrence of severe, persistent and widespread anoxia. In line with these objectives, the chosen indicators are catchment and estuary nutrient (total nitrogen and total phosphorus) concentrations; estuary chlorophyll *a* (as a measure of phytoplankton abundance); and dissolved oxygen concentration (see Table 1).

Table 1: Targets for the Swan-Canning Estuary and catchment.

Management objective	Potential measures or indicators	Indicator for numerical SCCP targets	Method
Reduce nutrient inputs from the catchment	Nitrogen (TN, DIN) Phosphorus (TP, DIP)	TN TP	• Fortnightly sampling at 15 catchment sites • Concentration based target
Reduce frequency of algal blooms	Phytoplankton cell counts No. of recorded blooms Chlorophyll *a* *In situ* fluorescence	Chlorophyll *a*	• Weekly sampling at fixed and randomly selected sites • Surface samples • Set by estuary basin
Reduce potentially toxic blooms in the Canning	No. of blooms of gazetted toxic species	Targets not set	• Weekly sampling, and • Opportunistic sampling • Phytoplankton ID and cell counts
Reduce anoxic periods in the Swan	Dissolved oxygen concentration	Dissolved oxygen (% saturation)	• Weekly sampling of surface waters
Reduce nutrients which feed algal growth in the estuary	Nitrogen (TN, DIN) Phosphorus (TP, DIP)	TN TP	• Weekly sampling • Concentration based target • Set by estuary basin

Catchment targets

The rivers and creeks of the south-west of Western Australia would have contained much less nitrogen (N) and phosphorus (P) before European settlement than they do today. Excess N and P entering the Swan-Canning river system has led to nuisance and potentially toxic algal blooms. Controlling nutrients entering the river system is essential to decrease the frequency of algal blooms and prevent further deterioration in water quality. Catchment targets have been developed which specify the concentrations of total N and total P allowable in 15 tributaries of the Swan-Canning catchment. In recognition of the long timeframes required for catchment management to affect nutrient levels in catchment streams, both short-term and long-term targets have been developed. For streams where water quality is already better than the short-term target, achieving the long-term target is the objective.

The SCCP targets for total N and total P are provided in Table 2. Extensive statistical validation confirmed that the ANZECC recommended concentrations for near pristine rivers were appropriate longer-term targets for both total N and total P, while levels of double the ANZECC recommendations were useful benchmarks to measure progress in the short term.

Table 2: Swan-Canning Cleanup Program targets for median total nitrogen (TN) and total phosphorus (TP) concentration in tributaries of the Swan-Canning River system.

Target	Total nitrogen	Total phosphorus
Short-term	2.0 mg/L	0.2 mg/L
Long-term	1.0 mg/L	0.1 mg/L

Concentrations vs Loads

Considerable debate occurred during the long consultation period during this target development on the respective merits of load based targets versus concentration based targets. The key requirement of an target indicator is that among year differences can be detected simply, repeatably and be stable. With load estimation there are many more sources of error and considerable expense is required to measure loads with sufficient precision to determine differences among years. The Water and Rivers Commission has developed robust systems to measure loads with required precision in the Swan Canning and understand very well the infrastructure and labour needs. There are currently only 3 or 4 sites where load based targets could be measured without substantial investment in infrastructure.

Concentrations are easily measured at sites where continuous flow data are not collected which allows 15 sites in the Swan Canning to be used for performance measures. Load based measures are very dependent on flow and therefore changes in annual rainfall. In the Swan Canning we have sufficient data to understand the concentration-flow relationship at most sites which shows that concentrations are reflective of the loading.

As estuarine managers we appreciate the importance of load measurements in overall nutrient budgets and understanding delivery patterns to the receiving water body and have developed robust field and statistical measures to compute loads from all 15 monitored sites. Combined with knowledge of fate and effects of the delivered loads valuable insights into estuarine response to catchment pressures can be gained. These data however are not amenable to target setting for many of the reasons discussed later in the context of indicators.

Estuary targets

The ultimate measure of success of the SCCP is how it can influence phytoplankton biomass and oxygen levels in the Swan and Canning estuaries. Therefore the key performance indicators of the Cleanup Program with respect to the estuary are the concentration of chlorophyll *a* (a measure of phytoplankton biomass) and the dissolved oxygen saturation. Targets have also been developed for nutrient concentrations (total N, total P) in the estuary (see Table 3).

Derivation of Estuary Targets

To ensure the relevance of water quality targets to management, it is important that they are achievable. For this reason the estuary targets were set – using statistical principles – to detect the smallest change in water quality that could be confidently taken to represent improvement or degradation in the system.

There are different criteria for assessing compliance and breach of the targets depending on whether the current water quality is acceptable or not. In areas where water quality is currently good, such as the lower estuary basin, the management goal is to maintain current water quality and breach of the targets is meant to provide early warning of degradation. In areas where water quality is unacceptable compliance with the target represents evidence of improvement, and by inference, that management is beginning to affect phytoplankton biomass and oxygen levels for the better.

Critically, these latter SCCP targets are intended to be just the first in a sequence of important benchmarks along a path of continual improvement. Once the management goal is achieved, breach of the target value will provide a warning of possible system degradation.

Chlorophyll a targets

The concentration of the key photosynthetic pigment chlorophyll *a* is widely used as an estimate of the total biomass of phytoplankton cells in a water sample. In ‘healthy’ Australian estuaries, which support relatively low phytoplankton biomass, surface chlorophyll a concentrations are usually between 3.0 and 5.0 micrograms per litre (µg/L). During phytoplankton ‘blooms’ concentrations can exceed 500 µg/L.

The Cleanup Program targets for estuary chlorophyll *a* are shown in Table 3. These targets are for 90th percentile chlorophyll *a* concentrations in the surface half metre of the water column. The range of target values reflects the current condition of the different estuary basins. In the lower estuary where phytoplankton biomass is currently low, the target value is set so that its breach would provide evidence of degradation in the system. In the other estuary basins, compliance with the target value represents evidence of a reduction in chlorophyll *a* (and therefore biomass) below current levels, and thus an improvement in water quality.

Dissolved oxygen targets

Dissolved oxygen is critical for the survival of fish and other aquatic animals. Low levels of dissolved oxygen are symptomatic of eutrophication and lead to increased nutrient release from the sediments. Dissolved oxygen can be measured as a concentration or as a percent saturation. 100 percent saturation is as much oxygen as can be dissolved in water at a particular temperature and salinity. The dissolved oxygen targets are expressed as percent saturation because this incorporates temperature and salinity variation. Oxygen levels in waters of a healthy estuary generally vary between 70 and 90 percent saturation. The targets are set for surface waters, where there is the greatest risk that low-oxygen conditions will stress and kill fish, and where it is likely that any initial improvement in dissolved oxygen levels will be detected.

The SCCP targets for estuary dissolved oxygen levels are shown in Table 3. These targets are for 5th percentile dissolved oxygen concentrations, which represent the occurrence of unusually low oxygen concentrations. Again, the range of target values reflects the current dissolved oxygen status of each estuary basin. In the lower estuary, if the observed 5th percentile dissolved oxygen value breaches the target, then this indicates a worsening of dissolved oxygen levels. Compliance with the targets for each of the other estuary basins indicates evidence of improvement in the system.

Nitrogen and phosphorus targets

The ANZECC water quality guidelines show that nutrient concentrations in estuaries in the southwest of Western Australia should be very low, around 0.75 mg/L total N, and 0.03 mg/L total P for median concentrations. Tidal exchange with the ocean ensures that the lower Swan-Canning estuary has low concentrations of N and P for most of the year. Nutrient concentrations in the middle and upper arms of the estuary are dependent on inputs from the catchment during the wet winter months, and groundwater discharge and releases from bottom sediments during dry periods. Total rather than dissolved or bioavailable N and P were selected as target variables because the rapid transformation of dissolved N and P into and out of plant biomass makes dissolved forms of N and P inconsistent indicators.

Target values for estuary total N and total P are shown in Table 3. These targets are for 90th percentile nutrient concentrations. Once again, because of the acceptable current state of water quality in the lower estuary, exceedence of this target value represents evidence of degradation in the system. In all other estuary basins, compliance with the target value represents an improvement in the nutrient status of the basin.

Table 3: Target chlorophyll *a* (90th percentile), dissolved oxygen (5th percentile), total N and total P (90th percentile) concentrations for the Swan-Canning estuary.

Estuary Basin	**Chl-a target** (µg/L)	**Surface DO** (% sat)	**Total N** (mg/L)	**Total P** (mg/L)
Lower Swan-Canning	3.55	82.1	0.509	0.058
Middle Swan	8.75	75.1	0.790	0.110
Upper Swan	19.98	81.2	1.009	0.119
Middle Canning	11.67	49.1	0.790	0.190
Upper Canning	39.00	15.4	1.330	0.300

■ **Water quality currently acceptable – breach of target provides early warning of decline.**
■ Water quality currently unacceptable – compliance with target represents evidence of improvement in the system

MONITORING FOR COMPLIANCE WITH THE CLEANUP PROGRAM TARGETS

To assess whether water quality in the Swan-Canning river system is consistent with its management objectives, sample data are compared with the target levels. Developing the sampling program – known as a compliance-monitoring scheme – and assessing the achievement of targets required the definition of three key things:

- When, where and how often samples are collected. In the estuary, sampling is carried out during the low flow period when there is less variation due to climate and the risk of nuisance phytoplankton blooms and anoxia is highest. In the catchment, compliance sampling is carried out while the rivers are flowing, between June and October.

- The statistic used to characterise quality may be an average, median or other percentile value. Note that compliance is not based on a single sample value, but on a set of data points obtained through monitoring.

- The 'compliance/breach' criterion that will be applied to the target. Taking into account sampling error, how many samples are permitted to exceed the target before it is decided that the target is breached (or met)?

The monitoring program

Catchment monitoring
An existing water quality monitoring program in the tributaries of the Swan and Canning rivers provides the data for the SRT to measure and report progress with respect to the catchment targets. With this monitoring program, one sample is collected from 15 freshwater inflows to the rivers once every two weeks during the main discharge period, June to November. This sampling program gathers about 10 samples per year for each tributary. The data from three consecutive years, a total of about 30 samples, is used to compare total N and total P concentrations in the rivers with the Cleanup Program targets.

Estuary monitoring
The sampling program to test compliance with the Cleanup Program targets for the estuary involves the collection of samples from each of five estuary 'basins' – both the upper and middle arms of the Swan and Canning estuaries, and the lower estuary below the Narrows Bridge. One random sample is collected from the lower estuary (Melville Water) and one sample is randomly selected from amongst the fixed monitoring sites in each of the other estuary basins, every week from January to May, which gives about 20 samples per year in each of the estuary basins. These 20 or so samples are then combined with the 20 samples from each of the previous two years to give a total of about 60 samples with which to test compliance.

The test statistic
Because of natural variation in water quality, compliance is not assessed against a single sample value, but against a key statistic derived from the set of monitoring data. The most commonly used measures of an overall change in quality relate to measures of central tendency such as the average or median. However, where the intention of management is to reduce the frequency of extreme events then a higher (or lower) percentile may be more relevant (see Figure 1).

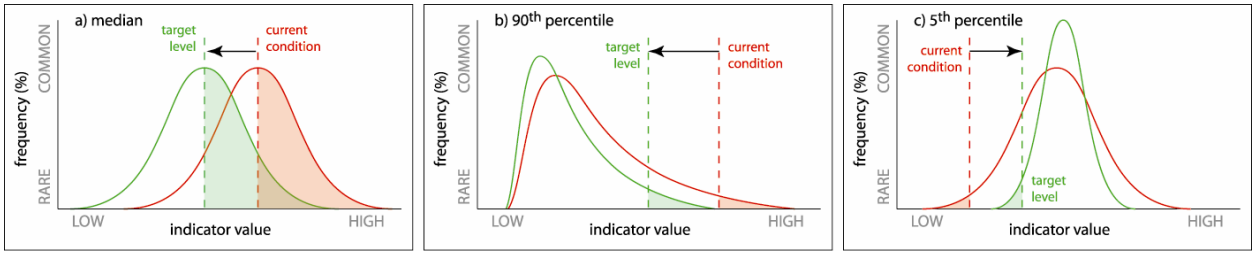


Figure 1: A decrease in the median value (a) represents an overall improvement in water quality, whereas a change in the 90th percentile (b) or 5th percentile (c) represents a reduction in the number of extreme events (eg algal blooms, deoxygenation events) even though there may be little change in the median.

Assessing compliance with percentile water quality targets is actually about examining the rate of excursion from target levels. The excursion rate is the period in which water quality is worse than the limit established by the target, and the maximum allowable excursion rate is specified by the population statistic used. For example, the maximum allowed rate of excursion from a 90th percentile target is 10 percent of the monitoring period – any more than this and the target has been breached.

The aims of the SCCP relate primarily to extremes in condition such as the frequency of blooms and the frequency of anoxia events. Therefore the estuary targets were developed (and compliance is tested) using extreme statistics – the 90th percentile for nutrients and chlorophyll, and the 5th percentile for oxygen. Compliance against the catchment targets is assessed using the sample median.

Table 4: Decision rules for catchment nutrient targets. The rules cover compliance decisions for median targets using 30 samples.

Prior condition	Decision rule
SCCP objective met	20 or more samples > target = SCCP objective not met
SCCP objective not met	11 or fewer samples > target = SCCP objective met

Table 5: Decision rules for the nutrient and chlorophyll *a* targets in the estuary. The rules cover compliance decisions made for 90th percentile targets using 60 samples.

Prior condition	Decision rule
SCCP objective met	11 or more samples > target = SCCP quality objective at risk and investigation may be necessary
	22 or more > target = SCCP objective is no longer met
SCCP objective not met	2 or fewer samples > target = SCCP objective met

The compliance/breach criteria

From the 30 or so samples collected in each catchment tributary, or the 60 samples in each estuarine basin, it is easy to calculate an excursion rate, which is simply the percentage of samples that exceed the target value. However, because the sampling data is collected at intervals (as opposed to continuous monitoring) the true rate of excursion above the target value cannot be known. The excursion rate determined from the available data is an estimation of the actual excursion rate in the stream. However, statistics can be used to calculate a range around the sample excursion rate within which the actual excursion rate is likely to lie. This range of values is known as a confidence interval. For the SCCP targets, decisions of compliance or breach are taken using a 90 percent confidence interval around the sample excursion rate (see Figure 2). There is a 90% probability that that the true population rate of excursion lies within this range.

For the lower estuary and those catchment tributaries where water quality is currently acceptable the target is breached when the entire confidence interval lies above the target value (Figure 2a). In this case it can be safely concluded (with 95 percent probability) that water quality has exceeded the target level. For those tributaries where water quality is currently worse than target levels the benefit of the doubt goes the other way. That is, the target is only achieved where there is a 95 percent chance that water quality has actually improved to better than target levels (Figure 2b).

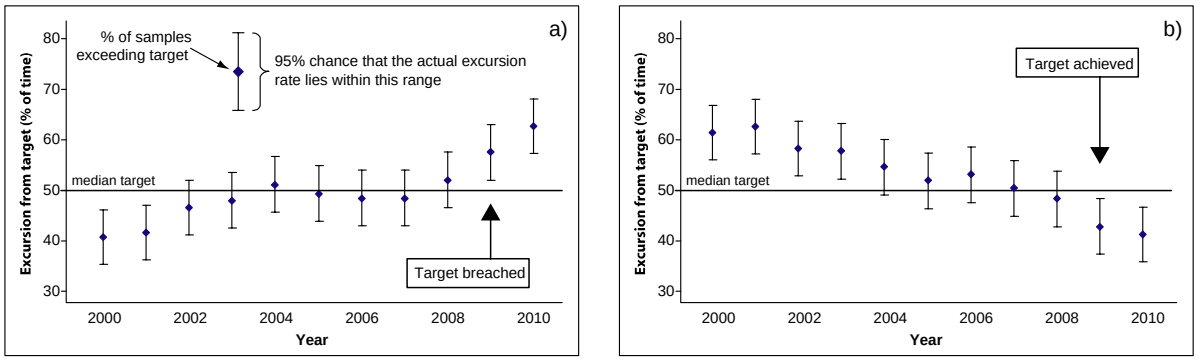


Figure 2: The confidence interval method for measuring a) breach and b) achievement of the SCCP targets

Using the confidence interval method, decision rules were developed, which specify exactly how many samples are allowed to exceed each target before the target has been breached, or met. Examples of the decision rules are given in Tables 4 and 5. In each case the confidence interval method results in two separate decision rules depending on whether or not current water quality is acceptable. Decision rules can be developed in exactly the same way for any number of collected samples, which is necessary in practice because the number of samples collected over the monitoring period is rarely exactly 30 for tributaries, or exactly 60 for estuary basins.

RESULTS OF CLEANUP PROGRAM PERFORMANCE MONITORING

Catchment targets

The results of the compliance-monitoring program against the catchment targets for total nitrogen and total phosphorus are presented in Tables 6 and 7 for the period 1998-2002. The table shows that in the case of total nitrogen, two of the tributaries, Bannister Creek (2001) and Mills Street Main Drain (2002) have achieved the short-term target for the first time. The South Belmont Main Drain has successfully achieved the long-term target. In the case of total phosphorus, two catchments – the Southern River (1999) and Mills Street Main Drain (2001) have met the short-term target and are now being assessed against the long-term phosphorus target.

Table 2: Compliance of monitored tributaries discharging into the Swan-Canning Estuary with short- and long-term nitrogen targets. The numbers within brackets represent the maximum number of allowed exceedances if the target is met. The numbers outside the brackets are the actual numbers of samples that exceeded the target level.

Tributary	1998	1999	2000	2001	2002
Ellen Brook	(10) 14	(11) 16	(12) 19	(12) 18	(12) 17
Mills Street Main Drain	(11) 26	(11) 20	(12) 17	(12) 13	(12) 12
Bannister Creek	(7) 11	(11) 13	(12) 14	(12) 10	(12) 30
Bayswater Main Drain	(11) 30	(11) 30	(12) 32	(12) 30	(12) 27
Southern River	(11) 30	(11) 27	(12) 29	(12) 26	(12) 23
Bickley Brook	(7) 17	(11) 26	(12) 27	(12) 25	(12) 21
Bennett Brook	(7) 17	(11) 24	(12) 24	(12) 22	(12) 21
Yule Brook	(11) 23	(11) 18	(12) 17	(12) 16	(12) 18
Blackadder Creek	(6) 16	(11) 22	(12) 20	(12) 16	(12) 14
Canning River	(11) 20	(11) 17	(12) 19	(12) 15	(12) 12
Helena River	(11) 21	(10) 15	(11) 15	(11) 13	(11) 14
South Belmont Main Drain	(7) 13	(11) 15	(12) 11	(21) 5	(21) 5
Avon River	(20) 16	(20) 14	(21) 14	(21) 14	(21) 10
Susannah Brook	(12) 8	(18) 10	(19) 11	(19) 10	(18) 9
Jane Brook	(13) 8	(19) 11	(20) 11	(19) 8	(19) 7
Short-term target met (%)	80	80	80	87	93
Long-term target met (%)	20	20	27	27	33

■ **Assessed against short-term target.**

■ **Short-term target achieved. Assessed against long-term target.**

■ **Both short-term and**

Table 3: Compliance of monitored tributaries discharging into the Swan-Canning Estuary with short- and long-term phosphorus targets. The numbers within brackets represent the maximum number of allowed exceedances if the target is met. The numbers outside the brackets are the actual numbers of samples that exceeded the target level.

Tributary	1998	1999	2000	2001	2002
Ellen Brook	(10) 29	(11) 29	(12) 32	(12) 30	(12) 30
Mills Street Main Drain	(11) 19	(11) 16	(12) 15	(12) 11	(12) 29
Southern River	(11) 12	(11) 8	(12) 26	(12) 25	(12) 27
South Belmont Main Drain	(7) 15	(11) 17	(12) 16	(12) 17	(12) 19
Bannister Creek	(7) 14	(11) 21	(12) 22	(12) 19	(12) 17
Yule Brook	(21) 8	(21) 8	(21) 4	(21) 7	(21) 11
Bayswater Main Drain	(20) 3	(21) 8	(21) 11	(21) 12	(22) 10
Bickley Brook	(14) 6	(21) 9	(21) 5	(21) 6	(21) 6
Blackadder Creek	(14) 2	(20) 3	(21) 1	(21) 2	(21) 2
Jane Brook	(13) 0	(19) 0	(20) 1	(19) 2	(19) 2
Avon River	(20) 3	(20) 2	(21) 1	(21) 0	(21) 0
Bennett Brook	(14) 5	(21) 5	(21) 2	(21) 0	(21) 0
Canning River	(21) 0	(21) 0	(21) 0	(21) 0	(22) 0
Helena River	(19) 0	(19) 0	(20) 0	(20) 0	(20) 0
Susannah Brook	(12) 0	(18) 0	(19) 0	(19) 0	(18) 0
Short-term target met (%)	80	87	87	93	93
Long-term target met (%)	67	67	67	67	67

■ **Assessed against short-term target.**

■ **Short-term target achieved. Assessed against long-term target.**

■ **Both short-term and**

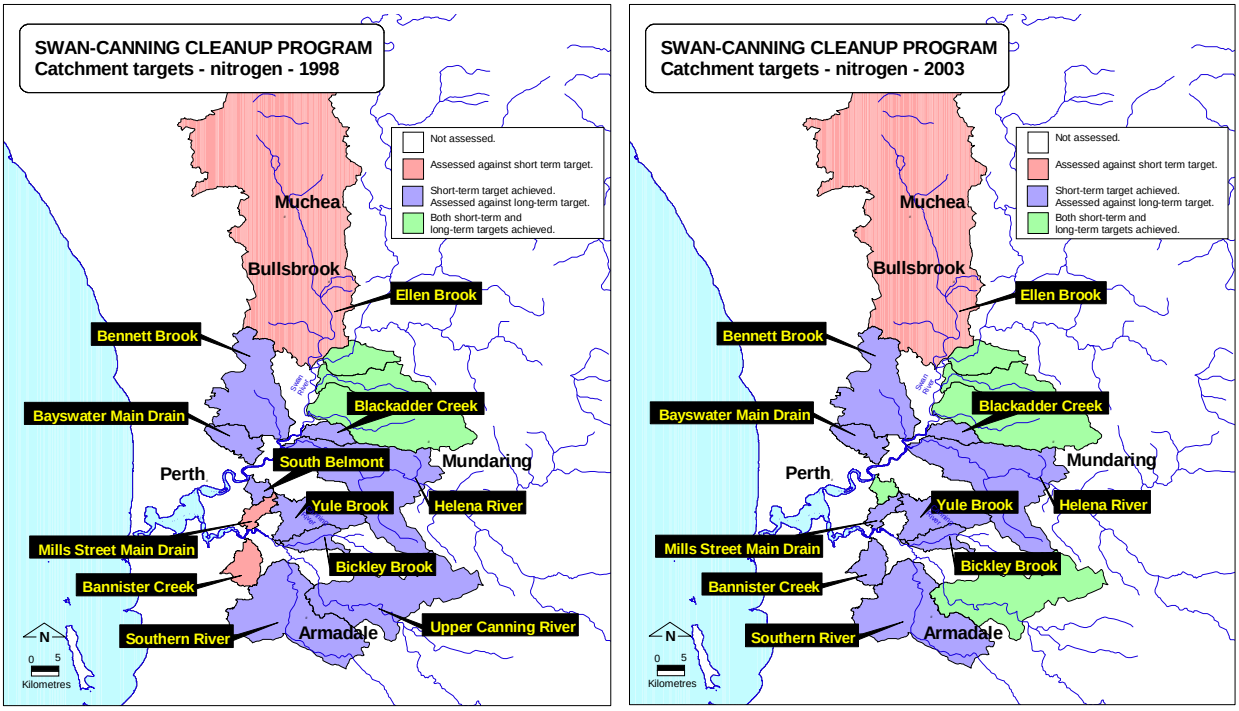


Figure 3: Map of compliance of monitored tributaries discharging into the Swan-Canning Estuary with short- and long-term nitrogen targets.

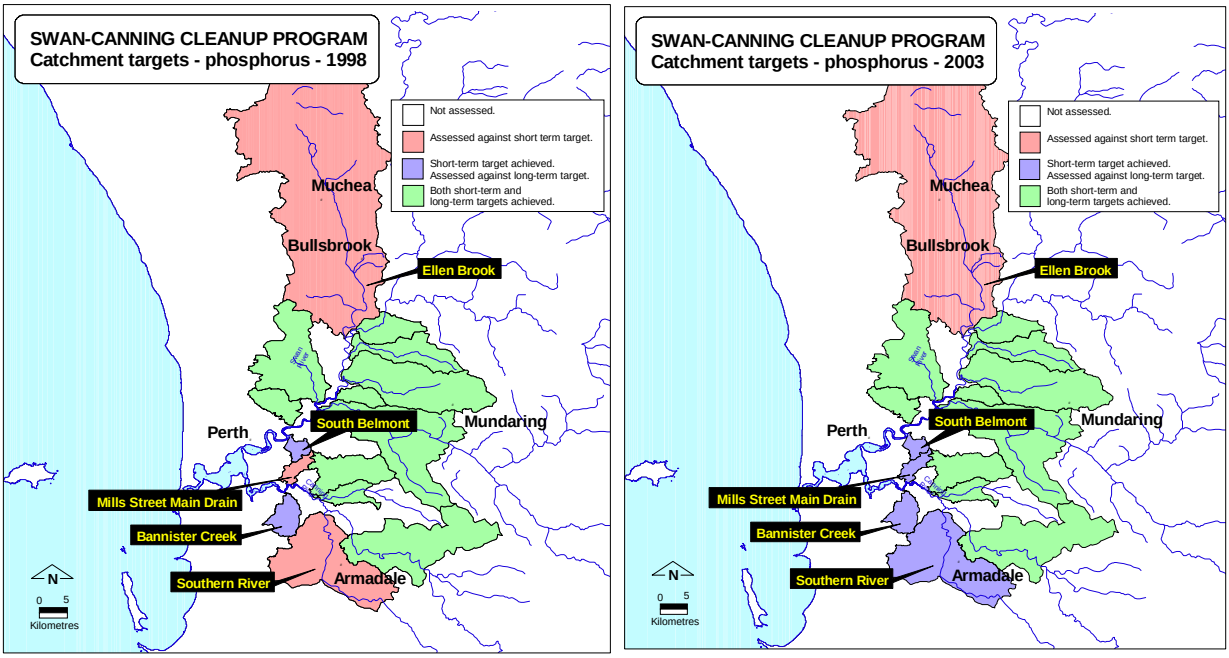


Figure 4: Map of compliance of monitored tributaries discharging into the Swan-Canning Estuary with short- and long-term phosphorus targets.

Estuary targets

In the estuary, performance against the Cleanup Program targets has been reported for the upper and middle arms of the Swan, and for the lower estuary (Tables 8 and 9). The upper and middle estuary have not yet met their chlorophyll *a* or dissolved oxygen targets. The lower estuary just failed to meet the dissolved oxygen target in 2001, but successfully met the target in 2002. Reporting for the upper and middle Canning will begin in 2003.

Table 1: Chlorophyll-a concentration in the basins of the Swan-Canning Estuary compared to the targets.

Basin	2001	2002	2003
upper Swan	(2) 15	(2) 18	(2) 25
middle Swan	(2) 18	(2) 18	(2) 18
lower Swan-Canning	(9) 6	(9) 4	(10) 3
middle Canning	Not assessed	Not assessed	(3) 8

Table 2: Dissolved oxygen saturation in the basins of the Swan-Canning Estuary compared to the targets.

Basin	2001	2002	2003
upper Swan	(0) 21	(0) 20	(0) 33
middle Swan	(0) 14	(0) 11	(0) 7
lower Swan-Canning	(5) 7	(5) 2	(6) 4

REVIEW OF CLEANUP PROGRAM TARGETS

A review of the SCCP targets is currently underway to determine the appropriateness of the selected indicators and the targets set.

Catchment targets

For some tributaries both the short-term and long-term targets have already been met for N and P. The challenge now is to maintain the values below the target criteria and to continue working to reduce nutrient losses from catchments. The recent dry years will have made a contribution to the achievement of the target. In the long-term it may be necessary to review the catchment targets based on an improved understanding of estuarine response.

Not all the catchments of the Swan-Canning river system are monitored (only 15 out of 31 on the Coastal Plain). Although these catchments represent about 80 percent of the coastal catchment area, the unmonitored catchments include a large proportion of the urban catchments on the Coastal Plain that may have a significant influence on the estuary. For many, the gauging stations are also some way from the estuary. In the case of Ellen Brook for example the gauging station is eight kilometres from the confluence, with many polluting land uses below that point. Future work to identify the N and P contributions of this unmonitored area is required.

Estuary targets

The Trust intends to review the performance of the targets and monitoring system after its first five years of SCCP implementation (in 2004). Given the short amount of time since the estuary targets were set it is likely that any change within the first few years would reflect natural variation rather than a real improvement or degradation in water quality resulting from a change in catchment condition. The targets were developed using data from 1996-1998, but will be reviewed using the monitoring data to 2003 to ensure that targets have been set outside the natural variation as it occurred over this longer period. In addition, the lower estuary targets were developed using existing fixed site monitoring data. Compliance monitoring against the targets is assessed using data collected from randomly selected sites across the lower estuary. The lower estuary targets may need to be adjusted to incorporate this greater spatial variation. Selection of target indicators should also be reviewed. If appropriate, targets could be set for additional parameters such as bottom water dissolved oxygen, soluble fractions of nitrogen and phosphorus, or integrated (taken through the water column) chlorophyll *a*.

DEVELOPING MANAGEMENT ACTION TARGETS FOR THE CLEANUP PROGRAM

The resource condition targets described in this paper can be used to gauge the progress and success of the Cleanup Program in improving water quality across the Swan-Canning river system. However, it is difficult to link these targets with individual management actions. Therefore, on a smaller scale, measures of how individual projects contribute to the achievement of the water quality targets are required. It is important to understand the effectiveness of remedial measures in reducing nutrient delivery to the Swan and Canning rivers so that more efficient targeting of remedial actions can be obtained. To develop meaningful management action targets a basic understanding of the nutrient pathways is required in combination with an estimate of the scale of impact of any remedial action. For example, the effect of one revegetation project in a large subcatchment may be difficult to detect in concentrations of N and P, whereas the impact of a similar size project in a smaller subcatchment may be easier to detect. Management action targets need to be developed which are appropriate to the scale, current condition and aspirations for management of individual subcatchments.

FUTURE DIRECTIONS FOR CLEANUP PROGRAM TARGETS

The Cleanup Program's compliance-monitoring program measures a small suite of water quality characteristics that are closely linked to the aspirations of the Cleanup Program for the Swan-Canning river system. The targets were developed specifically so the success of the Cleanup Program could be objectively assessed, and are not intended for broader adoption as management targets for other Natural Resource Management programs. The targets for the upper and middle estuary basins have been set at a level that provides good evidence of an improvement in quality. They do not represent ecologically significant levels. Nevertheless, the approach of adopting ever improving quality benchmarks can eventually lead to a level of water quality that is ecologically sustainable.

The SCCP targets are management and issue-based. The targets are not ecosystem-based and, as such, achieving the targets does not necessarily indicate that a healthy ecosystem exists. They are system wide targets to be reflective of all activities impinging on the Swan Canning. The catchment and estuary monitoring programs will be expanded to include ecosystem health components. The key to instigating such a monitoring program is to select appropriate river health and ecological health indicators based on our improving understanding of ecosystem function and response to stressors. This is not a straightforward task. It is necessary to select from the large suite of potential indicators those that are most suitable for measuring and reporting on current and future changes in the ecological condition or health of the rivers and estuary. In some cases some years of data collection may be necessary to understand the distribution and role of the selected indicator before a target can set. No one indicator can be used to achieve this. One approach could be to use a small suite of biotic indicators, such as measures of fish or invertebrate richness, in combination with the existing SCCP indicators, to develop a more comprehensive compliance monitoring system.

SPEAKING IN MANY TARGET LANGUAGES – A SUMMARY

As briefly noted in the discussion above there are a number of target languages and target needs among stakeholders in drainage reform. Clearly in a discussion or forum where target setting is discussed a clear definition of what is meant or required of a target is essential for constructive debate.

From a system wide viewpoint the dominant languages will be those of the NAP/NHT2 process and the EPP driven Riverplan. Identification of the target or performance assessment needs of all other stakeholders is important to service those needs and reduce confusion and duplication. The responsibility for target setting will depend on the ultimate governance arrangement for the Swan Canning. As it now stands the SRT has responsibility for implementing Riverplan targets and the Swan Catchment Centre has responsibility for the NAP/NHT2 targets setting. Both exercises are consultative among many stakeholders and the community and as such the methodology can not be prescribed by this paper.

Considerable target setting is already required through both the implementation of Riverplan and the Swan regional strategy. We caution the addition of any additional target setting outside of the Riverplan and regional strategy unless strictly necessary since reporting against targets is not always the most useful expenditure of money or the most effective form of communication to the community. The case example for the Moreton Bay Catchment included in this paper and in the Monitoring and Reporting paper shows that a highly effective monitoring program can be communicated without ever using the target word.

In the first phase of SCCP, system wide water quality targets were established and have become indicators of overall performance for the SCCP. They remain adequate to that purpose. The process used in developing the numerical SCCP targets has broader applications, especially for developing performance indicators for natural resource management programs where quality goals are pragmatic and realistic. In all cases where a numerical target relates to an indicator of resource condition, a sampling program needs to be designed based on sound statistical reasoning. A target compliance system developed without consideration of sources of variation in the target indicators, accounting for sampling error in decision making and how data will be collected is meaningless

CASE STUDY – MORETON BAY, QUEENSLAND

Ecosystem Health report card grades are generated for Moreton Bay and each of the major river estuaries in South East Queensland. Because Moreton Bay is large and diverse, grades are provided for each of the major regions of the bay. These reporting regions were differentiated by water depth and water residence time predictions.

Ecosystem health report card grades are generated from a combination of data analysis and expert interpretation of EHMP data. The process occurs in two steps:

1. Ecosystem Health Index => 2. Expert assessment => Report Card Grade

The Ecosystem Health Index (EHI) was developed during the 2002-02 monitoring year, to provide a quantitative and repeatable approach to assessing and reporting on the health of the region's waterways. In essence, the EHI is a measure of the area of the waterway that meets the water quality management objectives; these areas are referred to as 'compliance zones'. Experts also used the EHI in combination with their knowledge and understanding of waterway ecosystem health to generate report cards, which are used to communicate the effectiveness of coastal management action to managers and the community.

Environmental objectives have been defined in the South East Queensland Regional Water Quality Management Strategy. Monitoring data is compared to the environmental objectives to determine the spatial area within a region that complies with the objectives, the greater the area the higher its EHI value. For each indicator (related to environmental objectives) the annual median value at each of the monitoring sites was calculated and mapped. Median values for the areas in between sampling locations were then calculated using spatial prediction analysis and maps were then generated showing the spatially predicted median value for the monitoring period.

Within each reporting zone, the area of the zone that complied with the environmental objectives was referred to as the 'compliant area'. For each reporting zone and each key indicator, the proportion of the total area forming the compliant area was calculated. These compliance ratios were averaged across all key indicators for a reporting zone, generating a single number termed the ecosystem health index. (EHI).

Not all monitoring data was used directly in the calculation of the EHI values, particularly data that cannot be mapped. Monitoring data such as seagrass depth range, coral abundance and nutrient processing are examined by the scientific team and the outcome is then combined with the EHI values to generate the report card grade.

This entire program is a consensus, participatory, and non statutory partnership between industry, all levels of government, academia and the community. The term targets is avoided; performance is assessed against the report card. In our view this provides a useful counterpoint to our discussion.

RECOMMENDATIONS

Swan-Canning Cleanup Program

- Establish broader measures of ecosystem health, including biotic indicators of both river and estuarine condition for the next phase of the program in concert with the needs of the Swan regional strategy.
- Document all management activities related to SCCP in terms of location, size, and intended influence on nutrient reduction,
- Quantify a selected number of SCCP management actions so that efficacy, cost/benefit to purpose and contribution to achieving the targets can be determined,
- Implement monitoring programs for non-nutrient contaminants and if considered appropriate identify indicators and develop targets,
- Incorporate human health indicators such as pathogens and faecal coliforms, and
- Develop web based community reporting.

Overall Swan-Canning

- Reconcile the target setting frameworks of the EPP and the Swan regional strategy to avoid confusion and duplication of effort,
- Determine the role and responsibility for regulatory approaches,
- Develop robust but simple and transparent methodologies for target development and reporting,
- Collect process and system understanding information through both targeted investigations and well designed monitoring so that conceptual models relating target indicator behaviour and environmental health can be improved. Numerical and decision support models will also require information gaps to be filled.
- Collate and understand all stakeholder needs for targets, design criteria and performance measures and assist in providing these.
- The selection of numerical targets is not recommended unless a commitment can be made to appropriate compliance monitoring programs. In many cases non-numerical targets may be satisfactory

market equity
research and strategy

Market Equity Pty Ltd ACN 054 505 127
Level 1, 1292 Hay Street West Perth
Western Australia 6005

Postal: PO Box 984 West Perth WA 6872
Tel 08 9321 5415 Fax 08 9321 5463
Email marketequity@marketequity.com.au
www.marketequity.com.au

The Community Perspective on Drainage

A Report to the Drainage Management Forum
March 2004



a report for

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Executive Summary and Recommendations

Alongside the technical options for managing the health of Perth's rivers, another important consideration is how to effectively engage the wider community in the process. The community is integral to the solutions and ongoing management of the Swan and Canning Rivers, through responsibly using these waterways, fertilising their gardens and managing what flows into the system. The community may also have a role in funding the programs for managing the rivers.

Qualitative research consisting of three focus groups was conducted with a cross-section of the Perth general public to guide a community educational strategy and to assist the development of policy on a funding model for managing the rivers. The research explored current knowledge about the health of the rivers, and of the factors threatening the longer-term situation. Alternative funding options were presented and discussed, to determine which models the community is most willing to support.

The research shows that the community lacks any detailed understanding of the current state of the Swan and Canning Rivers, or all the contributing factors. There are different views regarding the current health of the rivers, and those who have close contact with the river itself (through recreational activities) are more inclined to see underlying problems such as litter and erosion of banks. Perceptions are largely based on personal observations of the river, and what people hear, or more often what they don't hear ('if there was a problem we'd hear about it'). There is widespread awareness of past algae blooms, based on media coverage, and these are viewed seriously. However, so far these major events have been addressed and are not necessarily seen as a long-term threat.

Despite having a limited knowledge of many details, the Perth community places immense value on the Swan and Canning Rivers on a number of dimensions, with lifestyle benefits being the most valued, as well as the icon status of the Swan River as an integral part of Perth's identity.

Ultimately, the response of the community to any proposed funding model will be strongly influenced by how the problem or challenge is presented to the community in the first place. The community has no clear understanding of the problem, and hence this needs to be explained first, with the associated funding model effectively matched. If there is an existing problem, then the community expects to be informed, educated and for the relevant agency(ies) to be addressing it. If there isn't an existing problem, the community still expects there to be responsible monitoring of the river and proactive management. There is seen to be an important role for some community education under any situation, given the importance of the river to Perth's lifestyle and identity.

Recommendations for a Communication Strategy

As the problems facing the rivers are not visible to the community (other than aspects such as litter) and therefore not widely understood, there is work to be done in explaining the current health and threats to the future health of the rivers. The importance of the river means that the community wants to be informed. At the same time, however, it will be important to inform the community about how these risks are being addressed, and what role the community and others can and should play.

The value placed on the river offers the opportunity for communications to be both positive and responsible. The recommended communication strategy should **involve the entire community in responsibly managing for the future**. This is in contrast to the alternative approach of engaging the community to fix a problem. The positive approach is proactive (which the community expects given the importance of the river) while a problem-solving approach implies there has been oversight and ignorance of the problem to date.

If there is rehabilitation to be done, and problems to be resolved, then **this also needs to be addressed and accompanied by an educational program to all those who have contributed to the problem**. The community also **expects to hear about the controls in place** for people or businesses that do not comply with controls, **and that these are enforced**.

Community education should be a major component of the communications, particularly informing all residents about positive behaviours in key areas such as fertiliser use. The community has been primed through other campaigns like those applied to water restrictions, and if modifying behaviour in fertiliser use will have a significant impact, then there is a virtual expectation that this will form part of an education campaign.

Considerations for a Funding Model

Despite the highly valued benefits of ensuring a healthy river system, the community is not currently open to accepting a pure 'beneficiary pays' model of funding. Any system of a separate levy or tax for a specified purpose is immediately viewed as the community being asked to pay for yet another problem, based on a perceived history of levies imposed to recover funds for various government overruns or bail-outs. There is some potential for the community to support a community-wide charge of some kind, particularly if people are made more aware of the issues and if the proposed solutions are also communicated. However, there is stronger support for a combined funding model that also penalises and discourages polluters from contributing further to the problem.

The success of any model for raising dedicated funds will be dependent on how the issues are communicated. With the right information, there is scope for the community to share the cost to be responsible managers of the rivers, but there is likely to be resentment if the community is asked to fund a program to fix problems that were created by someone else and could have been avoided.

> *"Well personally I know I would pay more money if I knew the problem was going to get fixed. If you know that the problem is going to get better if you contribute a bit more then fine, because it makes me angry when I see all this stuff that is happening, so if I could pay, I would."*

The more immediate reaction of the community is for the river to be managed by the relevant agencies (they do not know or necessarily care which ones), and for this to be funded from general taxes. If existing taxes are unable to fund these programs, some people favour a general increase in taxes rather than presenting the charge in the form of a separate levy, given the scepticism surrounding levies – *"once they are there they never take them off"*.

Whatever funding model is selected, it will need to be in line with the issues as presented to the community (ie, polluter pays to fix a problem, or community pays to preserve for the future). Also, the proposed application of those funds and timing of solutions needs to be communicated alongside.

Objectives and Approach

The community is integral to the solutions and ongoing management of the health of Perth's rivers. The community is the major user and a major beneficiary of the rivers, while also contributing to the rivers' declining health. The community is also one potential source of funding to enable proper rehabilitation and ongoing maintenance of the river system. As an input to the Drainage Management Forum in March 2004, market research was conducted with Perth residents to establish the underlying awareness, knowledge and perceptions towards the Swan and Canning Rivers and, in particular, the health of the rivers. The research also gathered feedback on potential funding options, to guide policy decisions about how rehabilitation and maintenance programs should be funded.

The core objectives of the research were to:

- Inform the extent to which an educational strategy is required to improve community awareness, attitudes and behaviours.
- Guide policy on a funding model, based on whether the community accepts the need for funds to be committed to address the health of the river.

The research was qualitative in nature, applying an exploratory approach to understand how the community currently thinks and behaves, and how the community would react to alternative methods of funding. The discussions focussed on listening to how the community currently thinks and feels, with limited information provided about the extent or nature of current problems. The main stimulus into the discussion was presenting three alternative funding approaches for discussion:

Option 1: Those who contribute to the problem pay (a tax, licence or fine as a result of an event).
Option 2: Those who benefit from the river pay (eg, through a levy, tax or rate).
Option 3: A combination of both contributor pays and beneficiary pays.

Three focus groups were conducted on 18 and 19 February 2004. Each group comprised between 7 and 8 people, all drawn from the general public and allocated into groups on the basis of where they live, as follows:

Group	Residential Location of Participants
1	**Affluent river suburbs** – Alfred Cove, Attadale, Applecross, Mt Pleasant, Nedlands, East Perth, South Perth
2	**Other river suburbs** – Maylands, Belmont, Rivervale, East Fremantle, Guildford
3	**Non-river suburbs** – Greenwood, Darlington, Tuart Hill, Girrawheen, Jandakot

During the recruitment process, anyone with a strong involvement in a community, environmental, government or other body connected with the river was excluded, to ensure we were speaking with the general community rather than people with a heightened interest or knowledge.

The moderator and author of this report, Julie Beeck, is the Managing Director of Market Equity and has 15 years experience conducting research in WA. Over the last 6 years Julie has worked closely with the Water Corporation on many community consultation projects covering topics such as water restrictions, wastewater re-use and water quality.

Detailed Findings

Awareness and Knowledge in the Community

"The average person doesn't really stop and think where it all comes from."

The Perth community loves the River. Everyone has their own interactions with the river, and memories often going back to their childhood. There is an understanding of what areas comprise the Swan River versus the Canning River, even if the precise spot where the two rivers join is unclear to most people. Also, there is common recognition of the concept of water flowing downstream from the hills 'and beyond', and of seawater mixing upstream from the ocean, in the lower reaches. There is a broad appreciation that stormwater run-off from houses and roads makes its way into the river, either via drains or through the groundwater, and therefore an appreciation that households can impact the river through what they put on their garden or what they tip down the stormwater drain.

However, residents have a very superficial knowledge of all these aspects, and low knowledge of the less visible elements of the drainage system, such as linkages to urban wetlands or the effects of run-off from inland farming communities.

The community's understanding of the river and drainage system is based purely on observation, so the more someone has been exposed to various elements, the more they know. For example, people who have lived in the upper reaches of the river system or in farming communities have a greater sense of the origins of the river. For most people, however, their considerations of the river system are largely based on everything within the metropolitan area, and above ground.

What is the Health of the River?

"I think it's probably doing all right."

Across the community there are clearly different views regarding the current health of the rivers. Typically those who have close contact with the river itself (through recreational activities) are the people who consider there to be underlying problems that need to be addressed. The Canning River was seen to be in worse shape than the Swan River, due to it being a smaller waterway with less water flowing through. However, residents broadly believe that the Swan River system is in reasonably good health, and that past incidents such as algae blooms have always been addressed and overcome.

People's impressions of the health of the river are based on their personal observations, as opposed to what they read or hear from other sources. This explains why any underlying concerns about the health of the river are most evident amongst people who get close to the river on a regular basis – through recreational boating, fishing or other activities that take them into the water. Perceptions of the health of the river are not necessarily a function of how close people live to the river, but rather whether or not they actively get close to the river – in it or on it. Even people who regularly walk or recreate around the river's edge have a fairly positive impression of the overall state of the river.

There are varying impressions of whether the health of the river has changed over the last generation – some people have a general impression that the water is not as clean or clear as it was in their childhood. Others, however, believe that the river is in better shape than it was several years ago, due to the work done as a result of spills or algae blooms.

The following quotes illustrate the range of views regarding the general health of the rivers.

Many People Consider There Is No Major Problem

> *"I think it's probably doing all right. I don't feel it's any different now than when I was a kid. I was raised in Como so we used to do our swimming lessons in the river. We always got ear infections and there were 101 jellyfish fighting for the prize positions, but I am certainly happy about my kids swimming in the river."*
>
> *"Compared to other parts of the world, I think it's very healthy because I've been overseas a lot but in general, in Australia it's not too bad."*
>
> *"If we had a couple of good seasons of rain, I am sure we would flush it out."*

"I think sometimes when it's windy and really choppy you actually see how brown the river really is and it's a shock. You only see that in different types of weather. But that's the nature of the watercourse that it is. It's actually a muddy sort of river; it's not a sandy sort of a river."

Some Feel the Rivers' Health Has Improved

"It's much better than it was before, but we are still having a lot of trouble with run off causing algae and it kills the fish."

"I think it's a lot cleaner than it was a few years ago. In my section between Canning Bridge and Mt Henry, it's probably the cleanest it has been for a long time. I wouldn't swim in it though, and I don't like my kids to swim in it, but maybe that goes back to my days at swimming lessons - the thing that turns me off is the jelly fish."

The Canning River Generates More Concern

"When I think of the Canning River, I always think of a very narrow, dead river and I always associate it with algal bloom. I just have this feeling that it's not as open and it's not as accessible, it's not as clean, it's not as appealing or inviting."

"The actual water itself - a lot of the times I refuse to get into (the Canning) because it is filthy."

Problems Identified by the Community

The major health problems identified by residents are:

- Litter – often associated with boating.
- Industrial waste entering the river unchecked.
- Erosion – impacts in specific areas by boating.
- Algae blooms – occasional and serious, but have so far been resolved with no lasting effects.

Litter

Litter problems were commonly mentioned, being very visible, and include rubbish and debris in the river or on the river banks. Oil from boating was also mentioned as a problem in specific areas.

"I think it's worse around ski areas. There is either rubbish thrown in, or you're tripping over it."

"There is a lot of oil scum from the ski boats as well."

Industrial Waste

This problem was not widely observed, even though most people acknowledge that it happens. A small number of people had seen problems or recalled past incidents (Ascot Racecourse being the best remembered incident).

> *"I think waterways that go along behind businesses, especially in Belmont, when they degrease and whatever they do - it goes straight into the Swan River and you can see there is all oil and there is rusty colours and all that goes straight into the river."*

> *"They always talk about they're going to fine these businesses or whatever and it's been there for years. You can walk there behind businesses and see it happening so why nothing has ever happened about it, I don't know."*

Erosion

Various people described problems of erosion of river banks, which they considered to be caused by boating, particularly ski boat areas.

> *"You get a lot of erosion now especially around the Belmont ski area – you can see where the paper bark trees have slowly died off because of the erosion in the banks and now they're under water and they tip into the water and they're dead. Over the years, it just keeps creeping up and now they're dead."*

Algae Blooms – These Problems Appear To Be Addressed

Everyone is aware of algae blooms and fish kills having occurred in the river in recent times. While this is seen as a serious issue and a cause for concern, people observed that the problems have been rectified and are a short term issue. Interestingly, the community's awareness of algae blooms and the occasional sewerage spill are the only observations that are driven by information gathered through the media, rather than through personal observation alone. Therefore, the serious nature of these events, and the high profile coverage given to them at the time, does raise the issue of the river's health in the community's mind. However, there have so far been considered to be short-term problems that can and have been rectified, and from the community's perspective, hopefully avoidable in the future.

> *"I was thinking that whenever there is a problem with the algal blooms or with spillages, it's always addressed very quickly and it seems to be fixed fairly quickly. They might say that the river is closed in a certain area but it's not for a very long period of time. I just think that they're on top of the situation and they're dealing with it as fast as they can and they have the resources to do that, otherwise they wouldn't reopen it."*

Some Impressions Are Instinctive

Beyond the observations, some people have an instinctive reaction that the river water is not completely clean and healthy, usually as a result of seeing the brown colour of the water. However, this instinctive reaction is not based on any detailed information.

> *"That's the funny thing because I have seen heaps of people fishing and I always wonder why. I wouldn't eat a fish that came out the river."*
>
> *"I was going to say that too – I watched a guy the other morning catching huge fish and they looked quite healthy but I thought to myself, there is no way I would eat that fish. I just don't really trust that the water is clean enough to eat the fish."*

The Community is not Equipped to make any Better Judgement

Group participants acknowledged in the discussion that they have no reliable means of really judging the health of the river. They base their judgements on a combination of what they observe in their normal daily routine, and also what they hear in the media – or more precisely what they don't hear. Therefore, when people observe the river to be attractive and relatively clean, with wildlife living in and around (birds, fish, dolphins as well as plants), they have no reason to question the river's health. On occasions where the weather stirs up the river, or a 'scum' appears on banks, or in locations where litter is more evident, the community sees a problem but associates it with the usage in that area or the conditions at the time.

This is reflected in the following comments:

> *"I don't actually know enough about what sorts of questions to be asking to actually decide whether or not there is something wrong (with the river)."*
>
> *"If there was a problem, we'd hear about it."*

When people start to think about the health of the river, and realise their level of knowledge, they quickly identify the need for regular monitoring, and anticipate (and trust) that this is already in place.

> *"I like to think there is a body, a Commission, that is monitoring it or looking after it and if there is a major issue, we will hear about it obviously through the media. But at the moment I don't think there is (a major issue)."*
>
> *"I would hate to think we would have to get to an emergency situation, I mean how do you fix it? It's a very big river. I think it's a bit scary to think that if it gets to a crisis point, how do you fix it once it gets to that point?"*

Who is Responsible for Impacting the Rivers?

"Everyone has some responsibility"

Given the low level of knowledge surrounding the actual health of the river, it is not surprising that the community also has a limited understanding of what or who is responsible for impacting on the river. Residents had a number of general impressions, again based on what they have observed, rather than any formal or secondary sources.

Awareness of What Impacts the Health of the River

The most visible factors affecting the health or the river were:

- Recreational use.
- Industry.
- Farming.
- Fertilisers.
- Pesticides and spraying.
- Climate.

The following comments from the groups illustrate how people understand these factors to impact on the river.

Recreational Use

Boating in particular was considered a major source of littering, as well as pollution in the form of oils and effluents (eg, people pumping out the toilets on their boats). This problem was linked to irresponsible use or over-use, rather than general boating being a cause for concern.

> *"People littering around the river, plastic bags and throwing things out of boats, emptying toilets out of the boats."*

Industry

Residents linked the problems to industry at large, rather than singling out any specific sectors. There was a common perception that there were insufficient controls on business to ensure they do not pollute the river, or that penalties are not imposed if it does happen.

> *"The vineyards, the residents – everybody is to blame. Probably some more than others, the big commercial places. Every year you hear of commercial spills into the river."*

> *"The lack of control on businesses...you know cooling tower water and all that kind of stuff goes down the stormwater drain."*

Farming

The effects from farming were associated with the growth in the number of semi-rural properties close to Perth, and some vague recognition of the effects from farming activities inland. However, farming effects were mostly associated with properties situated close to the river, which draw on the river for water or have immediate run-off into the river.

> *"Mainly people taking water out before it actually gets down so the flow of water is reducing. More people are up there, I know a friend who had a creek and he could actually pump it up into his garden so if everyone on their 5 acre block did that, I am sure that it would eventually drop down so less water is coming down so it's becoming slowly sluggish."*

Fertilisers

There is general understanding that fertilisers are impacting on the river, and this is recognised as a problem created by everyone. Large volume users such as golf courses were expected to contribute more to the problem than households.

> *"The problem is due to poor management – there are a lot of man made products going into the river nowadays – we are farming and everything like that and the amount of fertilisers we put on our gardens are probably a hell of a lot more than we used to. Everyone over-fertilises lawns and it's got to run off somewhere, and the river is where it runs off to."*

> *"Yes householders have got a certain responsibility (from fertiliser), and then it sort of passes on to whoever is running the waterways".*

Insecticides and Spraying

> *"Councils do it from time to time if there is a mosquito problem, and it would be done privately too, but Councils are known to spray if there is a mosquito problem."*

Climate

High temperatures and low rainfall are also linked to quality problems created when the river is not flowing fully.

> *"The climate has got warmer too. And it doesn't get flushed out – once it's in, it's in. Remember what Mandurah was like 10 or 15 years ago compared to what it is now."*

Awareness of Who is Responsible for Managing the River

Participants in the focus groups expressed a limited knowledge of the role of various groups involved with managing the river. The Swan River Trust was the best known organisation, and was seen (or expected) to be responsible for activities ranging from water testing through to applying regulations on building and development around the river. Other organisations mentioned include the Water and Rivers Commission (associated with managing the use of bores), CALM and EPA (both having a general role in environmental management) and local government (acting on a local level).

There was very low awareness of programs such as the Swan Canning Clean Up – the name was recognised by only one person across all three focus groups.

While residents expected there were management activities in place, they perceived there to be a lack of visible, ongoing management, and also a lack of visible regulation or guidance. For example, in the case of household use of fertilisers, there was no known direction for households on what represents responsible use of fertiliser. This reinforced attitudes that the rivers are not under threat, otherwise something would be said and done about it.

Is Anything Being Done About It?

> *"Not really. They keep saying we need to fertilise less and that but there doesn't seem to be any controls put in place to do it."*

The Value Placed on Perth's Rivers

> *"It's the heart of the place - it's the centre of everything. I can't imagine what Perth would be if the river wasn't there."*

Even though the community has limited knowledge of the factors impacting on the Swan and Canning Rivers, this does not detract from the immense value placed on the rivers by the Perth community. While the issues were being discussed in focus groups, people recognised that they take the river for granted. Further, if the health of the river did decline, or was already under threat, the community would be alarmed that such a valuable icon of the city had been allowed to degenerate.

> *"I am just realising this sitting here tonight, how very ignorant I am of the sorts of things that impact the health of the river. Now, if I don't know that, and most of the kids at school don't know that – they are living in a city that has one of the most beautiful rivers and unless they're educated as to how to keep it that way… it's not going to be a lot of good for somebody to turn around and say – 'hang on guys, we've got a problem here' "*

The Swan River in particular is highly valued by the community on a number of dimensions. The Canning River is also part of the same system and is therefore also highly valued, other than the fact that it is less central to the identity of Perth.

The value of the river is described in terms of:

- Lifestyle value – first and foremost.
- Icon value – Perth's identity.
- Nature value – both from an aesthetic beauty and an environmental perspective.
- Financial value – in real estate terms.
- Historical significance.
- Economic impact – via tourism.

The comments below are taken from the focus groups to illustrate the ways in which residents value the Swan (and Canning) River.

Lifestyle

In so many ways, the river influences the day-to-day lifestyle of people in Perth. This is highly apparent amongst people living near the river, who use the river and foreshores as an extension of their own recreational space. For people living away from the rivers edge, there are still a variety of lifestyle benefits, although less frequently used, from family picnics to attending major events hosted in and around the river (eg, Australia Day Skyworks).

The diverse lifestyle benefits of the river are seen as the single greatest value, which touches each and every person in some way.

> *"If you want a holiday and you are close to the river, you can do anything you like and have a damn good rest without going somewhere. There is always plenty to do around the river, not necessarily going into it - there is just so much on and around it that as long as it's there and you've got access to it and it's clean and maintained, it's a very, very soothing atmosphere."*

Icon Value

In many ways, the city represents Perth, and identifies who we are. People expressed various ways that the river defines Perth and its people. This icon value represents something that is difficult to put a value on, and makes it hard to imagine things being any other way.

> *"It centralises the city – everything branches from it. It is quite interesting how it divides the city to north and south."*

> *"It's a part of defining Perth. If I meet somebody who is also from Perth, the first question they ask me is am I north or south of the river – it's almost how we define ourselves in terms of our location around the river."*

Natural beauty

The rivers are considered to be in their natural state (or close enough to still be considered a natural waterway). The ability to have a natural waterway through a built up city is a prized asset for Perth, particularly as there is extensive access to the river for everyone to share.

The natural value of the river is also linked to the flora and fauna that the river supports. While there are observations of the environment being impacted in areas, the positive aspects are widely observed and highly valued.

"It has a natural beauty about it which we've built around without having developed it to a stage where it becomes fake."

"The other thing is, near us they have got a bird sanctuary that they've developed and you walk down there and you see so many birds that you've never seen before."

Financial – based on real estate values

"You've only got to buy a house down by the river to know how valuable it is."

Historical significance

"Well it's the reason that the city is here; that's why they chose this spot."

"The Old Mill used to be linked to the river and they bought in the wheat for milling there – they used to just have a canal coming in and quite a few of the landings are still around"

Economic value – as a tourism attraction

"It's an attraction for the city, for tourism."

Reactions to Funding Options

"The community is going to see it as yet another burden"

Residents reacted predictably to the concept of needing additional funds to rehabilitate and ensure the ongoing health of the river – the initial reaction was that management of the river should be funded by state government, through general tax revenue. This is an understandable reaction given the low awareness of the factors impacting the river and the threats to its ongoing health.

On the basis that additional funds are needed, beyond the current resources of government, group participants were presented with two alternative methods for generating dedicated funds – the Polluter Pays model and the Beneficiary Pays model. A third option was also considered, of applying both models together.

Reactions to the two models were based on considerations of fairness, and also the most effective way of raising sufficient funds to address the problem. The appropriateness of each model was also dependent on the current health of the river and therefore the nature of the problem to be addressed: **is it a problem that needs to be solved, or an asset that needs to be protected?**

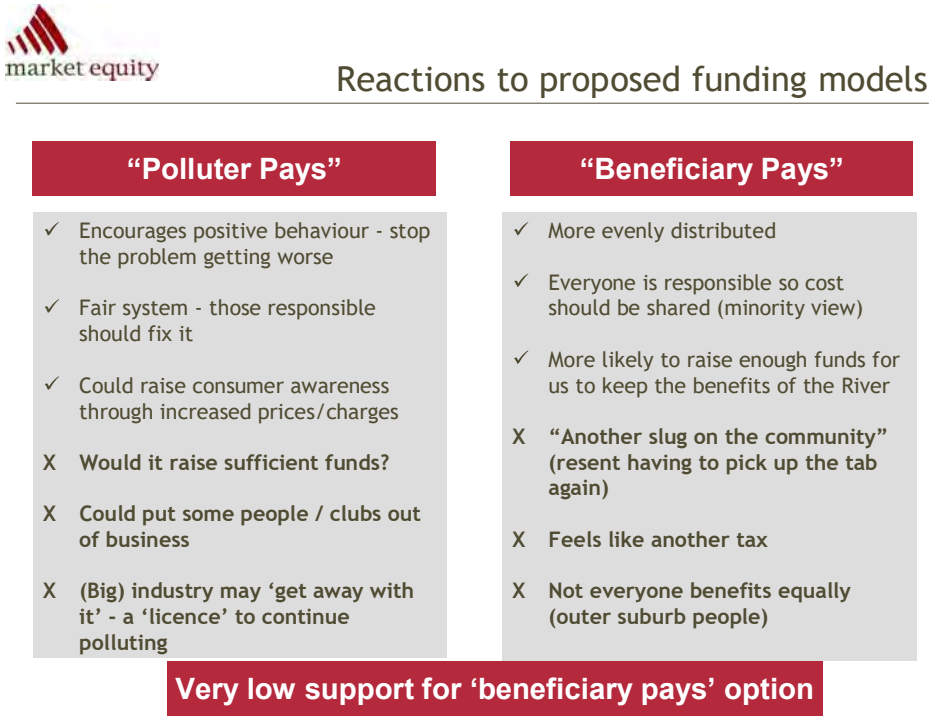
- If the river is already seriously impacted by pollution, then those responsible should be required to fund the recovery, and we need to implement a mechanism to modify poor behaviour and avoid further pollution happening.
- If the focus is protecting the river from impending threats, then it makes sense for beneficiaries (and the community as the current custodians) to share the cost for future benefit. Also, in these circumstances there is unlikely to be sufficient funds raised through a polluter-pays model to make an impact.

In the case of the "polluter" being farming practices of past generations, or the retention of pollutants in the soil until land is redeveloped, then residents accepted that the person responsible for the pollution cannot pay for the recovery costs, and so the responsibility falls on the current community, or the current landowner, to rectify the situation for the future benefit.

Ultimately, the response of the community to any proposed funding model will be strongly influenced by how the problem or challenge is presented to the community in the first place. The community has no clear understanding of the problem, and hence this needs to be explained first, with the associated funding model effectively matched.

Based on people's current knowledge, the most common reaction was that **a combined model was the most appropriate option**. There were some people in favour of each individual option, and their views reflected the pros and cons of the two alternatives. However, there was considerable opposition to the concept of beneficiary pays, in the form of a dedicated tax or levy, based on past experience with similar state government levies.

The pros and cons of each individual option are summarised in the chart below:



Neither option satisfies all concerns. Some of the reactions are illustrated in the following comments.

Option 1 - Polluter Pays

There is a sense of fairness in this option, with those causing the problem having to pay. But if this cost is passed on, and the consumer ends up paying, the principle of 'fairness' is less clear. Also, if the result is modified behaviour, then there may not be sufficient funds to address existing problems.

> *"If you go with the combined option, industry gets hit once, we get hit twice because we would get hit with our own levy plus passed on costs from the industrial side of things. At least with this option, I get the choice. If I know I am doing as much as I can, then I don't see why I should have to pay (a levy)."*

"Initially it sounds good that the people who are making the rivers dirty should contribute to cleaning them up. But then when you look further and see that costs will likely be passed on to consumers, it's less attractive."

"Just the fact that they do start increasing the cost for the consumers - that just makes you so aware of things. It's like handballing a problem rather than fixing it."

Some group members suggested a more positive approach might be better, based on incentives rather than penalties. Others indicated that any polluter pays approach must also be accompanied by education regarding the appropriate guidelines.

"Instead of a punishment, have a positive reinforcement – incentives to behave correctly. The community in general would be far more willing to fund something that is more positive, so instead of taking a negative wrap over the knuckles if they don't do it right, give a lollipop when they do."

"You can't hit the industry without at the same time giving them clear guidelines and you've got to inform the public as well on the way of using products or not to use them."

Option 2 - Beneficiary Pays

The initial reaction to this option was not as a beneficiary pays model, but as another 'tax' imposed on the community to pick up the cost for something that is outside of their control. It was immediately compared to other levies for debts or cost overruns incurred by government, which have all created a level of resentment and resignation. There was some appreciation that this time around there was actually a benefit to be gained from paying the levy or tax, but that was not sufficient to create wide support for the principle.

"I think taxpayers have been hit for so many things in the past, levies and things like that that, we have no control over and have no interest in either."

"The GIO insurance thing - were still paying for and that whole Bond thing or that Laurie Potters thing, we all paid for that and I could never see the sense because it didn't really relate to me. But everybody uses the river, it's where we live."

A Beneficiary Pays Approach Would Need To Be Accompanied With Details on How It Will Be Used

"If you're paying, you want concrete evidence that that money is going back into the Swan River and Canning River – where, what is happening, what is changing, what is being beautified, what is being improved."

"If there are solutions, it would be good to know and then you wouldn't mind paying."

The Need for Communications

> *"Because of the dominance of the river here, I would like to see a really intensive education program on how we keep (the river) healthy, rather than trying to make it healthy once it gets into trouble."*

Beyond the consideration of funding options, the community strongly endorsed, and frequently suggested, the need for communication and in particular, education. This raises a potential challenge, as raising the community's awareness of the issues immediately creates the expectation of a solution, and raises questions about how the problem was allowed to happen in the first place.

Therefore, it is important that solutions are known and understood, so they can form part of the communication. Also, the nature and extent of the problem needs to be reflected in the solutions and any proposed funding approach.

The specific communications needed, based on the feedback from group members includes:

- **Informing people of the actual health of the river**
  - This research indicates that people who are more aware of the problems are far more supportive of contributing to solutions.
  - However, these people are the active users of the River and have much to gain personally.
  - So there is no guarantee the rest of the community would respond as positively once they know the extent of the problem.

- **To gain support, the community will need to see the plans** - what is to be done, what it will cost and how long it will take.

- And, the community needs to understand what would happen if we did nothing.

- Another perceived gap is community education on how to ensure everyone protects the river – in particular responsible use of fertiliser.

> *"That's what I was getting at before, there is not a lot of good having a Government body sitting at the top of the whole thing monitoring the health of the river - if the community at large is not educated on how to stop it from getting sick in the first place."*

"But after the horse has bolted, it's a little bit late. I am just realising tonight just how very ignorant I am about a whole pile of things".

"They've got enough ads to do the "save the water" - they should start a program and see if they can educate people to cut down fertilising their lawns."

"Maybe when they put the Fuel Watch on every night, they should put a River Watch on!"

"If the Water Corporation sent me some thing addressed to the householder informing me of some of the stuff that I had learnt here tonight, I would have read it, I would have paid attention to it and I would have been completely shocked by a lot of it and I would have made sure I would have sat down and spoken to my kids about it".

Concluding Comments

This research sets the foundations for developing an effective and comprehensive communications plan. We know from past experience that getting detailed and potentially technical messages to the wider community is challenging, particularly on aspects that are not visible (eg, the impending effects of rising nutrient levels). The strategy calls for a detailed program of information across multiple media, to raise awareness of the issues and educate people at the same time. This will require collaboration across various agencies, to ensure a consistent message.

The Directors and staff of Market Equity would like to thank the Water Corporation for the opportunity of working on this project and we look forward to seeing the outcomes of the Drainage Management Forum.



JULIE BEECK
Managing Director

Ref: R 3493

WATER SENSITIVE URBAN DESIGN AND THE DEVELOPMENT APPROVALS PROCESS

IDENTIFICATION OF ISSUES & POTENTIAL SOLUTIONS FOR BETTER IMPLEMENTATION

Prepared for the Department for Planning and Infrastructure
By Essential Environmental Services
March 2004

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Client: Department for Planning and Infrastructure

Report	Version	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
Preliminary Report	V1	SSh	MMo, RGr, AMo & J H-K	Electronic	24 Feb 04
Draft Workshop Report	V2	SSh	MMo, RGr, DNu	Electronic	10 Mar 04
Draft Report	V3	SSh	MMo	Electronic	12 Mar 04
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EXECUTIVE SUMMARY

This report provides a review of the regulatory/statutory framework for the implementation of Water Sensitive Urban Design (WSUD) through the statutory approvals process, together with a preliminary assessment of the barriers to implementation in Western Australia.

Information contained in this report was obtained from an assessment of the WAPC/DPI policy framework, the local government planning system and discussions held with a number of key players in Local and State Government and the private sector (see Appendix 1).

Summary of Findings

Before WSUD can be effectively implemented on the ground, several obstacles should be addressed. These involve the lack of regional perspective with respect to drainage, confusion with regards to "who does what" within Government and a lack of commitment to implementation exhibited through a lack of effective funding.

Also critical, is the lack of water quality and quantity targets, standards and criteria. Without this information, it is very difficult to design appropriate and effective treatments. This is the responsibility of the "water agencies" to determine.

State and local government planning has the largest statutory role to play in the implementation of WSUD, primarily through the State and local government planning approvals system. As a component of WSUD is about optimising the impact of urbanisation on the water cycle, the assessment of new development is an appropriate time to ensure the principles of WSUD are incorporated into the approval of new development.

Key tools appear to be the planning policy framework, structure plans and subdivision conditions, however the most important issues and areas of concern relate to implementation on the ground – detailed design and implementation of specific WSUD treatments and on-going maintenance. Most concerns relate to the perceived cost of installation and maintenance and the lack of data on performance of treatments.

Recommendations

- Clarification of the roles and (most importantly) responsibilities for implementation of WSUD across Government, focusing on the "lower end" of the process, particularly as it relates to the roles and responsibilities of referral agencies
- Develop appropriate water quality (and quantity) targets on a "catchment" or biophysical unit basis for key threatened environments such as the Swan and Canning Rivers
- Improve the WAPC/DPI policy framework through the finalisation of the Water Resources SPP and the incorporation of Liveable Neighbourhoods principles into Development Control policy

- Develop new standard conditions (both specific and general) to enable statutory planners to impose WSUD conditions more easily
- Develop or modify the water quality monitoring framework to incorporate appropriate feedback systems to ensure that there is a process of continuous improvement with regards to implementation.
- Review and consolidate information on cost/benefit analysis of WSUD treatments in comparison with conventional drainage structures and release the information to key stakeholders
- Implement demonstration projects and ensure that their performance is reviewed over the medium to long-term The projects must involve monitoring, assessment, evaluation and extension of results to ensure ongoing learning within the profession.
- Develop an "easy-to-read" brief summary of what WSUD means to a statutory planner to aid in the imposition of appropriate and effective conditions.
- Undertake work and/or consolidate information on infiltration and nutrient export rates of WA soils and nutrient uptake of soils and grasses
- Review the appropriateness of the Australian Rainfall Quaility (ARQ) Guideline for their applicability to the Western Australian context.
- Development of a Communication Strategy for the new ARQ and training for LG engineers to ensure effective capacity building
- Further develop specific, technical guidance for local government engineers consistent with the draft ARQ Guidelines and the up-dated Stormwater Management Manual. This information must be based on Western Australian conditions and should recognise that every situation has its own characteristics, that some techniques may not be appropriate in all situations, and acknowledge the expertise of local officers – "local knowledge".
- Increase focus on planning and design of WSUD treatments particularly the demonstration and review of Best Planning Practices design solutions.
- Develop a Communication Strategy to raise the awareness in the general community of the importance of WSUD in urban areas. Until stormwater is looked at as a resource rather than a waste, we will be unable to achieve significant progress.

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WSUD AND THE DEVELOPMENT APPROVALS PROCESS – OPPORTUNITIES FOR AND BARRIERS TO ITS IMPLEMENTATION

INTRODUCTION

This report provides a review of the regulatory/statutory framework for the implementation of Water Sensitive Urban Design (WSUD) through the statutory approvals process, looking at the barriers to implementation in Western Australia and suggesting solutions where possible.

Information contained in this report was gathered in two stages. The first stage involved an assessment of the WAPC/DPI policy framework and the local government planning system. Discussions were also held with a number of key players in Local and State Government and the private sector.

This provided insight into the issues and allowed the development of a framework for a half day workshop designed to draw out and document issues. The workshop, the 2nd Stage of the study, was held on 26 February 2004 at the Grand Chancellor Hotel in Perth.

BACKGROUND

Recent and recurrent algal blooms in the Swan River are of significant concern to the community. Management of urban drainage has a significant role to play in reducing nutrients and sediment entering the Swan and Canning Rivers.

WSUD is one tool in a suite of mechanisms that may be used to improve water quality and provide other environmental/ecological benefits, as it is able to improve the water quality of runoff entering rivers and groundwater. The benefits of WSUD are generally acknowledged but implementation on the ground is limited. Therefore the Department for Planning and Infrastructure (DPI) and the Swan River Trust (SRT) are investigating whether the statutory land use and development control mechanisms available are adequate to achieve WSUD outcomes.

This project has been initiated as a result of discussions held at the Swan Canning Catchment Drainage Management Forum in November 2003. The output from this study is being presented to the second phase of the Swan Canning Catchment Drainage Management Forum to be held on 29 March 2004.

STAGE 1: REVIEW OF WSUD AND THE PLANNING SYSTEM

State and local government planning has the largest statutory role to play in the implementation of WSUD, primarily through the State and local government planning approvals system. As a component of WSUD is about minimising the impact of urbanisation on the water cycle, the assessment of new development is an appropriate time to ensure the principles of WSUD are incorporated into the approval of new development.

There is a large range of planning tools, both statutory and strategic, that can be used at different stages of the planning process to incorporate WSUD into new developments. These are depicted in Figure 1 and listed in Appendix 1, together with the mechanism through which WSUD outcomes may be achieved. The table in Appendix 1 also contains other information relevant to the discussion.

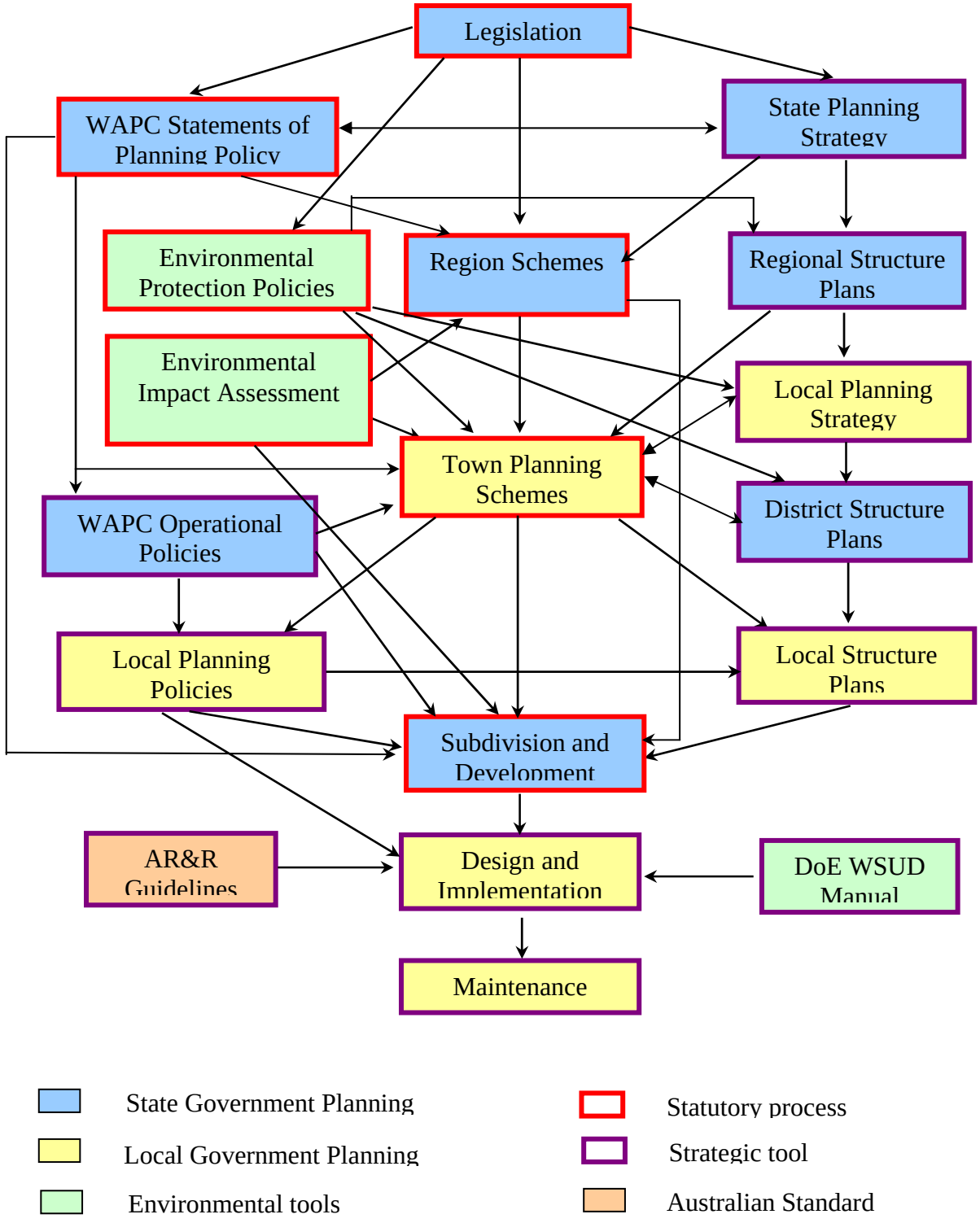


Figure 1: Development approvals process

Preliminary assessment suggests that the existing policy framework is sufficient, as it provides support for urban water management and WSUD at all levels of the process (See Figure 2). This is not to say that the policy framework is complete, as improvements can be made (and are being made) throughout the process.

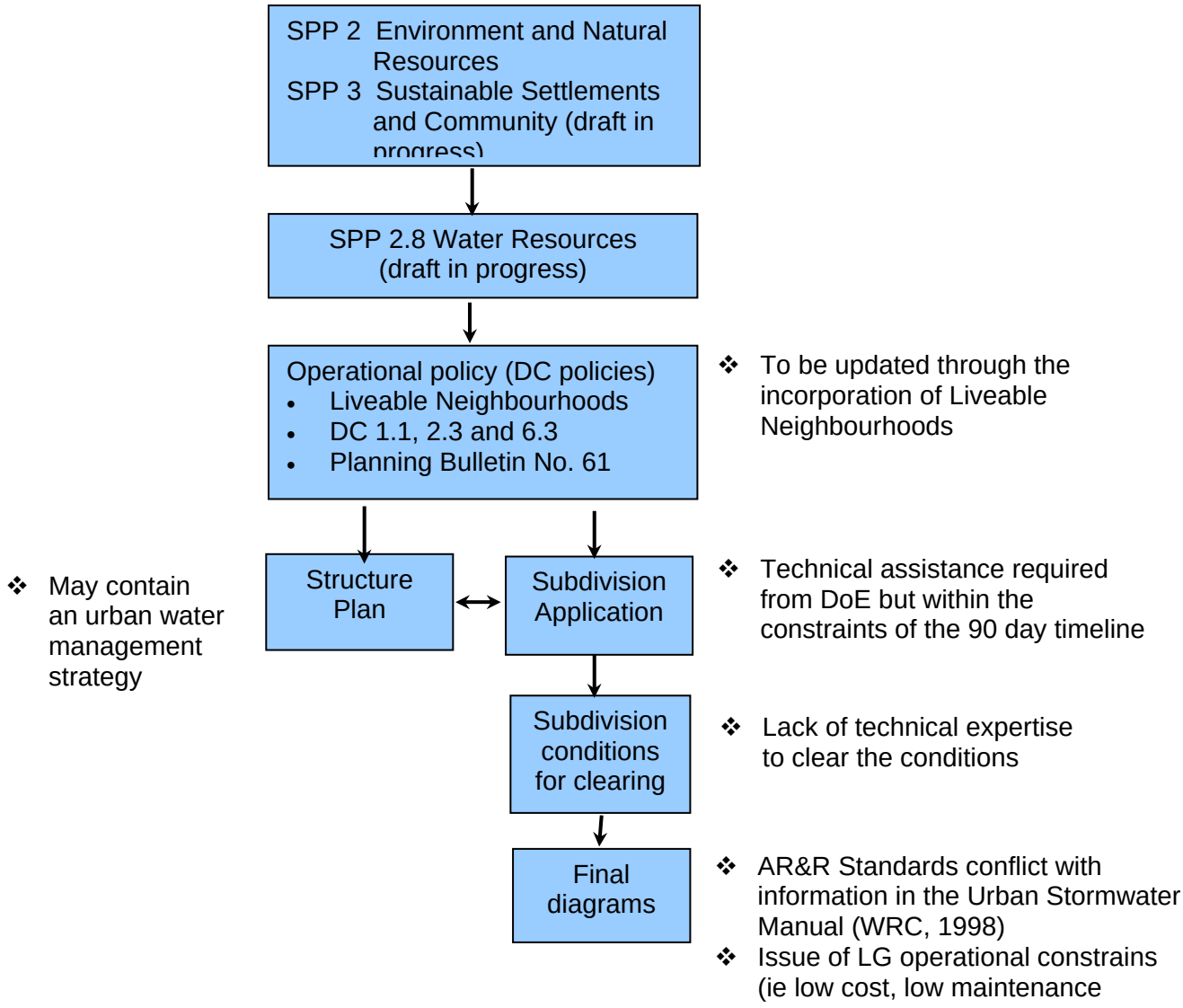


Figure 2: Key elements and considerations in the process

The part of the statutory approvals process where most of the progress towards implementation can be made is at subdivision, through the setting of conditions on the development. Current practice is usually to place the standard drain and fill condition ("Land being filled and/or drained at the subdivider's cost to the satisfaction of the WAPC"), together with the standard main drainage condition ("Certification from the Water Corporation that arrangements have been made with that body with respect to the drainage of the land either directly or indirectly into a drain under the control of the Water Corporation") on the approval with an Advice Note that may recommend a particular WSUD approach. For example, the advice note may refer to the preference

against installing drainage sumps and/or that the existing drainage patterns of the POS should not be disturbed or modified.

Improvements could and should be made with regards to the standard conditions, to make it easier for planning officers to require WSUD treatments. Conditions would need to be quite specific, however, to give the developer enough guidance to install the correct treatment, yet they still need to have the flexibility to apply to the wide variety of situations that occur.

Improvements in the wording of advice notes could also be achieved if more specific advice was received from DoE, rather than the recommendation to ensure that drainage was consistent "with WSUD principles".

An issue was raised as to the responsibility for clearing conditions on approvals. As the WAPC or the local government is the clearing authority on the majority of conditions, in-house expertise would be necessary to assess WSUD plans to clear these conditions. Town planners do not have the tools or technical skills to determine whether a proposed WSUD treatment train would facilitate compliance with water quality objectives (once they are defined). Local Governments also lack the in-house technical skills required to quantitatively assess the water quality outcomes of WSUD proposals.

Local Government is supportive of WSUD however there is a significant deterrent to its implementation in that the Australian Rainfall and Runoff Guidelines (AR&R) – the Australian Standard for stormwater drainage, do not acknowledge WSUD principles. This standard, if applied, protects the engineer from being liable for damage in the case of a flood. Many engineers therefore do not want to design treatments that are not consistent with the AR&R Guidelines. These guidelines have been revised to incorporate WSUD principles and are currently out for public comment, but their finalisation is at least a year away.

Another impediment to implementation at the local level is the perception by developers and the community that WSUD treatments are more expensive to install and maintain than conventional drainage, and are generally not aesthetically pleasing. Some local government engineers (generally those that have a long history of dealing with WSUD principles) understand that the stormwater management elements of WSUD can be implemented without significantly greater cost to their Council, yet there remains uncertainty as to the ongoing maintenance cost, as well as the replacement costs if the WSUD treatment train fails to provide effective flood and/or water quality protection.

This uncertainty reflects the lack of information in the professional and public arena regarding WSUD. Good, clear technical information available to local government is critical to this form of urban water management being accepted by local government, developers and the public. Unless local government is seen to support WSUD, few developers will try to incorporate it into their designs for fear of increasing the time taken to approve their drawings.

There is also a perception in Local Government that the State Government agencies responsible for providing advice do not take local conditions into account. It is clear that every application should be assessed on its particular circumstances, and what might apply in one instance will not necessarily be appropriate in another, for example, some WSUD treatments may not be appropriate in areas of high water table.

Moving from the local level to the regional level, there is a need to take a catchment approach to manage the overall quality and quantity of water resources, not just focus on drainage. There is a lack of regional guidance regarding drainage and urban water management. It is not clear though who would be responsible for the preparation of a strategic plan for drainage, however, nor who should set the standards and performance indicators for development. It is imperative though that good baseline data is obtained before water quality objectives are set.

WSUD is not just about drainage or stormwater management. It is also about water supply, sewerage and water recycling and re-use. Wastewater re-use and stormwater harvesting is not currently supported because the Department of Health and Water Corporation have yet to provide a statutory environment supportive of grey water re-use. This uncertainty has discouraged the building and land development industry from integrating such systems into their designs, although the majority of local governments are ready to support grey water re-use once given the mechanisms to do so.

Discussions with key players also revealed that there were some over-arching issues associated with the achievement of WSUD outcomes – not just in relation to specific stages in the process. These issues are:

- The institutional arrangements complicate the implementation of WSUD as no one agency is responsible for urban water management from top to bottom
- There appears to be no technical assessment of on-ground performance of WSUD Best Management Practices (BMPs) in Western Australia
- Technical information specific to WA is limited as most BMPs are derived from experiences in the eastern states. Therefore there seems to be no agreed approach to best practice that works well in WA.
- Can and will WSUD actually achieve a good outcome for the Swan Canning Catchment? How much impact will changing the water management of new urban areas actually affect the river system?

These issues (and others) were raised at the workshop for further discussion and so are discussed in greater detail in the next section.

STAGE 2: WORKSHOP

As previously stated, information gathered from Stage 1 of this study was used to scope issues that required further discussion and resolution by a cross-section of relevant stakeholders and practitioners. Attendees at the workshop were drawn from varied agencies, including the Department for Planning and Infrastructure (DPI), Department of Environment (DoE), as well as Local Government, the water engineering fraternity and the development industry. A list of attendees is contained in Appendix 2.

The aims of the workshop were to:

- identify the land use and development control mechanisms available to implement WSUD;
- assess their adequacy;
- identify barriers to implementation; and
- propose solutions to issues identified.

The workshop was organised in two parts. Part 1 involved a discussion of over-arching issues, while Part 2 looked at the development approvals process and barriers and solutions to implementation. This report discusses the outcomes within this framework.

Attendees were organised into 5 groups. Each group committed their combined thoughts to paper. These are contained in Appendix 3 and 4 for Parts 1 and 2 respectively.

Part 1: Over-arching issues

The first part of the workshop focussed on over-arching issues affecting the implementation of WSUD in the Swan Canning Catchment and WA generally, as identified from the first Stage of this study. Four issues were provided to the workshop and attendees suggested additional ones where appropriate. Key findings are provided below. The issues identified by each group are transcribed in totality in Appendix 3.

1. Institutional arrangements complicate implementation of WSUD as no one agency is responsible for urban water management from top to bottom

No one agency has the overall responsibility for the drainage system. This leads to confusion in the system and the community with respect to water quality outcomes. It is also likely that it results in duplication of processes and governance and leads to inaction on the issue as a whole through lack of acknowledged accountability.

There also appears to be a lack of an agreed approach to the incorporation of WSUD into new development. It is not clear which agency should be contacted for information and advice, nor what information is required at the different stages of the process.

Causes

- Lack of clarity of roles and responsibilities of various agencies
- Lack of effective legislative tools
- Not regarded as proven by professional associations/ practitioners
- Limited or ineffective funding commitment – retrofitting and maintenance have perceived high costs

Solutions

- Need a champion/leadership agency
- Clear definitions of responsibilities between the planning and water agencies including those that are shared and the processes through which the issues be resolved
- Good government examples of commitment and funding
- Statutory instruments which require controls on subdivision and developments
- Clear design guidelines

- Regional & local water management plans

2. No technical assessment of on-ground performance of WSUD BMPs

There is limited data available to conclusively demonstrate the effectiveness of various WSUD treatments in achieving improved water quality outcomes under WA conditions. Additionally, there is a lack of information regarding long term performance and local government are not convinced that the cost of implementing WSUD treatments will not 'blow out' in the long term.

Causes

- Lack of monitoring data
- Perceived cost of monitoring and performance assessment
- Who has overall responsibility?

Solutions

- Establish a Statewide monitoring and evaluation framework to accelerate learning
- Government needs to show leadership through pilot projects and demonstration sites
- Increased professional education and training among developers with subsidies and planning concessions
- Government can then get involved and do the monitoring and evaluation of the innovations

3. Technical information specific to WA is limited – there is no agreed approach to best practice

Land capability information suggests that a single or narrowly based approach to application of Best Planning Practices (BPPs) & BMPs is not appropriate. For example land with high water tables is poorly drained and often waterlogged and/or seasonally inundated. This reduces the opportunity for in-situ infiltration, which reduces bio-chemical interaction and nutrient uptake (particularly for nitrogen). It also increases the volume and flow of surface run-off into the river system.

The original design philosophy of WSUD was based on the concept of site responsiveness. That is that solutions (i.e. application of BPPs & BMPs) needed to be driven by a process of clarifying local or regional receiving environment targets and appropriate site or bioregional responsive solutions.

There has been concern that the Water Quality Guidelines Manual was written based on research from the Eastern States. Experience has illustrated that information from across the continent is not always applicable to Western Australia.

Further research on soil types, land uses, land management practices, nutrient loads and export rates, infiltration rates etc is needed before BMPs can be set.

Causes

- There is no systematic monitoring of practices

- WA & specifically Perth is very different to the rest of Australia – not all imported BMPs work here which has caused discouragement
- No funded R&D agency
- No overarching technical document

Solutions

- Need monitoring data and commitment to evaluation of techniques
- Need clear standards, methods and criteria for decision making
- Finalisation and application of ARQ (which includes WSUD and WQ) and the local Stormwater guidelines
- Capacity building at State and Local level for both engineering (technical) and planning aspects

4. Can and will WSUD actually achieve a good outcome for the Swan Canning Catchment?

The opportunities to use the planning system and in particular the statutory land use planning decision making processes to achieve improvements in the water quality of the Swan Canning system is limited. The planning system only deals with the planning and approval of new development. Existing approved development within the Perth metropolitan area will require other mechanisms to manage their ongoing impacts.

Much of the nutrients entering the Swan Canning system are from existing rural and urban catchments and from the existing road and main drainage systems. Better management and redesign (retro fitting) of these existing rural and urban drainage systems is needed to improve the water quality of the Swan Canning system.

Another important point is the greater volume of subdivision planning proposals received by the WAPC are for one or two lot subdivisions. This means that incremental improvements over the long term are possible only if clear guidance can be provided as to the type of WSUD techniques appropriate in the specific circumstance. It will be necessary to develop clear guidelines, specifications and conditions for these smaller subdivisions so that cost impost of complicated design solutions are overcome. This approach would also be applicable for renovation and rebuilding situations.

The greatest potential for application of WSUD is via the subdivision of new greenfield sites. It needs to be recognised that much of the greenfield development is in the northern or southern coastal corridors. While these areas are not directly linked to ground or surface drainage systems flowing into the Swan and Canning river system, it is appropriate for WSUD solutions targeted to the specific biophysical context to be applied.

Solutions

- Limited potential to address current problems but can contribute through application of WSUD in new development, however the effects will be seen only over the longer term .

- Important to establish demonstration projects up and running with QA monitoring, assessment, evaluation and extension of results
- Need established quantified water quality and quantity WSUD targets as requirements
- Need incentives for developers
- Dredge the river

5. Other issues and considerations

- The Aboriginal Heritage Commission must also be consulted on all developments that involve the river due to their cultural association with the Swan River. The Aboriginal Heritage Act requires consideration.

- Developments within the SRT Management Area are determined by the Minister for the Environment.

- We tend to focus on BMPs but we really need to focus on Best Planning Practice (BPPs). If there is no planning framework, even BMPs become a retrofitting exercise. Thus a regional framework in the form of structure plans incorporating water issues is vitally important. However, the framework cannot be developed without models and data to support it. Therefore it comes back to the gathering of data, monitoring existing performance, and setting targets and criteria.

- Implementation of BMPs requires some thought. The ARQ should not just be used as a "cookbook". Locally specific techniques are need to be trailed and validated.

- Community ownership of the issue is vital to its success as WSUD is not just about engineering (drainage) solutions. Water conservation is equally important, as are environmental water requirements (water balance).

- Tend to focus on stormwater only. This is only one element of WSUD. Water conservation is just as important

- **"Until stormwater is looked at as a resource rather than a waste, we will be unable to achieve significant progress."**

Part 2: Discussion of the Development Approvals Process

As previously stated, there are many tools within the statutory approvals process that can be utilised to incorporate WSUD into new developments. They range from higher order policies (Environmental Protection Policy – EPPs and Statements of Planning Policy – SPPs), through to operational policies (DC Policy) and subdivision and development conditions.

The workshop recognised that there are a range of planning tools, both statutory and strategic, to incorporate WSUD into new developments. Appendix 5 lists the tools in Figure 1 and identifies the agency with key responsibility for preparation, approval and implementation of the tool, together with other involved agencies. The table identifies the agency(s) that may be responsible for improving performance of the tool with regards to WSUD and implementing proposed solutions.

The workshop attendees were asked to score each tool with regards to its importance in implementing WSUD and also in terms of its current performance. The difference between the two scores provided a measure of its significance to the discussion – called the "gap". Gap scores within each group were calculated and recorded. Participants were then asked to prioritise the tools using the combined gap score and address those with the highest score before moving on to the remainder.

There was noticeable variation across the groups and within the groups in the gap scores and rankings of importance of tools (Figure 3). This may be an indication of the wide cross-section of backgrounds of the attendees and/or the varied understanding of participants with regards to the operation of each planning tool. There appeared to be a degree of knowledge and understanding of the process "at the top", however there was a significant amount of confusion regarding the "lower end" of the process.

There were some noticeable similarities in ranking of importance through. Most participants ranked the State Planning Strategy, Region Schemes and Building Approval low in importance, whereas Statements of Planning Policy, Subdivision Conditions, Design and Construction, and Maintenance were consistently ranked high. The remainder of the tools were of varied importance. The Swan Canning EPP was ranked 10th out of 17. It should be noted that no tools were ranked below 3 out of 5, so it is clear that participants felt that almost all planning tools can be used to implement WSUD through the development approvals system.

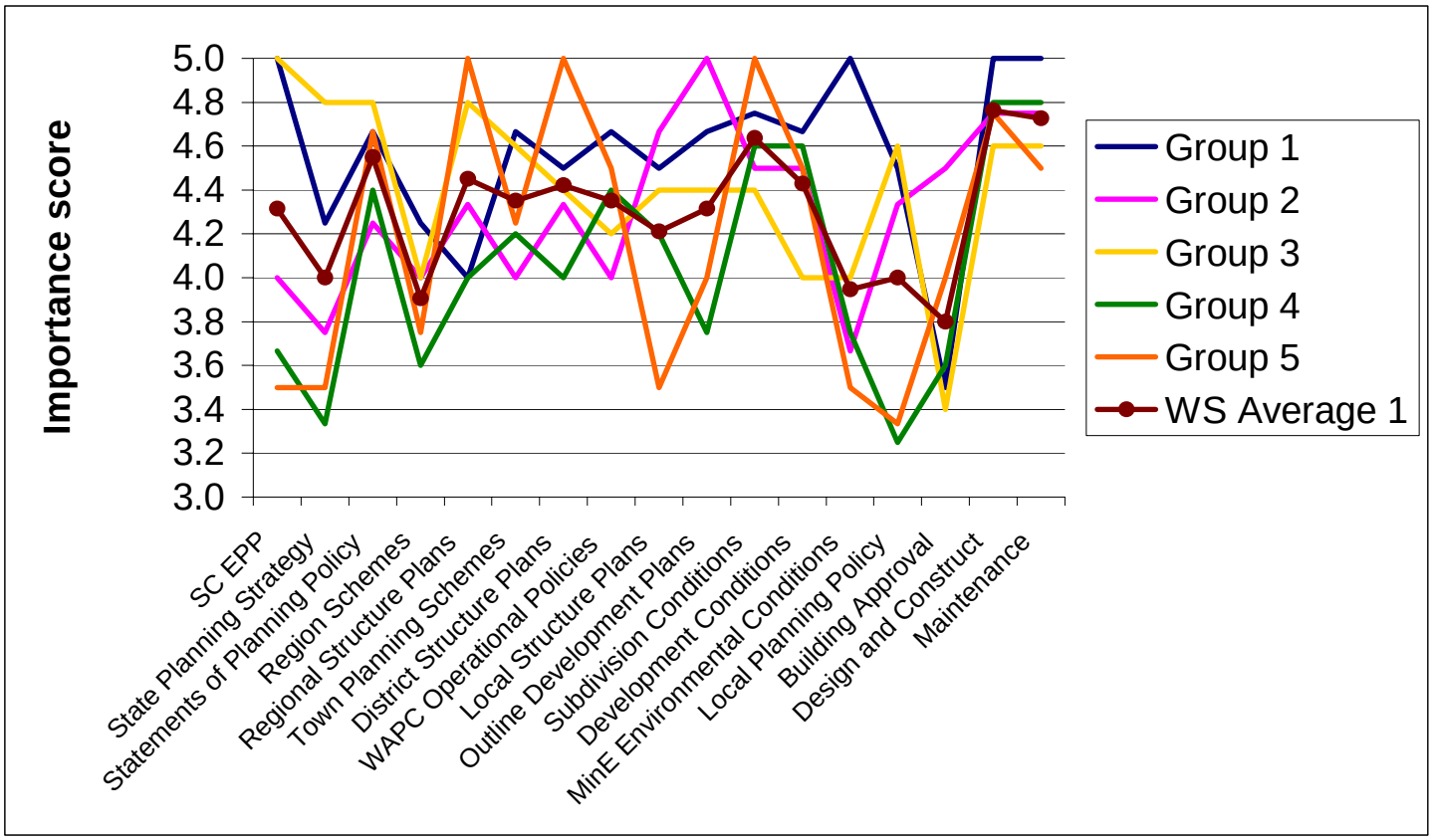


Figure 3: Group Scores of Importance of Planning Tools for WSUD Implementation

The top 5 tools regarded by the Workshop attendees as having importance for implementation of WSUD through the development approvals process are:

1. Design and implementation (construction)
2. Maintenance
3. Subdivision Approval and Conditions
4. Statements of Planning Policy
5. Regional Structure Plans.

Comments from each group are recorded in Appendix 5. Comments regarding the top 5 ranked tools are summarised below.

1. Detailed Design and Implementation (Construction)

This phase of the process is about development of detailed plans for design and construction of WSUD BMPs for subdivision or development. The detailed plans are approved by the Local Government engineer.

There is generally a perception by developers and the community that WSUD treatments are more expensive to install and maintain than conventional drainage structures. Additionally, many engineers prefer to construct something consistent with the AR&R standard due to liability associated with flooding and their familiarity with the design and construction of this type of infrastructure.

Barriers

- Lack of performance standards for design and implementation
- Lack of criteria for design eg nutrient stripping, infiltration
- Cost/economic implications of complicated treatment trains

Solutions

- Develop agreed management practices to achieve required performance (LG, IPWEA, IEA)
- LG & State capacity building to ensure WSUD standards (ARQ) are enforced/complied with
- Set responsibility for monitoring and reporting of performance against conditions

2. Maintenance

Currently the developer is responsible for around 2 years maintenance after which the Local Government takes over the long term maintenance of WSUD treatments. Once the developer has handed over maintenance of the treatments the Local Government is responsible and if the treatment fails, the cost of repair is often substantial.

There is also limited information relating to the long-term effectiveness and cost of treatments. There is a perception that “natural” treatments require more maintenance and therefore cost more that simple grassed swales.

Barriers

- Lack of funding (LG)
- Implementation cannot be enforced
- Lack of performance standards with regards to design
- High cost of maintenance to LG

Solutions

- Use demonstration projects to inform both LG and designers
- Full cost/benefit analysis of WSUD treatments compared with conventional treatments is required. If this information exists, it needs to be collated and presented in a more effective manner.
- Review funding arrangements and transfer mechanism to ensure adequate resources for management over the long term

3. Subdivision Approval and Conditions

Subdivision approval involves the setting of conditions on subdivision which need to be cleared before the proposed development can proceed (to allow the final plans to be signed). Conditions may be used to impose requirements on drainage and other land use activities likely to contribute to cumulative impacts on water quality. Current practice is to impose standard conditions which are general in nature and so achieve limited outcomes. However, if conditions need to be specific to achieve defined outcomes, DPI/LG do not have the in-house expertise to clear them and the timelines and volume of applications do not facilitate WSUD implementation. Furthermore, DPI does not generally recommend a more specific condition unless requested to by the DoE or the LG.

Nevertheless, subdivision approval is seen as the stage where WSUD BMP treatment train plans could be imposed as a condition by both State and Local Government.

Barriers

- The existing standard conditions are inadequate
- Conditions lack specificity/currency
- Clearing of conditions without adequate technical expertise supported by approved guidelines, criteria and data
- Lack of quantifiable, binding WSUD conditions that can be imposed (threat of overturing by TPAT)
- On-going conditions (post development) don’t exist

Solutions

- Update conditions
- Set management targets based on receiving environment requirements (i.e. a range of targets may be developed for the different biophysical zones or receiving water requirements – it will be harder in some locations than others).
- Assess what is achievable from installation of individual BMPs. This can be used to back-up targets in conditions.
- Incorporate clear, quantifiable water quality and quantity WSUD targets in conditions

- LG (& State) capacity building to ensure WSUD standards (ARQ) are enforced/complied with

4. Statements of Planning Policy

A Statement of Planning Policy (SPP) is a 'higher order' planning instrument and Local Governments are required to have "due regard" to the intent and actions of the policy when preparing or amending their town planning schemes.

The Environment and Natural Resources SPP contains general policy measures as well as water resources measures to

- *"ensure that land use and development is sited and managed to safeguard or where possible enhance the quality of surface and ground water resources, waterways, wetlands, estuaries and marine environments; and*
- *encourage urban water management including water sensitive design approaches to better manage stormwater quality and quantity, by reducing the impact of stormwater flows to streams, wetlands and coastal waters, removing pollutants to improve water quality, retaining habitats, conserving water and providing for recreational opportunities through multiple use drainage systems"*

A Draft Water Resources SPP is currently being prepared by the DPI.

Barriers

- Generic or generalised policy measures - not specific enough to achieve outcomes on the ground at subdivision level
- ENR SPP contains words like "encourage" and "where possible". This makes it easy to discount
- SPPs are not holeproof as they are only required to "have due regard for" – may be considered and dismissed

Solutions

- Need to be more specific (include water quality objectives)
- Need to ensure incorporation into TPS
- Involve stakeholders in development
- More technical rigor

5. Regional Structure Plans

Regional Structure Plans provide context for Region Schemes and Town Planning Schemes. They may include an (urban) water management strategy. Environmental constraints (of regional importance) should be identified at this scale but are sometimes overlooked. Regional Structure Plans (RSPs) are seen as an opportunity to identify regional drainage infrastructure requirements and systems.

Barriers

- Current planning practice and existing RSPs don't adequately consider the 'water' issues
- Lack of knowledge, information and data to provide the context for an urban water management strategy
- Lack of targets for performance assessment and monitoring of effectiveness of outcomes

Solutions

- Need to "optimise" WSUD and water quality outcomes in planning policy – make targets/objectives clearer and specific
- EPA/Water agencies to set targets
- Monitor water quality
- Need investment for monitoring and implementation identified at regional levels
- A prioritised program of developing regional and sub-regional structure plans to ensure incorporation of water management plans
- Setting appropriate and clear guidelines to achieve required outcomes (LG, WAPC/DPI, EPA, SRT) with each party contributing funding based on its benefit

SUMMARY OF FINDINGS

Before WSUD can be effectively implemented within the planning and approval processes and ultimately on the ground, several obstacles should be addressed. These involve the lack of regional perspective with respect to drainage, confusion with regards to "who does what" within Government and a lack of commitment to implementation exhibited through a lack of effective funding.

Also critical, is the lack of water quality and quantity targets, standards and criteria. Without this information, it is very difficult to design appropriate and effective treatments. This is the responsibility of the "water agencies" to determine.

The Western Australian Planning Commission (WAPC), the Department for Planning and Infrastructure (DPI) and Local Government have the largest statutory role to play in the implementation of WSUD, primarily through the State and Local Government planning approvals system. Key tools appear to be the planning policy framework, structure plans and subdivision conditions, however the most important issues and areas of concern relate to implementation on the ground – detailed design and implementation of specific WSUD treatments and on-going maintenance. Most concerns relate to the perceived cost of installation and maintenance and the lack of data on existing and ongoing performance of treatments.

RECOMMENDATIONS – ACTION TABLE

Area of Focus	Required Action	Proposed Responsibility
Policy and Regulation		
Institutional arrangements	Clarification of the roles and (most importantly) responsibilities for implementation of WSUD across Government, focusing on the "lower end" of the process, particularly as it relates to the roles and responsibilities of referral agencies	DPI/LG/DoE
Targets	Develop appropriate water quality (and quantity) targets on a "catchment" or biophysical unit basis for key threatened environments such as the Swan and Canning Rivers.	DoE
SPPs and Operational policy	Improve the WAPC/DPI policy framework through the finalisation of the Water Resources SPP and the inclusion of specific principles and objectives, and the incorporation of Liveable Neighbourhoods principles into Development Control policy (currently occurring). Element 5 of Liveable Neighbourhoods should be expanded to give better indication of what outcomes are required from implementation of urban water management measures	DPI/WAPC
Subdivision Conditions	Develop new standard conditions (both specific and general) to enable statutory planners to impose WSUD conditions more easily. Information on how to clear the conditions should be developed by DoE	DPI/WAPC
Decision-making		
Regional framework	Develop or modify the water quality monitoring framework to incorporate appropriate feedback systems to ensure that there is a process of continuous improvement with regards to implementation	DoE/WC
Cost/benefit information	Review and consolidate information on cost/benefit analysis of WSUD treatments in comparison with conventional drainage structures and release the information to key stakeholders	DoE
Demonstration projects	Implement demonstration projects and ensure that their performance is reviewed over the medium to long-term. The projects must involve monitoring, assessment, evaluation and extension of results to ensure ongoing learning within the profession. Government leadership is required	Landcorp, Homeswest, Redevelopment Authorities, in conjunction with DoE & DPI

Area of Focus	Required Action	Proposed Responsibility
Planning Information	Develop an "easy-to-read" brief summary of what WSUD means to a statutory planner to aid in the imposition of appropriate and effective conditions. In particular highlight the role of Best Planning Practices and how they are applied and assessed.	DoE
Technical Information	Undertake work and/or consolidate information on infiltration and nutrient export rates of WA soils and nutrient uptake of soils and grasses	DoE
Implementation		
Detailed design	Ensure timely release of the new Australian Rainfall Quality (ARQ) Guideline incorporating WSUD into the AR&R standard. Development of a Communication Strategy and training for LG engineers is also imperative to ensure effective capacity building.	Engineers Institute of Australia/DoE
Detailed design	Further develop specific, technical guidance for local government engineers consistent with the draft ARQ Guidelines and the up-dated Stormwater Management Manual. This information must be based on Western Australian conditions and should recognise that every situation has its own characteristics, that some techniques may not be appropriate in all situations, and acknowledge the expertise of local officers – "local knowledge".	DoE
Planning practice	Increase focus on planning and design of WSUD treatments particularly the demonstration and review of Best Planning Practices design solutions.	DPI
Community awareness	Develop a Communication Strategy to raise the awareness in the general community of the importance of WSUD in urban areas. Until stormwater is looked at as a resource rather than a waste, we will be unable to achieve significant progress.	DoE/DPI/LG

APPENDIX 1: PLANNING TOOLS AND ISSUES AND MECHANISMS FOR THE IMPLEMENTATION OF WSUD

Tool	Statutory/ strategic	Mechanism	Key points
EP Act	Legislation	• S48A-J assessment of planning schemes and amendments • Part V – pollution control	• prevails over other legislation • Part V is not relevant to the development approvals process unless there is the potential for existing or future contamination
SC EPP	Statutory	• Environmental quality objectives	• Regarded as ineffective due to lack of policing and enforcement • Resources of the DoE do not allow policing and enforcement
State Planning Strategy	Statutory	• Environmental Principle: To protect and enhance the key natural and cultural assets of the State and deliver to all Western Australians a high quality of life which is based on environmentally sustainable principles • Strategy: Ensure that water resources are conserved and their quality protected • Criteria: Ensure that new residential areas incorporate water sensitive design principles. • Action: Promote WSD in urban subdivisions and local structure plans	• Motherhood statement needs to filter down through the system but what does this mean for a specific project at the condition setting stage
Statements of Planning Policy	Statutory	• TPS must have “due regard” for SPPs • ENR SPP – general policy measures as well as water resources measures	• Higher order policy • Draft Water Resources SPP should contain more specific principles and requirements • Often generic or generalised policy measures not specific enough
Region Schemes	Statutory	• Zoning and reservations • Land use provisions • SCA’s • Referral to EPA	• Broad regional drainage requirements and framework should be determined at this stage
Regional Structure Plans	Strategic	• Provides context for Region Schemes and TPS • May include an (urban) water management strategy	• Environmental constraints (of regional importance) should be identified this scale • Opportunity to identify regional drainage infrastructure requirements and systems

Tool	Statutory/ strategic	Mechanism	Key points
Town Planning Schemes	Statutory	• Zoning/reserves • Land use provisions/land use table • SCA's • Referral to EPA	• Should identify land for drainage infrastructure and WSUD treatments • Can include provisions consistent with WSUD principles and outcomes • Can refer to planning policy
District Structure Plans	Strategic	• Provides more detail and context for zoning/reserves and development for the area	• Should include an urban water management strategy that identifies issues relevant to water management including identification of drainage needs and WSUD BMP eg. multiple use corridors etc
WAPC Operational Policies	Strategic	• Guides decision making on subdivision and development • DC1.1 – subdivision should be of a standard of public utility that is appropriate for its intended use • DC6.3 – ensures that water resources are considered within the metro region • DC2.3 – outlines the POS credits that can be granted for drainage infrastructure	• **considered at all stages** • Applied at subdivision and D/A approval • Element 5 of Liveable Neighbourhoods relates to Urban Water Management • The DC policies are currently being reviewed to incorporate LN considerations • Planning bulletin 61 addresses Urban Stormwater Management
Local Structure Plans	Strategic	• Provides the context for development at a local scale • Should identify specific requirements for urban water management including environmental constraints	
Subdivision and Development Approvqal Stage and setting of approval Conditions	Statutory	• Impose requirements on drainage and other land use activities likely to contribute to cumulative impacts on water quality	• tend to be general conditions • if specific, DPI/LG do not have expertise to clear **Should be the stage where WSUD BMP drainage plans are imposed as a condition by both State and local govt**
Local Planning Policy	Strategic	• May be a specific policy for urban water management or the goals and objectives of UWM reflected in other policies	• Most LGs seem to support UWM but don't have a specific policy position.
Building Approval	Statutory	• LG can impose specific requirements for urban water drainage to a very specific level • Approval makes the approving authority liable for any impacts related to design	• LGs will prefer to approve a plan that is consistent with the Australian Standards

Tool	Statutory/ strategic	Mechanism	Key points
Design and Construct	Operational	• Plans need to be approved by the LG engineer • Provides detail level plans for design and construction of WSUD BMP for development	• Engineers prefer to construct something consistent with the AR&R due to liability • Needs to be linked to Subdivision approval conditions
Maintenance	Operational	• Developer currently responsible for generally 2 years maintenance • Local authority take over long term maintenance	• "natural" treatments require more maintenance • once the developer has handed over the maintenance, the LG is responsible and if the treatment fails, the cost of repair is often huge
Planning Control Areas	Statutory	• Gives all development control power to the WAPC • Good tool for water resource management – currently used for catchment management	• Only used for regionally significant issues If development is refused, this has implications for WAPC acquisition of land
Outline Development Plans	Strategic	• Support new TPS's and amendments	• Similar to structure plans, these should outline the urban water management considerations and provide the context for treatments recommended
Reservation of Land	Statutory	• may reserve areas as P&R where they are critical to the achievement of water quality outcomes	• Only used where the asset is of regional significance
Acquisition of land	Operational	• may acquire areas as P&R where they are critical to the achievement of water quality outcomes. These areas tend to be reserved	• Only used where the asset is of regional significance
Ministerial Environmental Conditions	Statutory	• Environmental conditions on Subdivision and development approvals	• Not adequately monitored or enforced • Placed at the end of the process

APPENDIX 2: ATTENDEES AT THE WORKSHOP

Group 1

Len Lance	DPI
David Deely	Acacia Springs Consultancy
Bill Till	DoE
Trevor Moran	Landvision Consultants
James Duggie	Conservation Council

Group 2

Robert Griffiths	DPI
Judy Bell	DPI
Antonietta Toore	DoE
Patrick Tan	City of Belmont
Andrew Bruce	City of Armadale

Group 3

Brendan Toohey	Water Corporation
Mick McCarthy	EMRC
Greg Davis	DoE
Adrian Wong	City of Swan
Peter Cock	Bowman Bishaw Gorham Consultants

Group 4

Paddy Strano	City of Cockburn
Vince McMullen	DPI
Bruce Low	Landcorp
Thor Farnworth	City of Canning
Mike Mouritz	DPI
Simon O'Sullivan	TBB Planning
Richars Morup	Peel Development Commission

Group 5

David Nunn	DPI
Marino Evangelisti	Parsens Brinkerhoff Consultants`
Marion Thompson	DPI
Peter Howard	DoE

APPENDIX 3: PART 1: DISCUSSION OF OVER-ARCHING ISSUES

	Group 1	Group 2	Group 3	Group 4	Group 5
Institutional arrangements complicate implementation of WSUD as no one agency is responsible for urban water management	**Causes** • Lack of agreed, clear vision and definition of WSUD • Mismatch between metro/Swan catchment capacity and historic land use impacts • Lack of State Government commitment to WSUD implementation – lack of resources and misdirection of existing funds • Lack of integrating process • WA is an "aquatic freeway". There is no excuse for run-off **Solutions** • Sell the vision better to stakeholders • Embrace uncertainty of effectiveness and environmental response and operate with this in mind • Develop a single agency or body ("neutral broker") responsible to connect up "the hoppers" (agencies). Accountability is key	**Causes** • lack of clear understanding of WSUD • difference between administrative and catchment boundaries • No "bang for your buck" • Lack of strategic direction • Funding – retrofitting and maintenance have perceived high costs **Solutions** • Clear definitions of responsibilities including those that are shared • Good government examples of commitment and funding • Statutory instruments which require controls on subdivision and developments • Clear design guidelines • Regional & local water management plans	**Causes** • Non-acceptance of roles and responsibilities • Lack of effective legislative tools • No demarcation • Not proven in professional associations/ practitioners • Non-alignment of agencies (DPI, DoE) **Solutions** • WSUD requires statutory backing • One State Government agency should have overall responsibility • Need for professional education and training • Need a planning policy	**Causes** • Agencies are currently pointing the finger at each other – "It is someone else's problem" • LG cannot deliver outcomes without WOG support • Implementation arrangements are currently dysfunctional **Solutions** • Someone needs to take ownership of the problem • Greater resources are required for implementation agencies • Need to define who does what and when • Negotiate water quality objectives and define in statutory instruments and expressed in multi-agency enforced urban water management strategies	**Causes** • No single agency oversees the delivery of WSUD/UWM or has responsibility • Two agencies have "water" in their names. • There is perceived to be a sort of "turf war" going on **Solutions** • Integration of processes is required including clear delineation of responsibilities between the planning and water agencies • Need a champion/leadership agency

	Group 1	Group 2	Group 3	Group 4	Group 5
No technical assessment of on-ground performance of WSUD BMPs	**Causes** • Lack of resources to do it • Lack of a quality assurance culture • Resistance to change linked to perceptions/ being unconvinced by BMP performance and cost effectiveness **Solutions** • Encourage innovation among developers with subsidies and planning concessions • Government can then get involved and do the monitoring and evaluation of the innovation • Existing drainage schemes need to be evaluated against WSUD criteria and retro-fitted on a prioritised basis	**Causes** • Limited resources • No auditing process **Solutions** • Increase resources in both State and Local Government	**Causes** • Perceived cost of monitoring and performance assessment • No agreed monitoring framework • Inadequate resources to monitor and report outcomes **Solutions** • Establish statewide monitoring framework • Government needs to show leadership through pilot projects and demonstration sites • Increased professional education and training	**Causes** • who has overall responsibility? • There is too much focus on flooding at LG level **Solutions** • Upfront agreements • Context based rules • WSUD should focus on WC drainage catchment areas • Define lifecycle costs of BMPs • Mandatory monitoring of BMPs	**Causes** • Lack of monitoring data **Solutions** • Need a monitoring framework • Demonstration projects • Funding • Subdivisional level assessment

	Group 1	Group 2	Group 3	Group 4	Group 5
Technical information specific to WA is limited – no agreed approach to best practice	**Causes** • There is no systematic monitoring of practices • WA is very different to the rest of Australia – not all imported BMPs work here which has caused discouragement **Solutions** • "Hold the course" – keep trying for BMPs that will work here	**Causes** • Lack of commitment by lead agencies • No funded R&D agency **Solutions** • Greater emphasis on practical solutions • Sharing of experience/knowledge • Review WRC manual • Develop specific criteria	**Causes** • Limited R&D • No cost/benefit comparisons of WSUD and traditional development • There is no 1 solution – it is a complex problem • WA is a unique landscape with sandy soils **Solutions** • Increased investment in WSUD • Be flexible and innovative • Requires multidisciplinary approach – possibly a Focus Research Group	**Causes** • Unclear quantification needs – don't know what information to collect **Solutions** • Need monitoring data • Need clear standards, methods and criteria for decision making	**Causes** • No overarching technical document like AR&R • LG lack technical knowledge **Solutions** • ARQ (which includes WSUD and WQ) • Capacity building at State and Local level for both engineering (technical) and planning aspects
Can and will WSUD actually achieve a good outcome for the Swan Canning Catchment?	**Causes** • Yes – 150 year timescale **Solutions** • Get demonstration projects up and running with QA monitoring, assessment, evaluation and extension of results • Need established quantified water quality and quantity WSUD targets as requirements • Need incentives for developers	**Causes** • Limited potential to address current problems but can contribute through new development **Solutions** • Dredge the river	**Causes** • Yes – statutory basis through SCEPP • Some data supports this (long term though) **Solutions** • Community education • Nested planning frameworks based on catchment management • Need linkage with planning policy • Incentives need to be identified	**Causes** • Rural upstream LU is the main issue and needs to be controlled • Lack of data **Solutions** • Need information • Need to achieve "pre-development" levels (i.e. vegetated block) in urban areas	**Causes** • Rural outputs have contaminated the river **Solutions** • State investment in treatment of Rural areas • Policy for urban areas which incorporates best practice

	Group 1	Group 2	Group 3	Group 4	Group 5
Other		• Political will is short-term only which leads to diminished resources • Public is interested only when there is an outbreak therefore increased community awareness is required • There is a resistance to change culture in WA • Market acceptance of WSUD treatments is required	• Long term cost of WSUD infrastructure places a burden on LG as funding is not identified and planning or development phases. • Need community ownership of the problem as there is currently a lack of political will and public understanding. Need to provide greater support to community catchment groups and survey the community – what are you prepared to pay?		• There are currently no targets which are necessary so performance can be measured and audited • WSUD is about planning (design) as well as the technical stuff • Tend to focus on stormwater only. This is only one element of WSUD. Water conservation is just as important • Liveable Neighbourhoods should be “beefed-up”

APPENDIX 4: PART 2: DEVELOPMENT APPROVALS PROCESS AND BARRIERS AND SOLUTIONS TO IMPLEMENTATION

	Group 1	Group 2	Group 3	Group 4	Group 5
SC EPP	Score: **2** **Barriers** • Totally ineffective to date because no quantified targets established & incorporated in planning process/regulation • Lack of integration with planning process **Solutions** • Set quantifiable targets from sub-catchment to subdivisional scale to implement/achieve objectives	Score: 14	Score: 2 **Barriers** • Lack of catchment plan • Lack of implementation mechanism • Too general • Lack of Government support • No link to planning • No ownership by other stakeholders/agencies **Solutions** • SC Catchment Plan (EPA/SRT) • Catchment Manager • Shared funding (NHT, State Govt) • Supporting SPP with statutory link to TPS and enforcement powers	Score: 15 **Barriers** • No water quality and quantity objectives **Solutions** • Define the environmental values, water quality objectives and water V objectives	Score: 13
State Planning Strategy	Score: 14	Score: 14	Score: 10	Score: 15 **Barriers** • Motherhood statement **Solutions** • More direction required for WSUD	Score: 15
Statements of Planning Policy	Score: 17	Score: 11	Score: 3 **Barriers** • To generic and difficult to implement **Solutions** • Need to be more specific (water quality objectives) and link to TPS • Involve stakeholders in development • More technical rigor	Score: 6 **Barriers** • SPP implementation is a compliance issue **Solutions** • Require WAPC and LG decisions to comply with SPPs – revise sSA	Score: 14

	Group 1	Group 2	Group 3	Group 4	Group 5
Region Schemes	Score: 14	Score: 8	Score: 14	Score: 11 **Barriers** • implementation is limited by financial resources **Solutions** • Create IMRF for regional schemes	Score: 9
Regional Structure Plans	Score: 11	Score: 5 **Barriers** • Lack of agreed and acceptable ways of implementing WSUD **Solutions** • Setting appropriate and clear guidelines to achieve required outcomes (LG, WAPC/DPI, EPA, SRT) with each party contributing funding based on its benefit	Score: 5	Score: 4 **Barriers** • Too broad scale **Solutions**	Score: 1 **Barriers** • Planning practice • Lack of knowledge, information and data • Lack of targets **Solutions** • Need to "optimise" in planning policy – make them clearer and specific • EPA/Water agencies to set targets • Monitor water quality • Need investment • WAPC "hands-on" management of regional and sub-regional structure plans

	Group 1	Group 2	Group 3	Group 4	Group 5
Town Planning Schemes	Score: 9	Score: 8	Score: 4 **Barriers** • Too focussed toward LU and zoning • Not catchment based • Not reviewed enough • May not have environmental factors **Solutions** • Need to be supported with local planning strategies that incorporate catchment issues, SOE reporting & WSUD principles • Establish mechanisms for WSUD implementation eg density bonuses etc	Score: 11 **Barriers** • Lack of model planning provisions **Solutions**	Score: 5
District Structure Plans	Score: 14	Score: 8	Score: 7	Score: 8 **Solutions** Define objectives and strategies	Score: 9
WAPC Operational Policies	Score: 5	Score: 11	Score: 7	Score: 3 **Barriers** • Encourage and require **Solutions** • LN & DC review (DPI)	Score: 7
Local Structure Plans	Score: 11	Score: 5	Score: 10	Score: 9	Score: 11
Outline Development Plans	Score: 5	Score: 5	Score: 5 **Barriers** • No requirement to include WSUD/environmental requirements	Score: 13	Score: 11

	Group 1	Group 2	Group 3	Group 4	Group 5
Subdivision Conditions	Score: 7 **Barriers** • Lack of quantifiable, binding WSUD conditions included • On-going conditions (post development) don't exist • Lack of clarity about the chain of responsibility for compliance with conditions (eg developer to LG handover is not clear) • Lack of clear responsibility for monitoring and evaluation of conditions and enforcement of compliance **Solutions** • Incorporate clear, quantifiable water quality and quantity WSUD targets in conditions • Set responsibility for monitoring and reporting of performance against conditions • Set responsibility for evaluating and enforcing compliance with conditions	Score: 3	Score: 10	Score: 6 **Barriers** • Co-ordination of multiple owners • Lack of co-ordination/agreement of delegating authorities **Solutions**	Score: 1 **Barriers** • Conditions lack specificity/currency • Clearing of conditions **Solutions** • Update conditions • LG (& State) capacity building to ensure WSUD standards (ARQ) are enforced/complied with
Development Conditions	Score: 4	Score: 17	Score: 7	Score: 5 **Barriers** Co-ordination of owners	Score: 7
Ministerial Environmental Conditions	Score: 9	Score: 14	Score: 10	Score: 15	Score: 15
Local Planning Policy	Score: 7	Score: 11	Score: 7	Score: 15	Score: 15

	Group 1	Group 2	Group 3	Group 4	Group 5
Building Approval	Score: 11	Score: 2 **Barriers** • Unenforceable guidelines • Solutions • Setting achievable targets for developers (DoE) • Approvals of statutory schemes and local planning policies which facilitates implementation	Score: 15	Score: 9	Score: 5
Design and Construct	Score: 3	Score: 3 **Barriers** • Lack of performance standards • Design dictated by funding availability **Solutions** • Develop agreed management practices to achieve required performance (LG, IPWEA, IEA)	Score: 7	Score: 1 **Barriers** • lack of criteria for design eg nutrient stripping, infiltration • cost/economic implications **Solutions** • DoE to provide information on techniques and how this can be accessed	Score: 1 **Barriers** • Lack of demonstration projects • Need to measure performance of BMPs **Solutions** • Capacity building

	Group 1	Group 2	Group 3	Group 4	Group 5
Maintenance	Score: 1 **Barriers** • Unclear responsibility • Not yet incorporated into regulation (i.e. not in conditions as no mechanism for on-going condition requirements subsequent to condition clearance) • Perception of ongoing (open ended) costs • Lack of "ownership" of responsibility of environmental outcomes **Solutions** • Establish ownership across all levels of government for achieving and maintaining environmental outcomes. Especially LG • Need mechanism for ongoing requirement by LG for maintenance	Score: 1 **Barriers** • Lack of funding (LG) • Cannot be enforced • Lack of performance standards **Solutions** • Monitoring process with targets is required to justify funding (DoE)	Score: 1 **Barriers** • Lack of responsibility • Funding • Strategic Management framework • Standards • Different approach between Commonwealth, State and Local Gov'ts **Solutions** • Ongoing funding – developer, State and LG • Agreed funding arrangements and transfer mechanism • Enforcement – finding for resourcing (WAPC/EPA/LG)	Score: 1 **Barriers** • cost of maintenance to LG **Solutions** • developer acceptance of longer maintenance periods • Develop an acceptable "cost per Ha" figure for BMPs	Score: 1 **Barriers** • What are the "real" costs? • Who pays? **Solutions** • Use demonstration projects to inform • Full cost/benefit analysis

APPENDIX 5: TOOLS AND RESPONSIBILITIES

Tool	Key Responsibility			Involved agencies (for WSUD issues[1])
	Prepare	Approve	Implement	
SC EPP	DoE	EPA	SRT	SRT, DoE, DPI, AgWA, DIA, WC, MRWA, LG, HD
State Planning Strategy	DPI	WAPC	WAPC	SRT, DoE, EPA, DPI, AgWA, DIA, WC, MRWA, LG, HD
Statements of Planning Policy	DPI	WAPC	WAPC	DPI, EPA/DoE, SRT, DIA, WC, LG, HD
Region Schemes	DPI	WAPC	WAPC	DPI, SRT, EPA, DoE, AgWA, DIA, WC, LG, HD
Regional Structure Plans	DPI	WAPC	DPI	SRT, DoE, AgWA, DIA, WC, LG, HD
Local Planning Strategy	LG	WAPC	LG	DPI, SRT, EPA, DoE, AgWA, DIA, WC, HD
Town Planning Schemes	LG	Min P	LG	DPI, SRT, EPA, DoE, AgWA, DIA, WC, HD
District Structure Plans	DPI	WAPC	DPI	LG, SRT, DoE, AgWA, DIA, WC, HD
WAPC Operational Policies	DPI	WAPC	DPI	DPI, SRT, DoE, WC, LG, HD
Local Structure Plans	LG	Council	LG	DPI, SRT, DoE, DIA, WC, LG, HD
Subdivision Approval and Conditions	DPI	WAPC	WAPC	DPI, SRT, DoE, WC, LG, HD, TPAT
Ministerial Environmental Conditions	EPA	Min E	WAPC/ LG	DPI, SRT, DoE, AgWA, WC, LG, HD
Local Planning Policy	LG	Council	LG	DPI, SRT, DoE, AgWA, DIA, WC, LG, HD
Development Approval and Conditions	WAPC	WAPC/ Min E	WAPC	DPI, SRT, DoE, DIA, WC, LG, HD
Building Approval	LG	Council	LG	DPI, SRT, DoE, WC, HD
Detailed Design	LG	LG	LG	DPI, SRT, DoE, WC, HD
Implementation	LG	LG	LG	DPI, SRT, DoE, WC, HD
Maintenance	LG	LG	LG	SRT, DoE, WC, HD

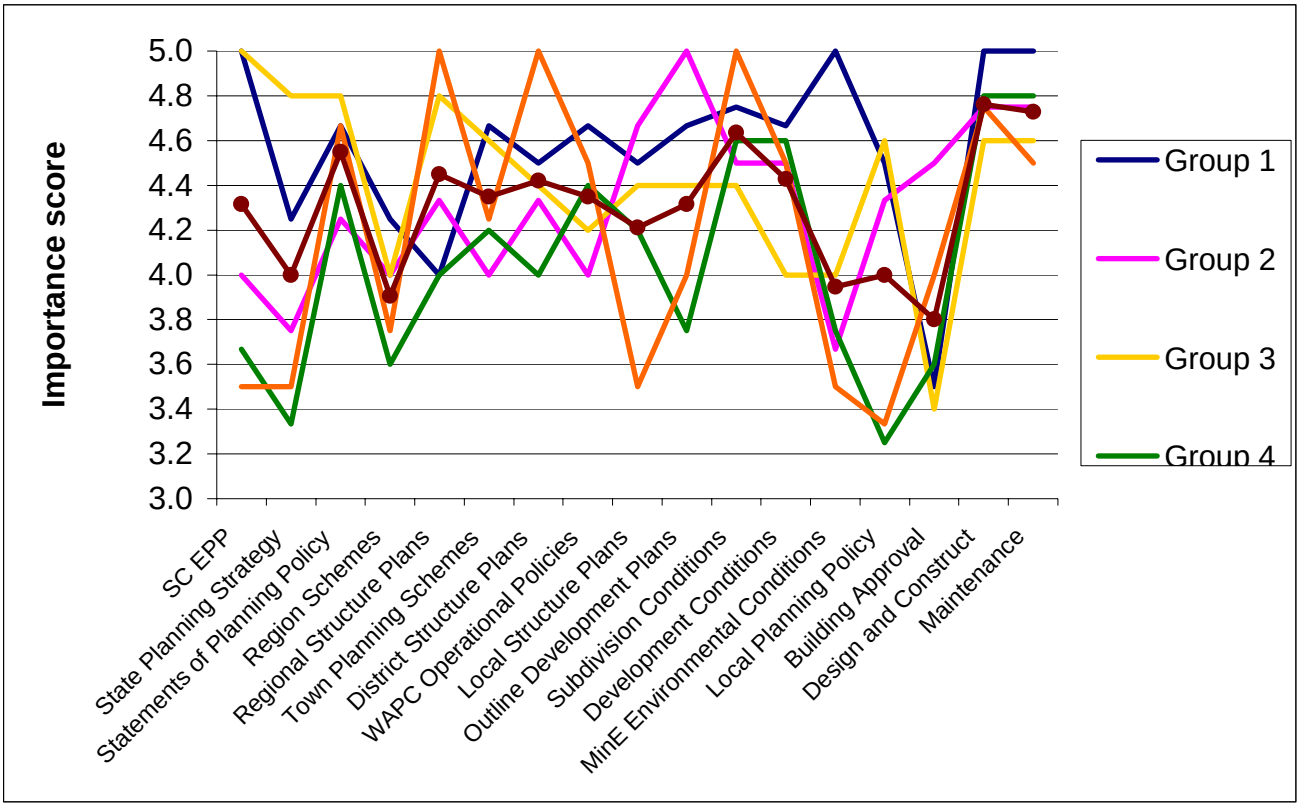
[1] This relates mainly to the management of stormwater rather than other aspects of WSUD as it applies in the Swan Canning Catchment

Agency key

AgWA	Department of Agriculture
DoE	Department of Environment
DIA	Department of Indigenous Affairs
DPI	Department for Planning and Infrastructure
EPA	Environmental Protection Authority
HD	Health Department
LG	Local Government
MRWA	Main Roads WA
SRT	Swan River trust
WC	Water Corporation

APPENDIX 6 IMPORTANCE SCORES OF PLANNING TOOLS

	Group 1	Group 2	Group 3	Group 4	Group 5	WS Average
SC EPP	5.0	4.0	5.0	3.7	3.5	4.32
State Planning Strategy	4.3	3.8	4.8	3.3	3.5	4.00
Statements of Planning Policy	4.7	4.3	4.8	4.4	4.7	4.55
Region Schemes	4.3	4.0	4.0	3.6	3.8	3.90
Regional Structure Plans	4.0	4.3	4.8	4.0	5.0	4.45
Town Planning Schemes	4.7	4.0	4.6	4.2	4.3	4.35
District Structure Plans	4.5	4.3	4.4	4.0	5.0	4.42
WAPC Operational Policies	4.7	4.0	4.2	4.4	4.5	4.35
Local Structure Plans	4.5	4.7	4.4	4.2	3.5	4.21
Outline Development Plans	4.7	5.0	4.4	3.8	4.0	4.32
Subdivision Conditions	4.8	4.5	4.4	4.6	5.0	4.64
Development Conditions	4.7	4.5	4.0	4.6	4.5	4.43
MinE Environmental Conditions	5.0	3.7	4.0	3.8	3.5	3.95
Local Planning Policy	4.5	4.3	4.6	3.3	3.3	4.00
Building Approval	3.5	4.5	3.4	3.6	4.0	3.80
Design and Construct	5.0	4.8	4.6	4.8	4.8	4.76
Maintenance	5.0	4.8	4.6	4.8	4.5	4.73



National Experience?? more like My perspective: Catchment repair

Mike Mouritz

Executive Director

Strategic Policy & Evaluation

Dept for Planning & Infrastructure

Framework of the talk

- My perspective – Hopefully provocative
- Some might have heard it before
- Some paradigm shift ideas - WSUD
- Some examples – of catchment repair
- Relationship to Dialogue with the City – Greater Perth
- Where to from here opportunities

A few thought starters ??

- Drainage Forum????
- Surely a better title – to develop a vision language is important.
- Change happens – language – thinking - praxis
- What about “ Drains to living streams” or “New ways with rain water” or
- Seeking solutions for “catchment repair” for the Swan - Canning

Starting point

- Just returned - last decade in the east…
- Becoming reacquainted with the issues / challenges facing Perth
- Observations - a city sprawling into the distance – the urban energy seeping into the sand plain…regular air pollution events …more road / car park per head than US
- A debate only just beginning about growth management
- Aridity recognized - a State Water Strategy – watering 2 times a week produces better gardens
- The Swan acknowledged as an “icon”…Why not the drains - Every new subdivision has a water feature as entry statement ???
- The spirit of the waters – the Wagyl – well worth celebrating

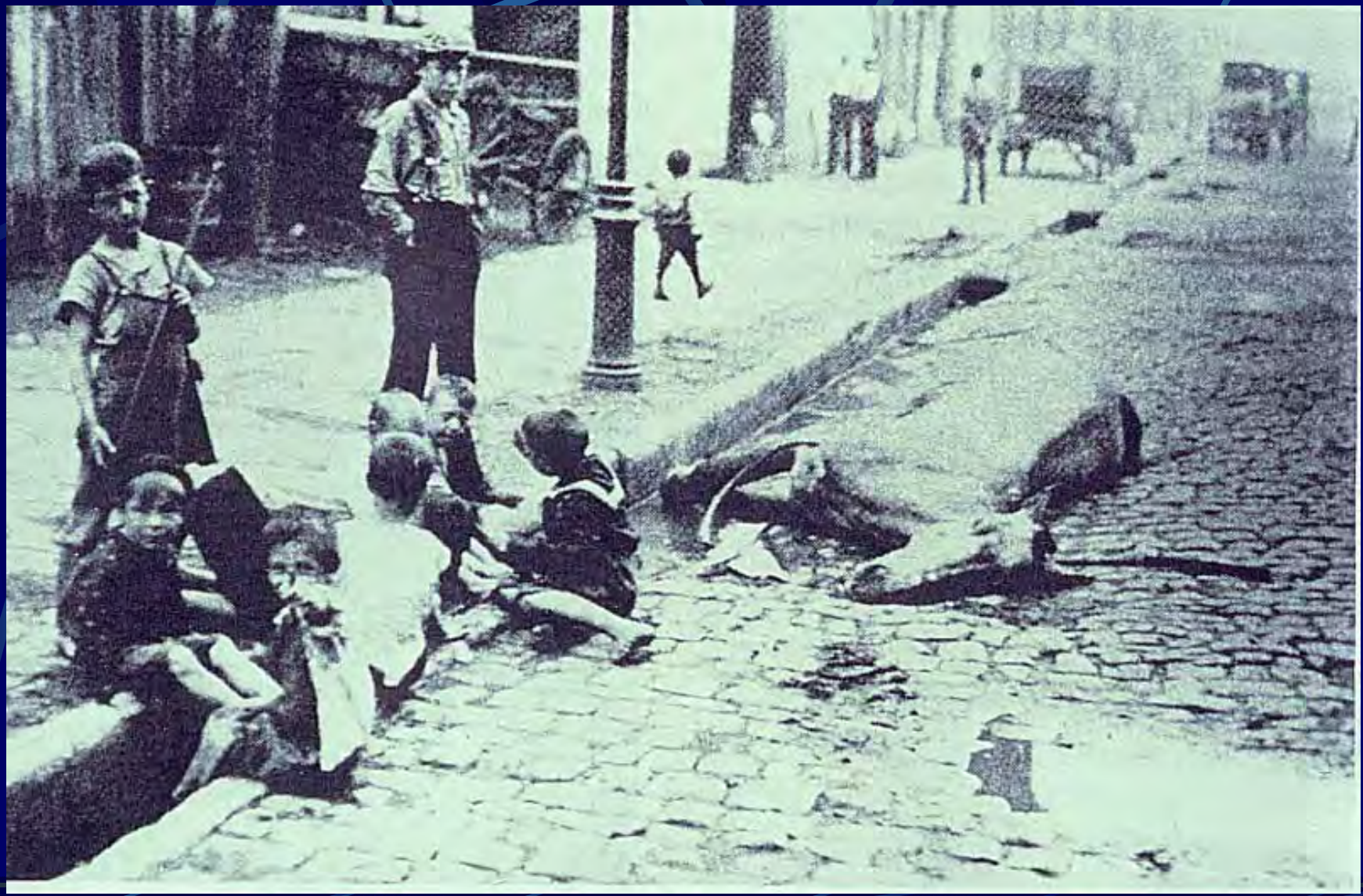
Chittlebrough & Keating 1986 – WA Environmental Review – released by the Democrats

- "In effect, we in WA (like other communities) have been living beyond our means for some time and now have a accumulated environmental debt which must be met if we are to restore sustainability….Deferring action will only compound problems, leading toward the situation now evident in other dry countries where land once in fair condition has been degraded…to a point where it will no longer support existing populations.
- …if we are to identify attractive pathways through the coming decades, we shall require more than a series of cosmetic actions…" page 57
- *This was hopeful document looking for a restorative approach … now a sustainability strategy*

Paradigm Ideas : Values and Urban Water Technology

- No technology is value free
- Technologies are politics in disguise, or the result of interplay of - politics - values - technical knowledge
- Based on public health needs of 100 plus years ago
- Notions from the “Enlightenment” & “modernist” traditions -
  - applied science could master then environment
  - economies of scale
  - human health much more important than ecological health
- Natural monopoly – only because of the technology

Sanitary Conditions



Floods Are Real



Problems with 19th Century Urban Water Management

- **Receiving waters cannot sustain organic loads and, especially nutrient loads from outfalls.**
- **Urban creeks and wetlands are now valued inherently i.e. for their ecological and recreational qualities rather than their ability to channel or dilute wastes.**
- **Stormwater from sprawling bitumen-based cities is excessive in quantity and quality.**
- **Cost of “big pipes” infrastructure is becoming too high.**
- **Water supply augmentation solutions are becoming economically and environmentally questionable.**

(Source: Newman & Mouritz 1994)

Times of Transition - The Shift is Occurring

- Ecological integrity of urban and near waterways - (i.e. Brisbane River & Morton Bay)
- CSIRO 1992 & recent reports - highlighting rethink of research priorities
- World Water Vision & Framework for Action
- Asset management & replacement challenge
- “Why are we cracking up” - SMH - 25/7/00
- Ageing pipes and Murky Waters - NZ

Urban Policy is Shifting - sustainability

- More livable
- More efficient in terms of land and infrastructure
- More efficient in terms of energy and resource use
- Even debate on “ecological footprint” (i.e. Sydney draws on 37 times it’s area)
- Creating communities – DPI priority

Water-oriented Goals for a Sustainable City

- Reduced import of water into cities.
- Ocean and river outfalls made redundant.
- Recycling of water for various urban and peri-urban uses.
- Recycling of nutrients and organics.
- Creeks and wetlands an integral part of city and managed for their ecological integrity & landscape value
- Increased soft surfaces (and reduced urban sprawl) for stormwater retention.
- Reduced requirements for large pipes.

(Source: Newman and Mouritz 1994)

WSUD - Planning & Design Concept

- Codify emerging values
- Part of new paradigm
- Optimise and integrate urban planning and management of urban water cycle
- Range of scales and time horizons
- “A more humble and unified way of conceiving the relationship between earth, water and human life” (Cosgrove 1990)

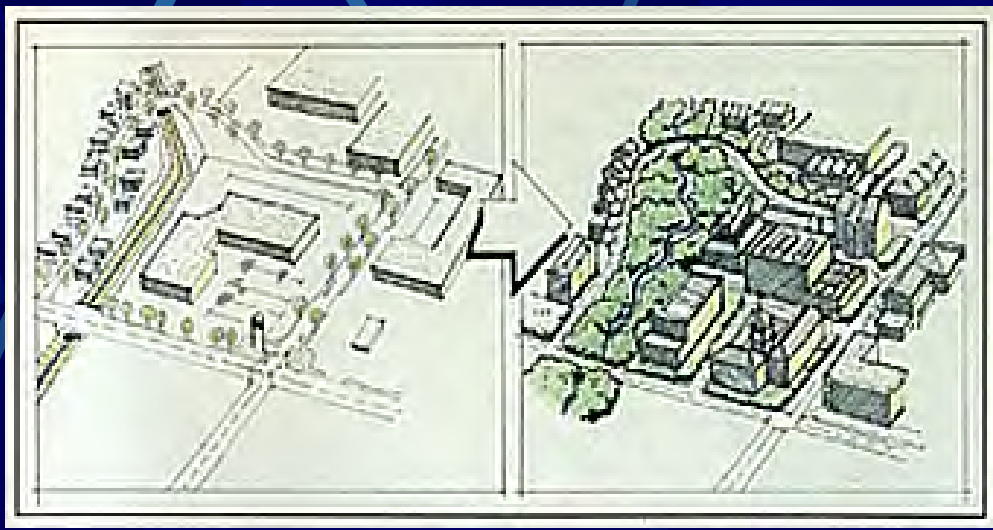
WSUD - a Tool for Catchment Repair

- I mean “repair” not just management or “spinning wheels”.
- Catchment repair is about leadership - “developing the path forward”.
- Repair implies improvement.
- Re-generative approach to rainwater /stormwater - part of an urban ecology that is healing / repairing.



Vision of a Co-evolution of Human Settlements and Ecosystem

Hard and soft technologies designed and applied to optimise the production / consumption system of the city in terms of health of regional ecosystem, as well as human health and welfare. - All makes better real estate??

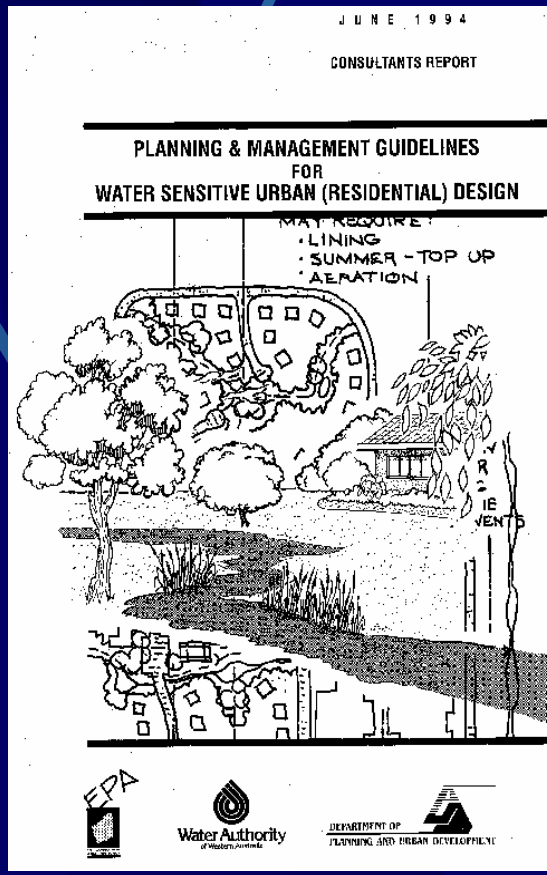


WSUD

- Optimising the rain that falls on the city - water harvesting.
- Reducing the amount of water imported into the city.
- Optimising water balance and flood management.
- Improving water quality.
- Incorporating water related social & ecological objectives.
- Spirit of the water – the Wagal

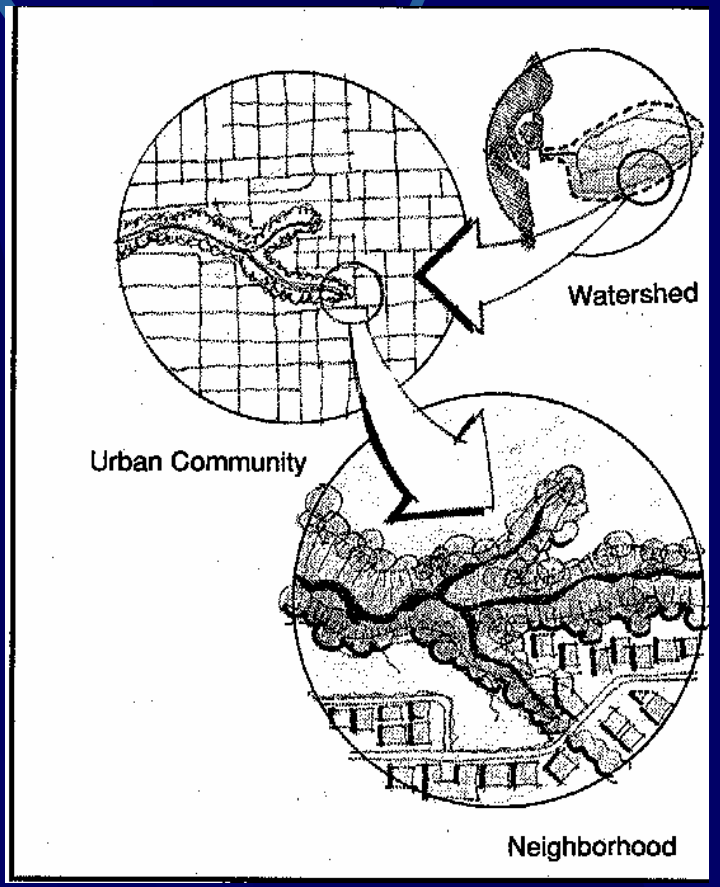
The WSUD Guidelines

- Menu of best planning and best management practices.
- Research and consultancy projects illustrated the viability and potential.
- But some got the perception it was just about swales and wetlands
- “Treatment trains” - hard and soft solutions.
- Even linking art, architecture, technology and ecology.
- Recipes - design manuals being developed (Engineers Aust -).
- Capacity building – www.wsud.org



The Ideal - a Policy Framework of Agreed:

- Urban design / planning outcomes
- Environmental outcomes
- Water resource outcomes
- Plus design and approval process that support these
- Design teams that know how to innovate



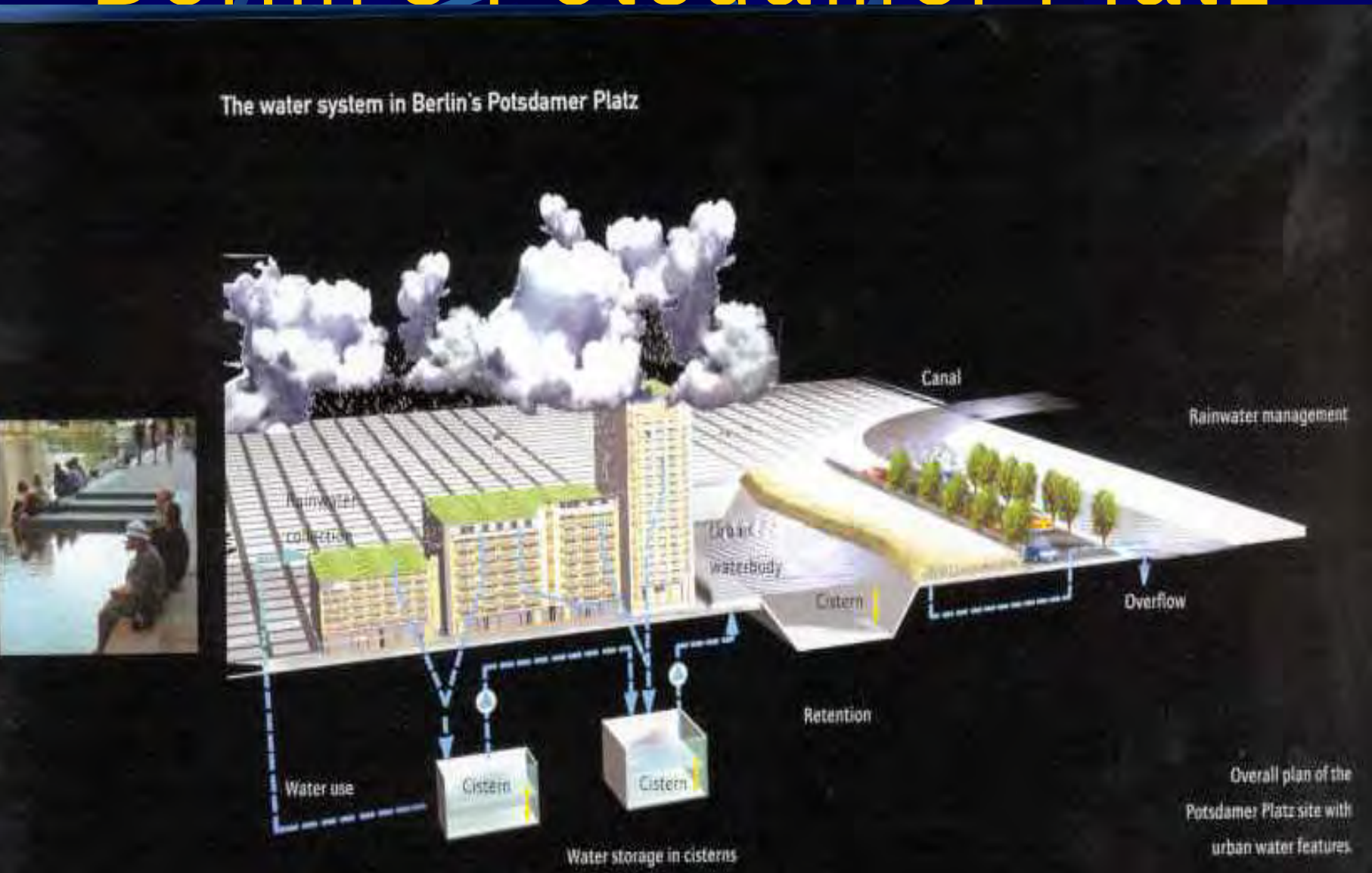
Concept is Evolving - developing meaning of its own

- Because it can capture the imagination of practitioners & developers.
- Inspired by Tony Wong and others in developing water quality design tools.
- Water harvesting practice and analysis of John Argue, Peter Coombes, George Kuczera.
- Realising distributed systems envisioned by Richard Clark and others in scenario work.

In a Wider Context

- Consistent with best European & US & Japanese practice.
- i.e. - “New Ways with Rainwater” Gieger & Dreiseitl.
- Within a more academic / discipline development context.
- Part of ecological conditions / opportunities approach - rather than constraints approach.
- Consistent with labels like ecosystem planning, ecological design, ecotechnologies.
- About linking ecological planning/design with ecological engineering.

Berlin's Potsdamer Platz

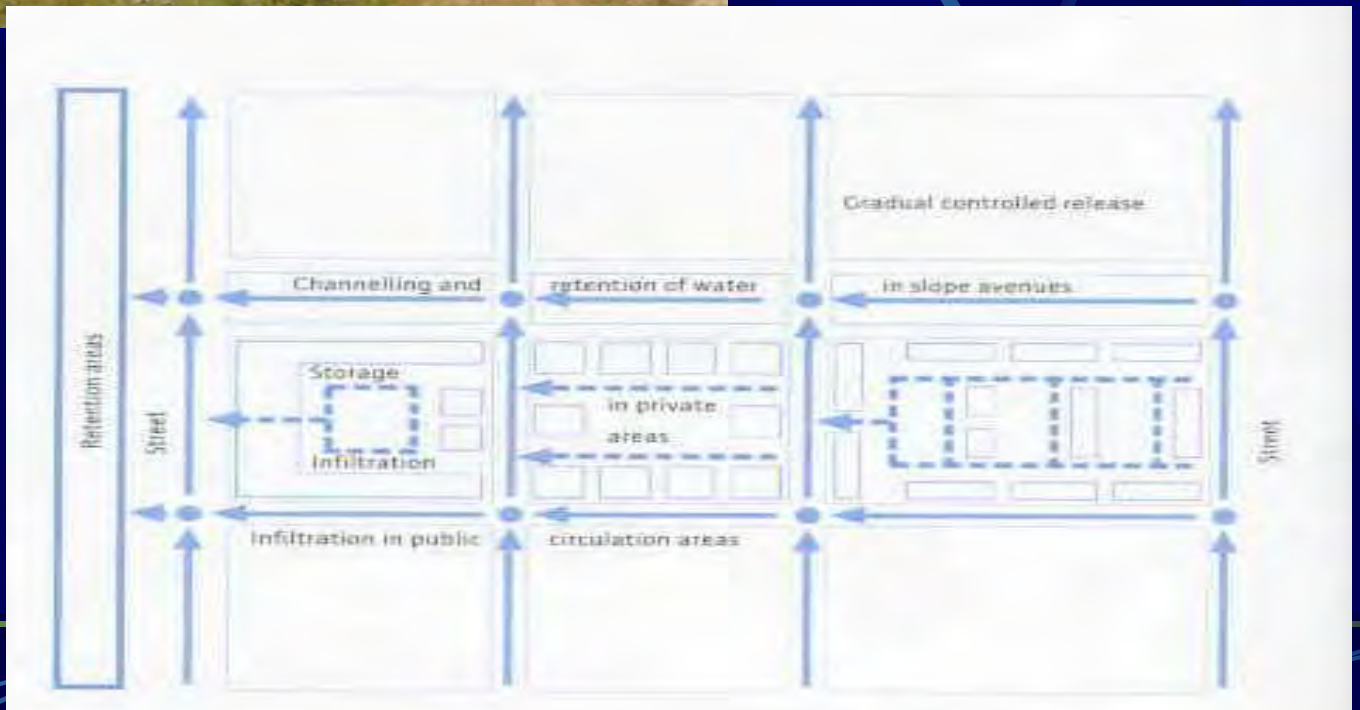




Integrated design

more examples

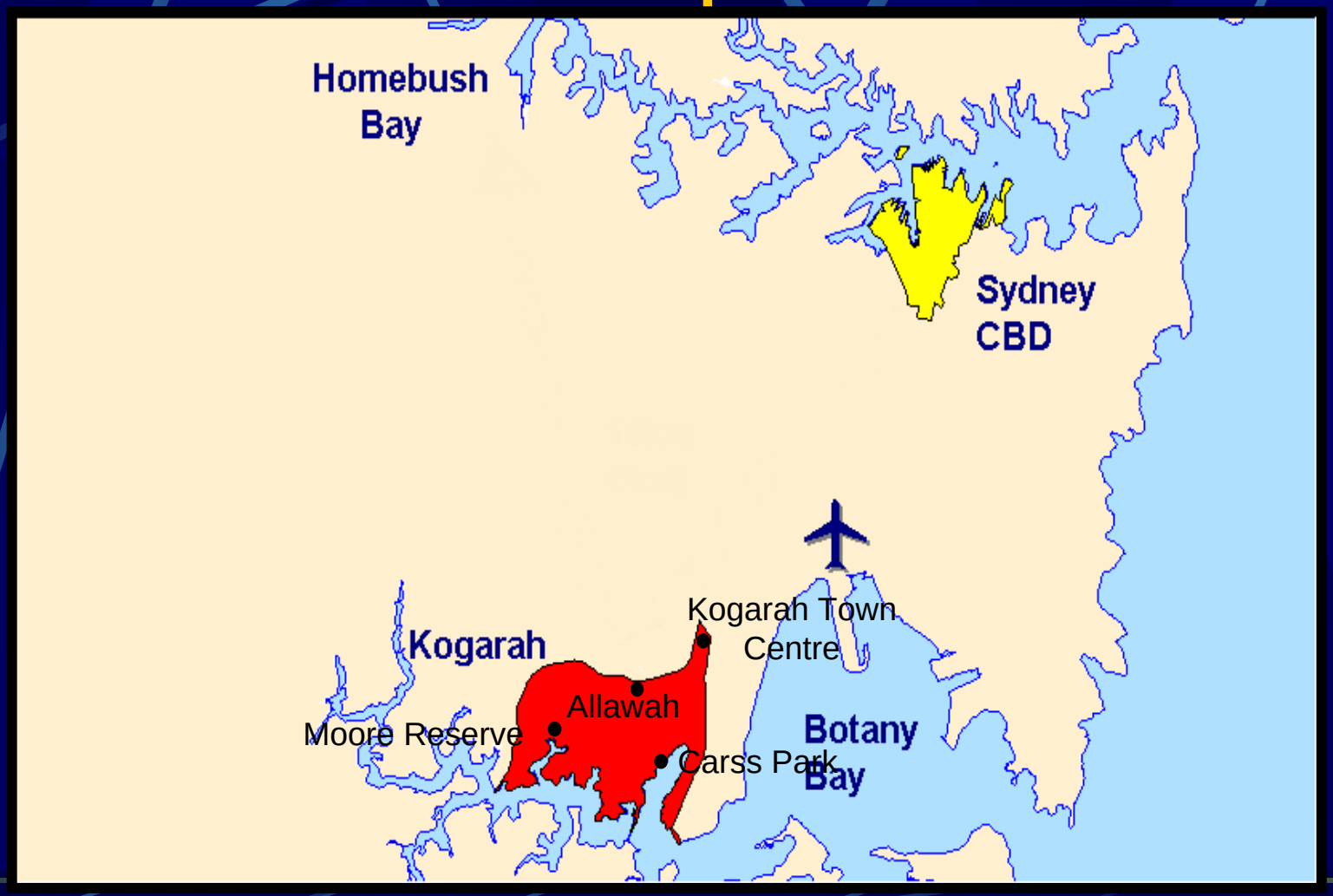
www.dreiseitl.de



Example – catchment repair

- Urban Renewal
  - Allawah – didn't work
  - Kogarah Town Square – did work
- Wetland – Creek line
  - Moore Reserve – did work

Location Map



Allawah -The Design Proposed:

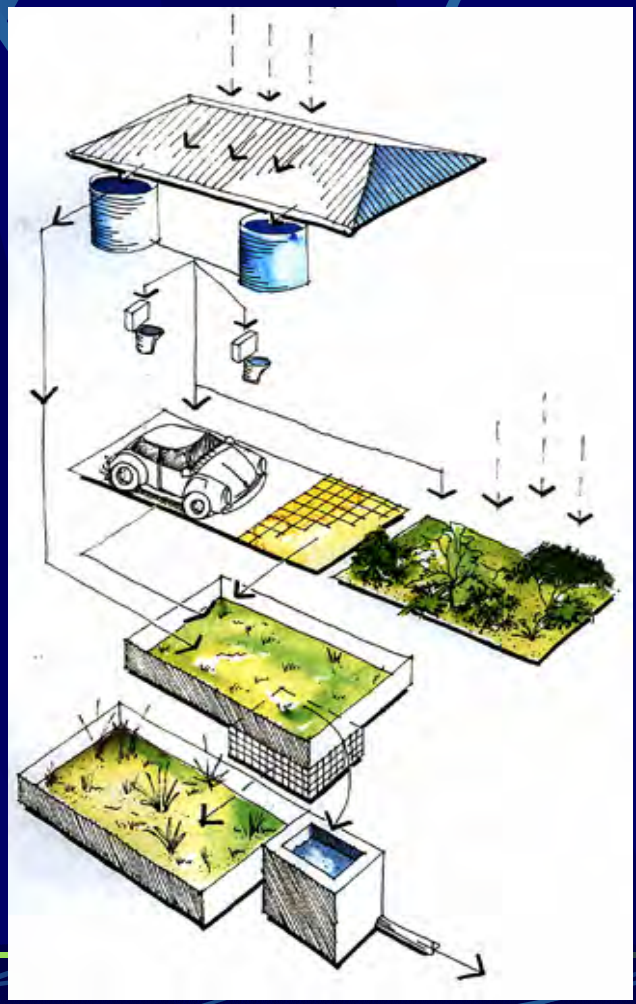
- Solar passive design and natural ventilation which would theoretically save 70% energy on comparable development.
- Rainwater reuse for irrigation, toilet flushing.
- 38 of the 42 bathrooms and car washing saves 600, 000 l/year.
- Stormwater & flood control coupled to landscape and sub-surface treatment proposed to treat 93% of run-off.

Water Achievements

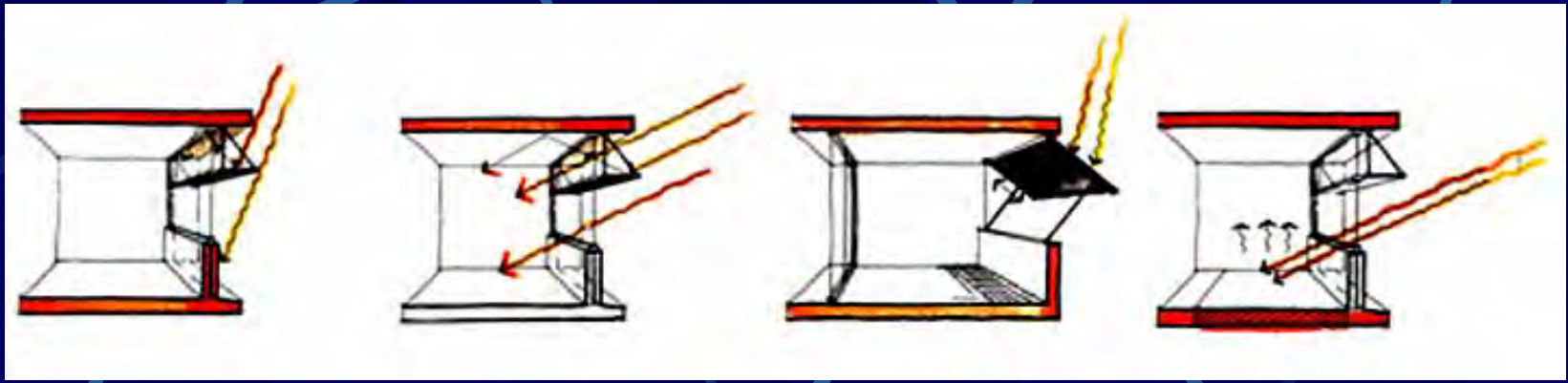
- Treatment of up to 1:3 month flood control.
- Rainwater for irrigation, car washing, toilet flushing for 38 or 42 bathrooms.

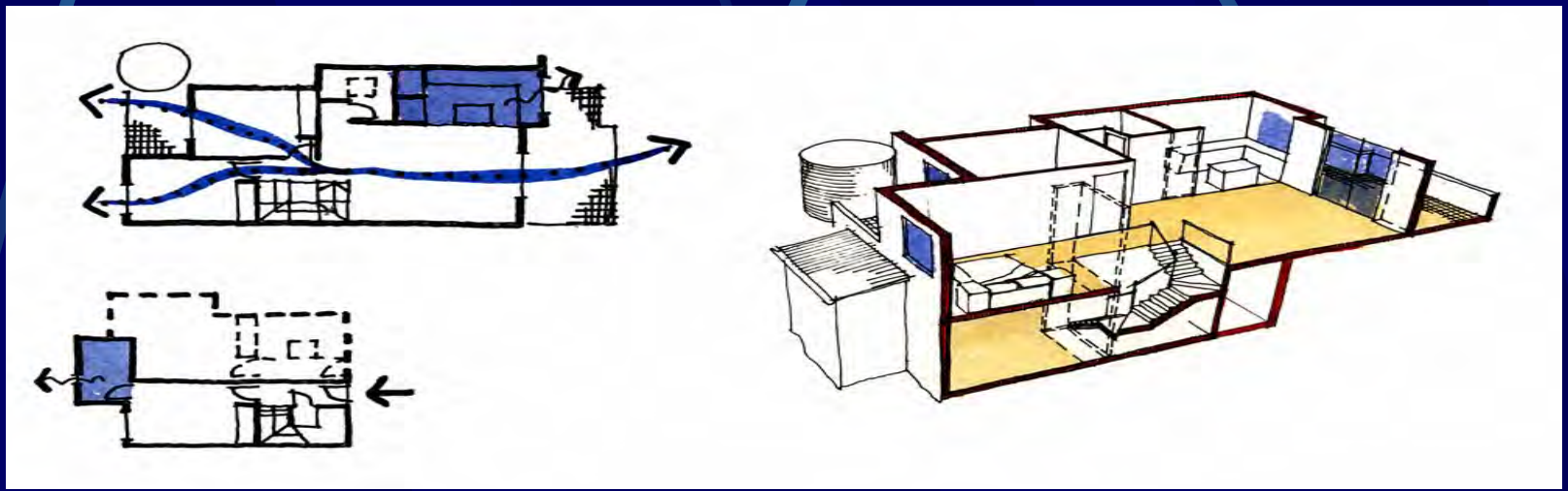
EQUALS

- 600,000 litres of potable water saved.
- 93% of stormwater treated to tertiary standard.



Passive Solar & Ventilation





What We Learnt

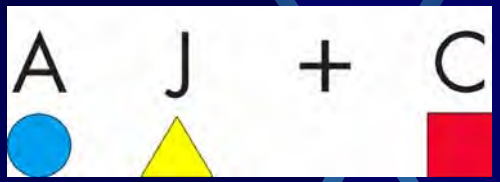
- It can be done ... and is cost effective ... on paper.
- Some of the Councillors believed we lost $$$ on the land sale.
- The developers bought without looking - but looked for modification during construction.
- Half the job - modifications where approved by others, so much of the innovation was lost.
- The development controls set the value land; what can be built and how,
- Councils can/should build in the controls to get the outcome they are looking for.
- Confidence to implement firm stormwater controls in our normal Development Controls

Kogarah Town Square

- 10,000 m^2 site, where a mixed-use complex
- Approximately 3000m^2 retail and commercial, 190 apartments
- A 1400m^2 public library and underground public parking.
- New Town Square
- Best practice urban and environmental design features - Solar Kogarah & WSUD

PARTNERSHIPS



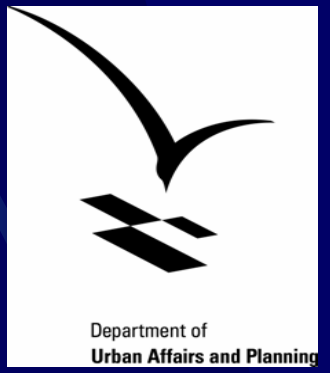


HIGHTRADE









Cultivate opportunities

ENVIRONMENTAL DESIGN

large livable terraces

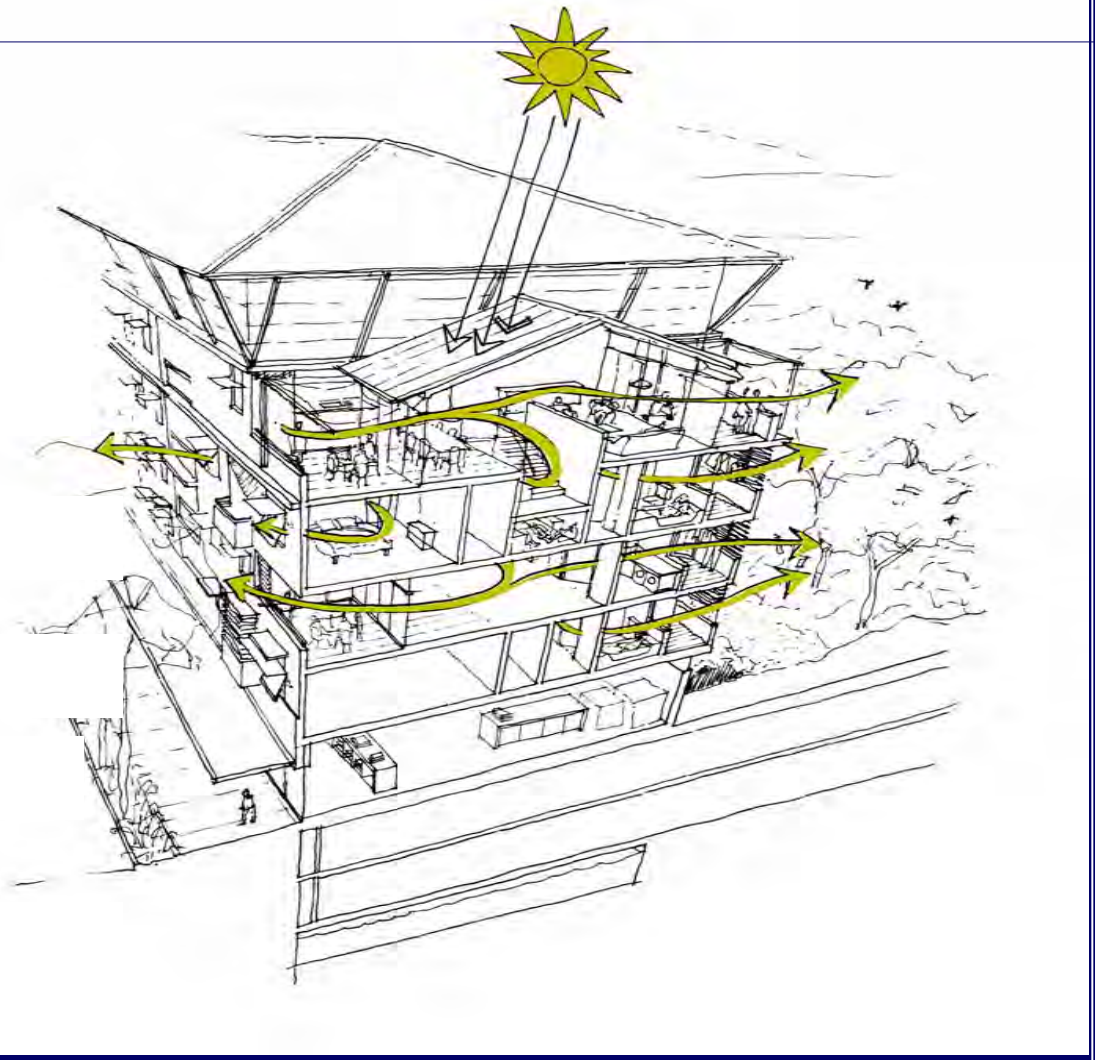
bathrooms and kitchens located on external walls

cross ventilation

high thermal mass

ctive street edges

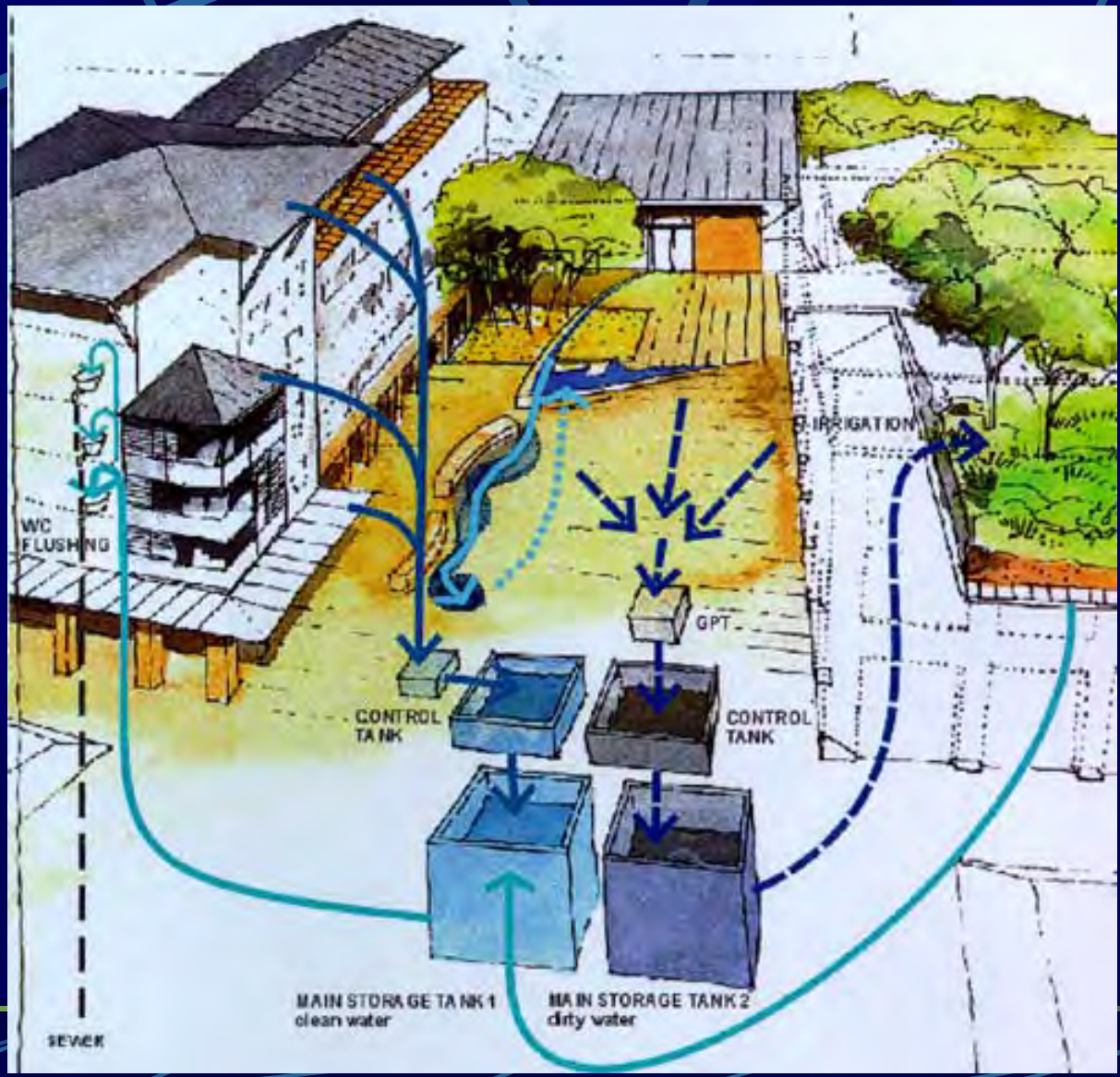
space and light and air



Integrated design outcome



Water System Design



Water System Design

Objectives

- detention - flood control
- conservation
- treatment - receiving waters
- awareness - public awareness
- aesthetics - quality of design & construction

Design Principles

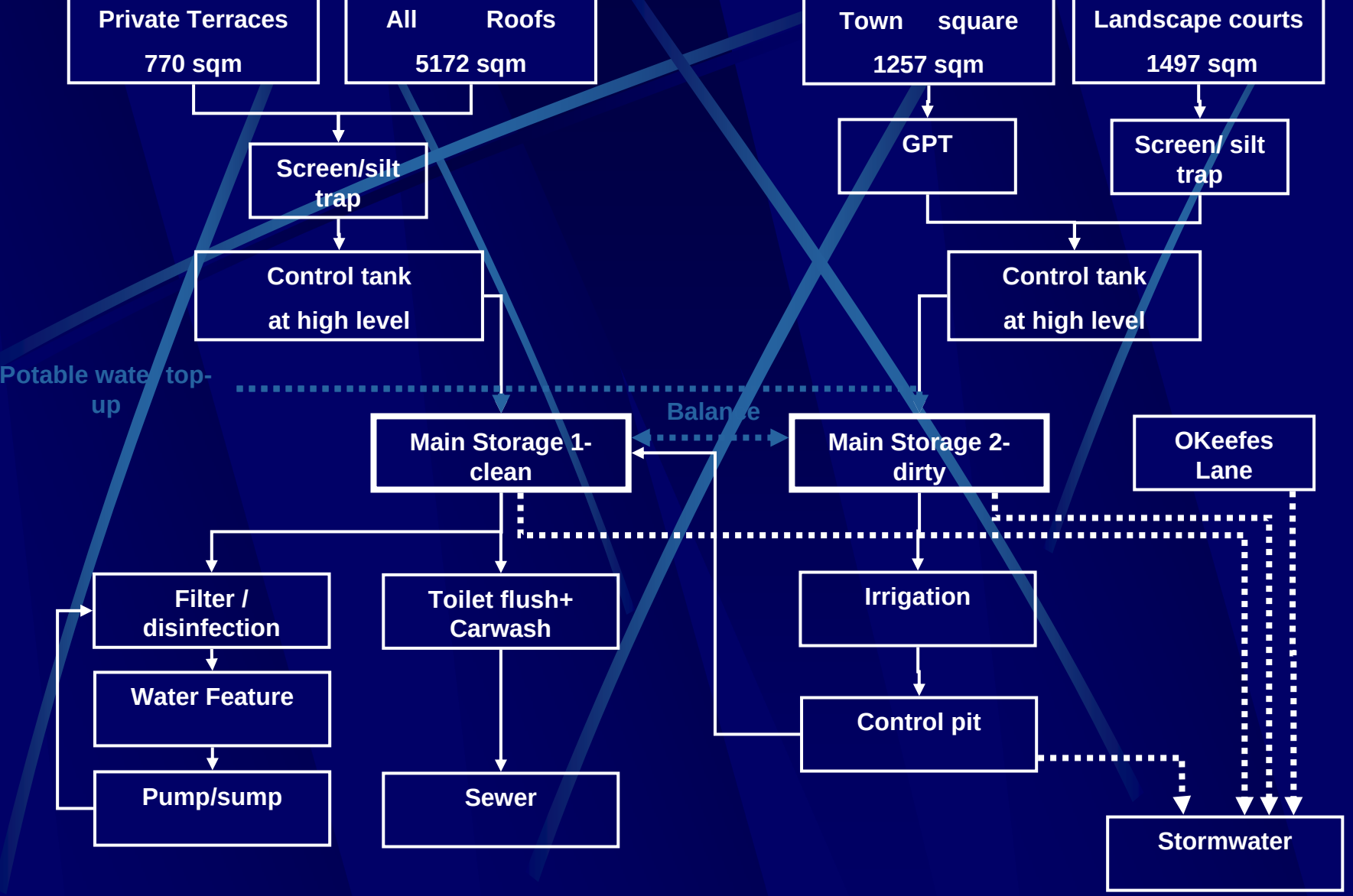
- fit for purpose
- recycling
- minimise treatment
- design to match objectives

Design Criteria

- structural implications
- buildability
- maintainability
- cost effectiveness - avoidance of duplication

Surface Areas

Roof	5172.6	sqm	55%		
Terrace	770.6	sqm	8%	64%	"Clean"
Landscape	1497.6	sqm	16%		
Setback	634.5	sqm	7%		
Townsquare	1257.0	sqm	13%	36%	"Dirty"
Total	9332.3	sqm			


Private Terraces
770 sqm
All Roofs
5172 sqm
Town square
1257 sqm
Landscape courts
1497 sqm
GPT
Screen/ silt trap
Screen/silt trap
Control tank at high level
Control tank at high level
Potable water top-up
Balance
Main Storage 1- clean
Main Storage 2- dirty
OKeefes Lane
Filter / disinfection
Toilet flush+ Carwash
Irrigation
Water Feature
Control pit
Pump/sump
Sewer
Stormwater

Flows

Kogarah – under construction









Moore Reserve

- 14.2 ha park – lower part of catchment
- Rubbish tip until late 1970's
- 2 square kilometre catchment
- Ecological restoration strategy
  - off line wetland
  - leachate treatment
  - bushland restoration
  - recreation
  - investigated landfill
- Consultation

Moore Reserve Masterplan - version 1



Artist impression that went wrong



Agreed Masterplan

- Funds from Stormwater Trust
- Georges River Foreshore trust
- Council



Moore Reserve Wetland Construction











Finished & working well

Catchment repair service as business opportunity

- Stream restoration, flood management, open space improvement, localised water harvesting.
- May also become a developer - to redevelop areas along drains.
- Outcome higher quality housing and living steams.
- In new subdivisions integrated water services - water / waste/ compost/vegetation management.
- Might sell nutrient rich water and feed stock into eco-industrial cluster.

Funding Catchment Repair

- Challenge of delivering Stormwater management plans
- Significant scale - no mechanism to implement across Sydney
- Kogarah $10 million - first phase
- 50,000 people, 18,000 households
- Scaled up to Sydney - $700 Million to $1Billion
- Threshold problems need bold political responses

The Funding / Policy Proposal

- Establish ‘institutional arrangement’ - councils and/or trusts and/utilities to borrow at state government loan rates.
- Create a “loan pool” of up to $1 Billion for long term - low interest public infrastructure financing endorsed by the Treasury.
- Establish a “catchment repair” levy collected by councils / trusts.
- Implement community agreed catchment repair plans.

Back of envelope calculations

- Borrow $700 million @ 6% over 30 years with monthly repayments of $ 4,196,854 per month.
- Sydney's population of 4 million people with average household size 2.7/household equates to a rate-base of 1,476,564 households.

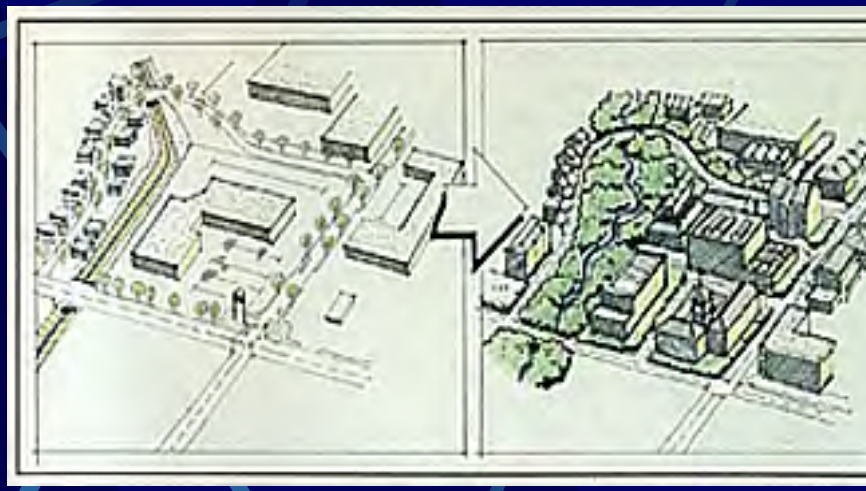
Therefore, monthly repayment per household is approximately = $2.84/hsld/mth. Allowing for exempting for low income - under $1 per week per household.

What has this got to do with Perth

- Dialogue – said wanted a connected city with urban growth boundary – no sprawl
- Clean green environment, water ways etc
- Alternatives to car
- More efficient use of resources
- Housing & Architecture & landscape that is responsive to environment
- Most liveable city – got a lot of work to do!!

Opportunities

Partnerships – to drive catchment repair



- EPA – an EPP to set direction
- DPI - supportive planning policy - WSUD integrated into “Liveable Neighborhoods”
- Development authorities & LandCorp - demonstration projects
- Water Corporation – draining management becomes catchment repair service
- Local Authorities – catchment plans outcomes in Local planning schemes

Identifying Barriers

- “Green technologies”- hindered by technical, economic, institutional barriers.
- New “artifacts” don’t fit the selection environment / institutions which supports old regime.
- “Power relationships” often hinder innovation - usually professionals and their bureaucracies - change is slow if not cultivated.

Impediments

- Physical mismatch
- Know-how mismatch
- Financial
- Institutional inertia
- Lack of community acceptability
- Political
- World -views/belief systems

Priorities - Policy Framework

- World views - be clear about our values and goals in Policy
- Selling catchment repair – capacity building
- Institutional arrangement - overcoming resistance
- Policy integration - range of scales and time horizons – use the policy tools

Priorities - Professional Praxis

- Willingness to integrate across institutions and professional boundaries
- Partnerships - public / public - public / private
- Role of professional bodies - facilitate

Priorities - Technical Know-how

- Ecological literacy - understanding the nature of the place
- Menus, recipes, ingredients - guidelines, manuals & tools
- Working with community - building skills

Priorities - Demonstration

- Learning by doing - document results – good & bad
- Outside the square - most creative innovation outside the systems

Summary - Enhancing Innovation

- Covered some history, philosophy, practice, my vision
- Dialogue - reflection, sharing, considering - provoking our imagination
- Catchment repair - explicit about our values - ‘big P - little p’
- Enhance our technical know how and community ownership

Finally

"Water is the precious life substance of the earth. Its value to the environment, climate and life of our world will be increasingly recognised. Violated, humiliated, piped, contaminated, less and less can it unfold its selfless qualities and fulfil its life-supporting task. Awareness, care and perceptive consciousness are being asked of humanity."

Herbert Dreiseitl



Drainage costs

Cost recovery in other States

New South Wales

- Sydney Water provides trunk stormwater network in southern Sydney – **charges set by IPART**
- Local councils manage majority of Sydney's stormwater systems
- All inner city LGAs responsible for their drainage, including disposal & costs of upgrading, O&M
- Developers responsible for infrastructure provision and pay for connection to local government retic. system
- Cost recovery (all O & M costs) through general rates
- No identification of costs to the user in rates notices
- No direct subsidies
- Partial headworks cost recovery by Bega Valley Shire Council, and levies for special projects

Victoria

- Melbourne Water responsible for arterial drainage
- Local councils control local drainage systems
- MW funded from specific Drainage and River Improvement Rate **on rateable (serviced) properties**
- MW provides limited services where farms historically exempt from rates
- Drainage schemes allocate costs of new facilities
- Implementation is funded by contributions from developers, **with all areas contributing on pro-rata basis**.
- Developments in non-scheme areas dealt with case-by-case
- Local drainage scheme O&M costs recovered through general rates
- No identification of costs to users in council rate notices

Queensland

- Brisbane City Council undertakes strategic planning, construction, operation and maintenance
- Infrastructure capital costs recovered from developers in accordance with strategic Infrastructure Charges Plan
- O&M costs recovered through Council rates, including costs of upgrading older sub-standard systems
- No identification of costs to the user in rate notices
- Redevelopment costs recovered from landowners, where there will be extra loading on the system
- No direct subsidies

South Australia

- Local Govt responsible
- **No arterial drainage system**
- Inner city councils covers all costs of upgrading, O&M
- Cost recovery (all costs) through general rates
- No identification of costs to the user in rate notices.
- No direct subsidies.

DRAINAGE SYSTEM

‘A Service Provider’s Perspective’

Garry Meinck
General Manager
Planning & Development
WATER CORPORATION



Drainage History

- 1833 - First Drainage problems experienced in Fremantle;

- 1848 – To deal with flooding the first drain was constructed from Lake Kingsford to Claisebrook;

- 1858 – Drainage and flooding continued and eventually Perth City Council took over drain construction;

- Flooding and drainage problems continued throughout the late 1800's, which in association with drinking water quality and deaths related to the lack of sanitary resulted in the Government centralising all disciplines with the Proclamation of the *Water Supply, Sewerage and Drainage Act 1912.*

- 1921 - The Public Works Department was separated into Country and Metropolitan areas;

- Construction of drainage network has continued in parallel to the Growth and Development in regional as well as Metropolitan areas

Fig. 1.6 Drainage problem, longitudinal sections of High St and Cliff St, 1833.

Drainage Governance

Pre 1996

Strategic Planning at catchment, sub-catchment and Local scale

- Water Authority Western Australian
- EPA

Detailed planning at Local and site scale

- **Local Government/ Development Industry**
- SRT

Post 1996

Regulators

- EPA
- OWR

Strategic Planning

- DoE (WRC)
- SRT

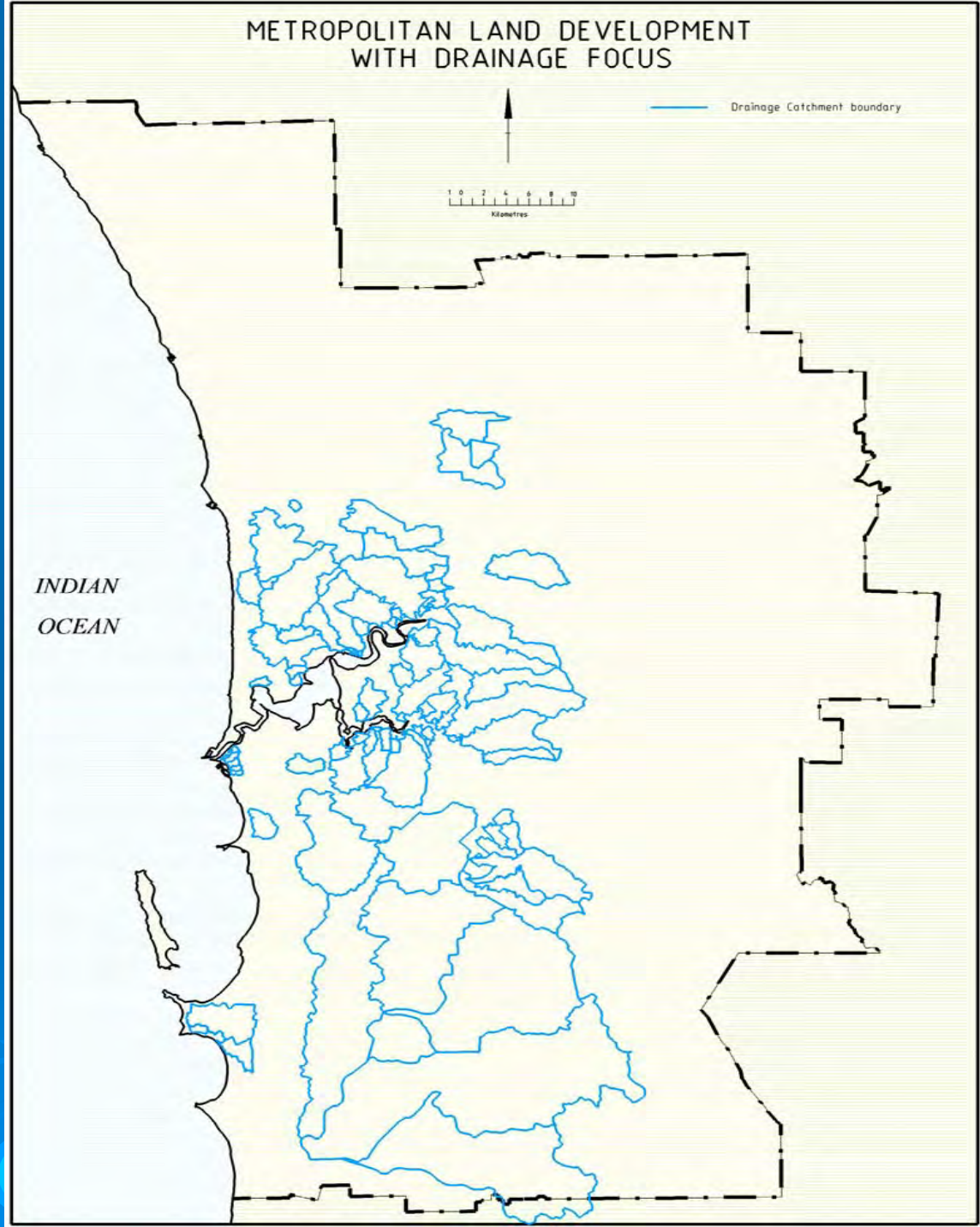
Regional & Local Infrastructure/Service Providers

- LG & Development Industry
- WC

Water Corporation Operating Licence

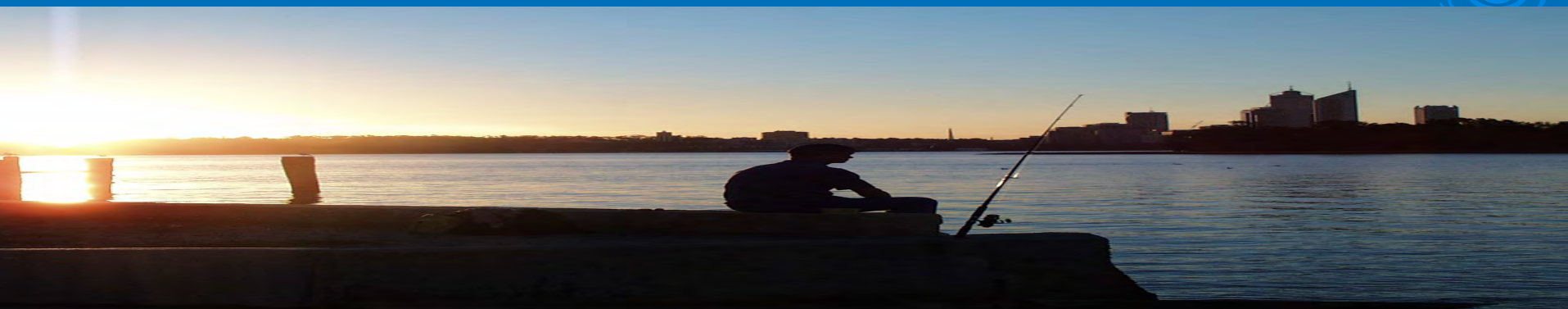


Metropolitan Drainage



Current Business Metro/Country

- Conveyance of stormwater and groundwater.
- Protect life and property from floodwaters.
- Liaise with Developers and Local Government to cater for additional flows.



From a Drain - to a Community Asset



Meeting the Sustainable Agenda ?



Existing Infrastructure Constraints



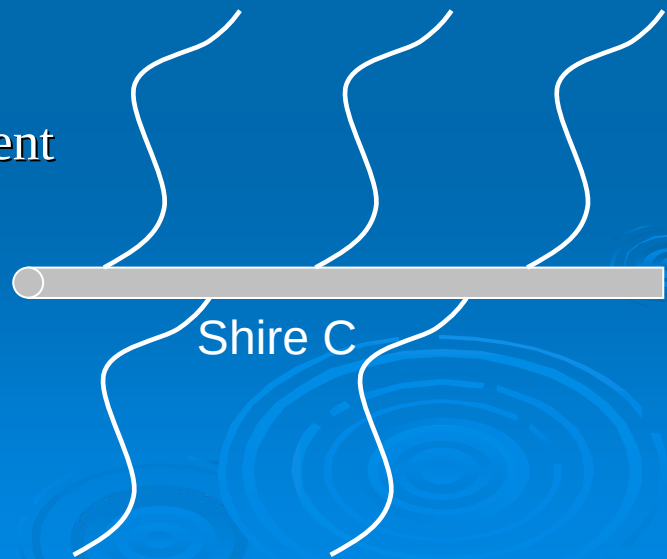


How drainage revenue is raised

- Drainage Service
  - Only on property owners in the metropolitan declared catchments;
  - Based on Gross Rental Value
  - Headworks



- Local Government
  - Revenue is raised through Local Government rating system (i.e. Gross Rental Value);
  - It is estimated that expenditure of drainage infrastructure is about 1% of Local Government's Works Budget



Examples of Water Quality Management

- Bartram Road Buffer Lake



- Henley Brook Nutrient Stripping Basin



Catchment Management

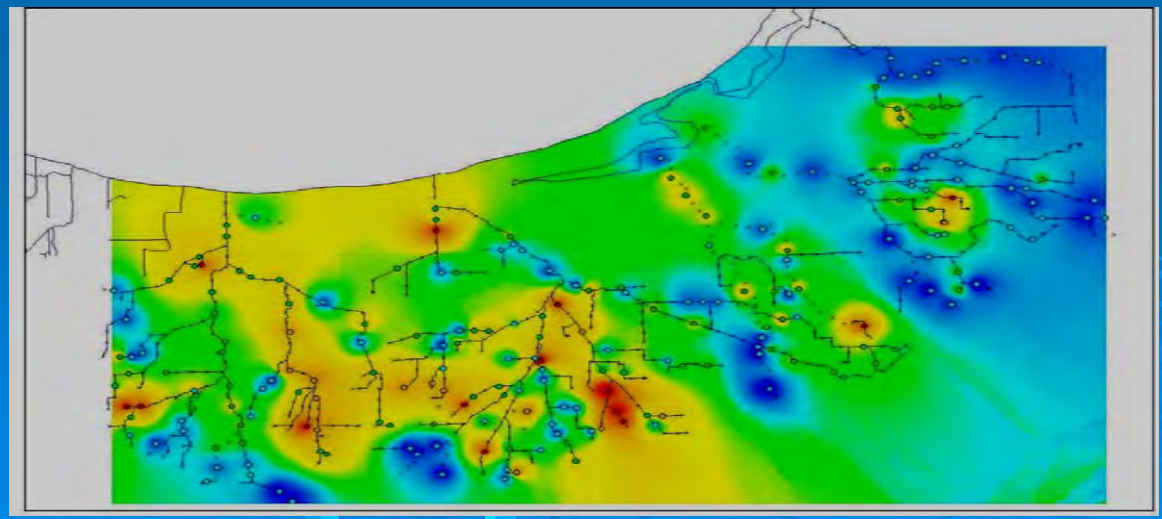
Busselton Environmental Improvement Initiative

Geographe Bay is under stress from nutrients originating from the urban and rural catchments.

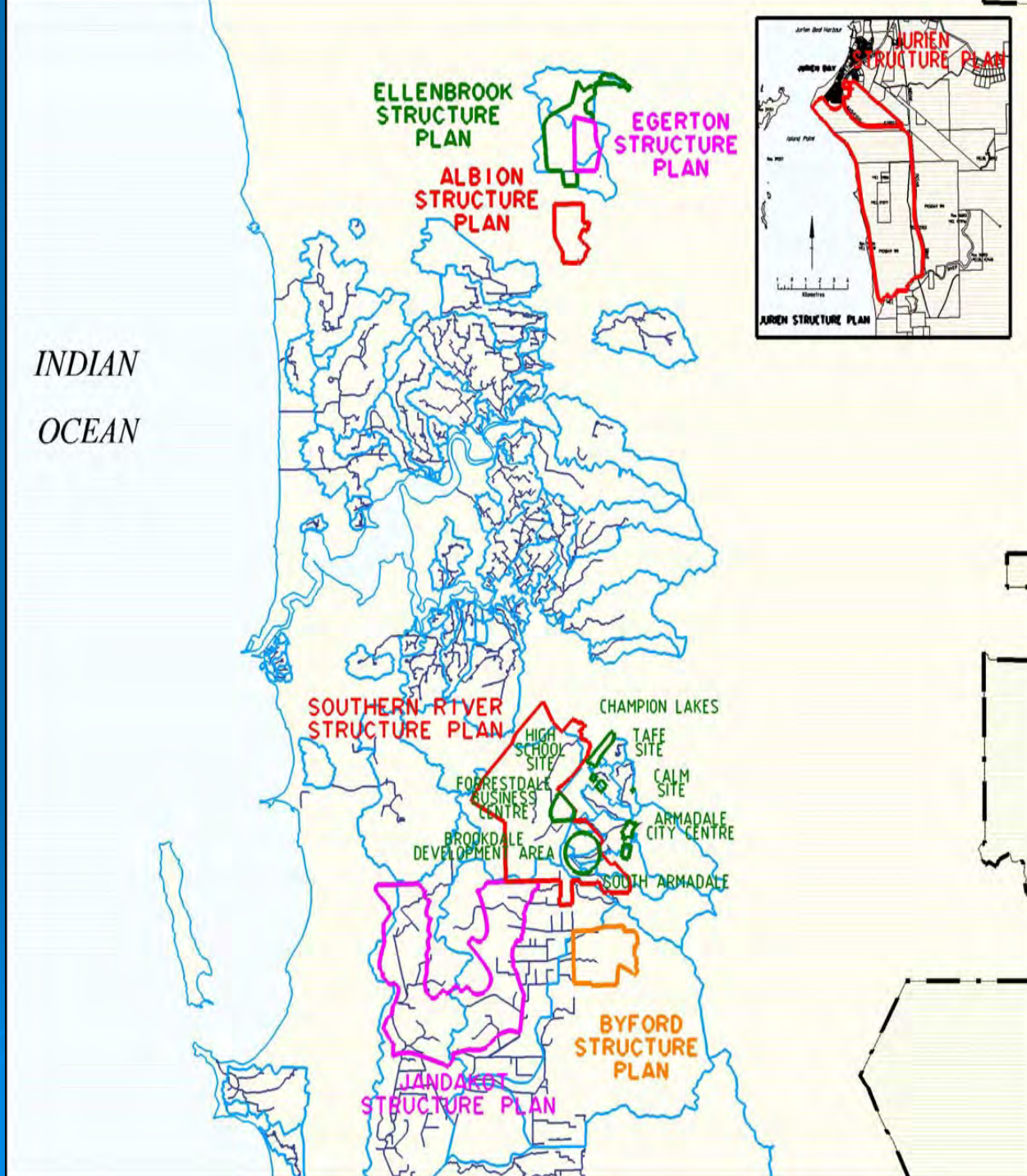
The Busselton EII is a whole of catchment program centred on a partnership arrangement with farmers to assist them to reduce nutrient discharge to Geographe Bay.

Beneficial Outcomes have included:

- The reduction of nutrients into Geographe Bay; and,
- The power of partnerships.

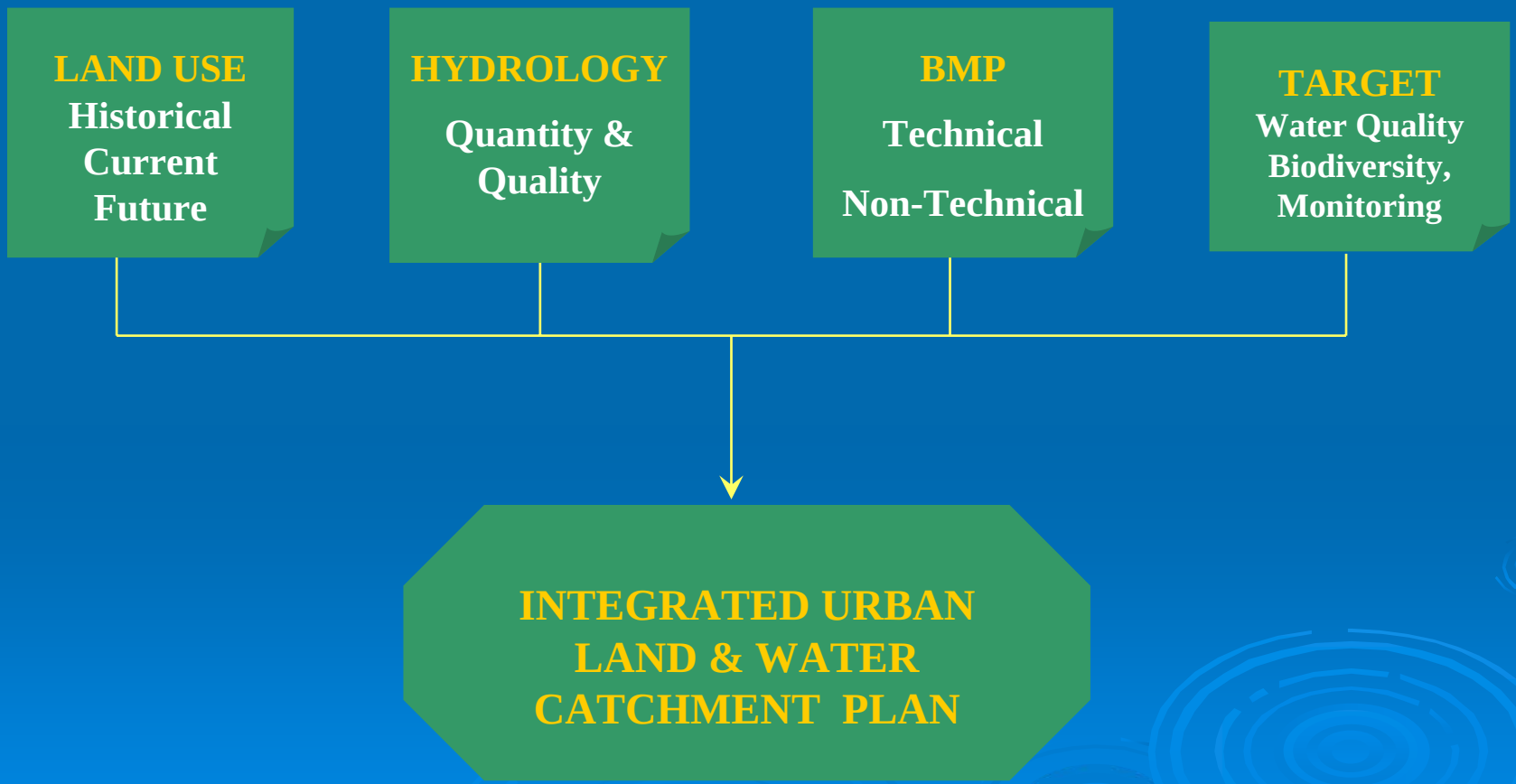


New Development New Approach



Step Change

Integrated Urban Land and Water Catchment Plan



Key Learning's

An Integrated and Co-ordinated Approach

Tool Kit



The Targets



Integrated Urban land and Water Catchment Plan



Land use: Previous, now and into the future



Community



Buffers





Drainage and Waterways

Improving Stormwater Outcomes

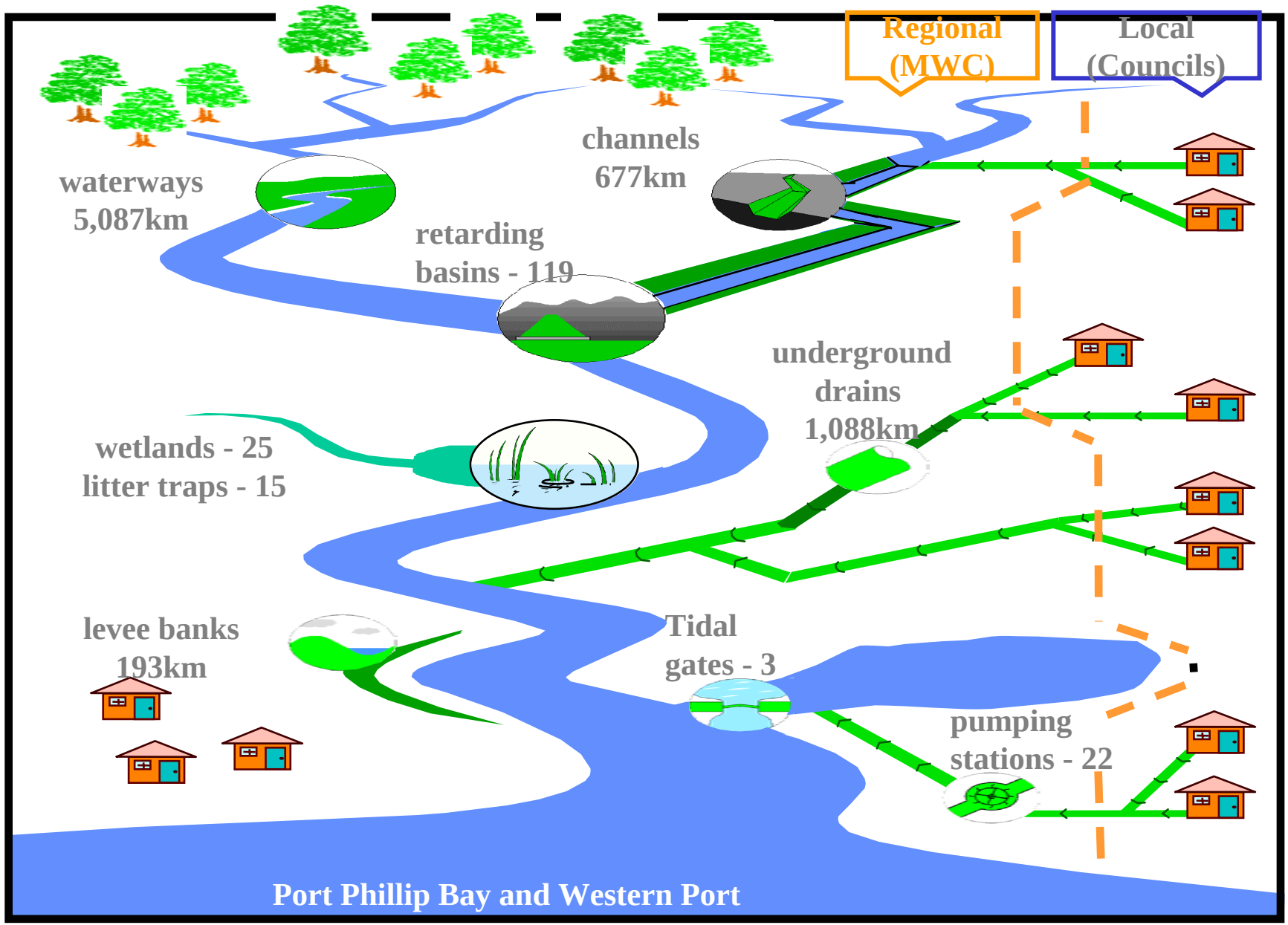


Ross Young

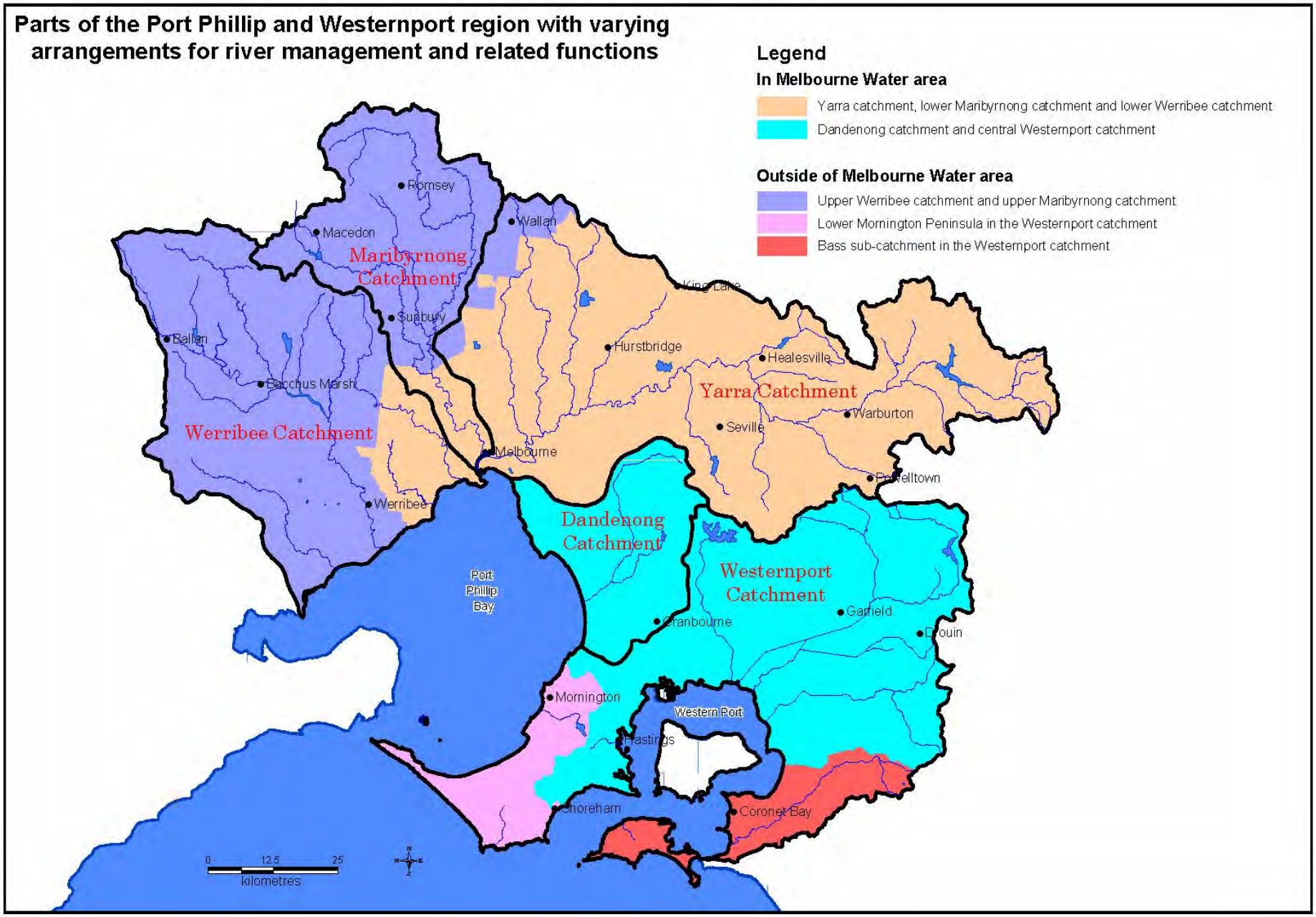


Accountabilities within Port Phillip and Westernport Catchments

- Councils – local drainage
- Melbourne Water
  - regional drainage, waterway management and floodplain management
- Catchment Management Authority
  - Catchment Reporting and Coordination
- Dept. of Sustainability and Environment
  - Natural Resource and Land Management


Regional (MWC)
Local (Councils)
waterways 5,087km
channels 677km
retarding basins - 119
underground drains 1,088km
wetlands - 25
litter traps - 15
levee banks 193km
Tidal gates - 3
pumping stations - 22
Port Phillip Bay and Western Port

Operating Area





Causes of the Problem

- **Property rights for stormwater are ill defined due to non excludable nature of products/services. This leads to "free riding"**
- **Many stormwater products/services are non-rival in consumption**
- **Lack of signalling and feedback mechanisms**



Drivers for Improved Stormwater Outcomes

- Reducing nitrogen loads to bays
- Impact of stormwater discharges on beaches and waterways
- Reducing litter
- Improving flood protection
- Stormwater as a resource



Key Elements of a Successful Stormwater Management

- Integrate floodplain, waterway and urban stormwater management to the greatest extent possible
- Stormwater included in statutory planning process
- Ability to intervene in the development/redevelopment process



Key Elements of a Successful Stormwater Management

- Good data
- Community knowledge of stormwater
- Involvement of key stakeholders
- Leadership



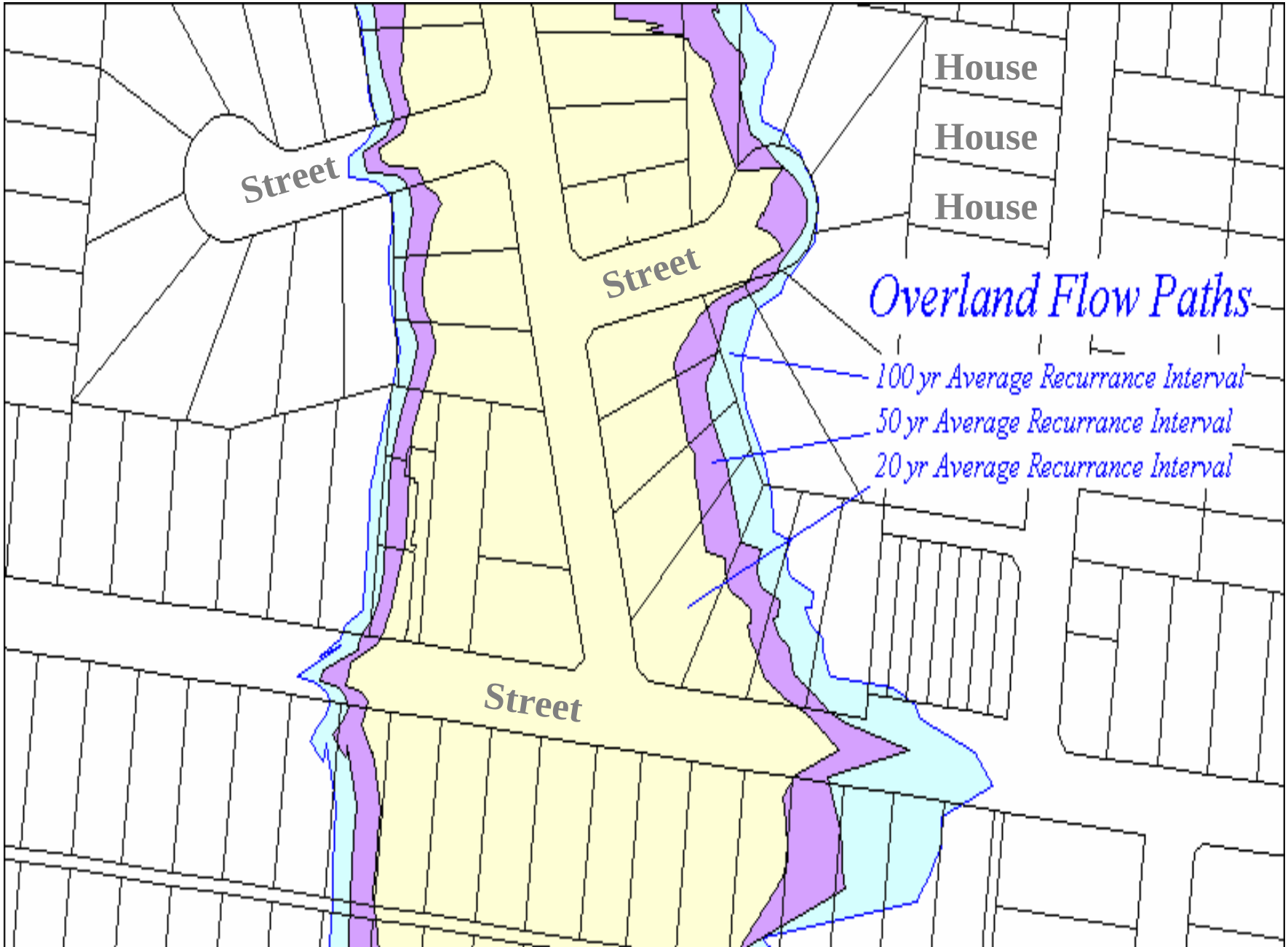
Important Tools

- Drainage schemes
- Special building overlays
- Best practice guidelines
- Good models eg MUSIC
- Operating Charter

Doreen Drainage Scheme



Flood areas demarcation in a planning scheme





The Way Forward

- Nitrogen trading
- Redevelopment drainage schemes
- Water sensitive urban design
- Stormwater as a resource

Wetlands



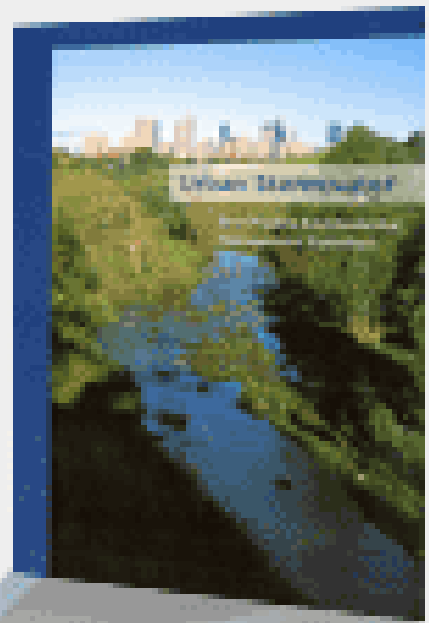
Water Sensitive Urban Design

Urban Stormwater

Urban Stormwater:

Best Practice Environmental Management Guidelines

Chapter 5:
Water Sensitive Urban Design



More...











MAIN DRAINAGE CHARGES

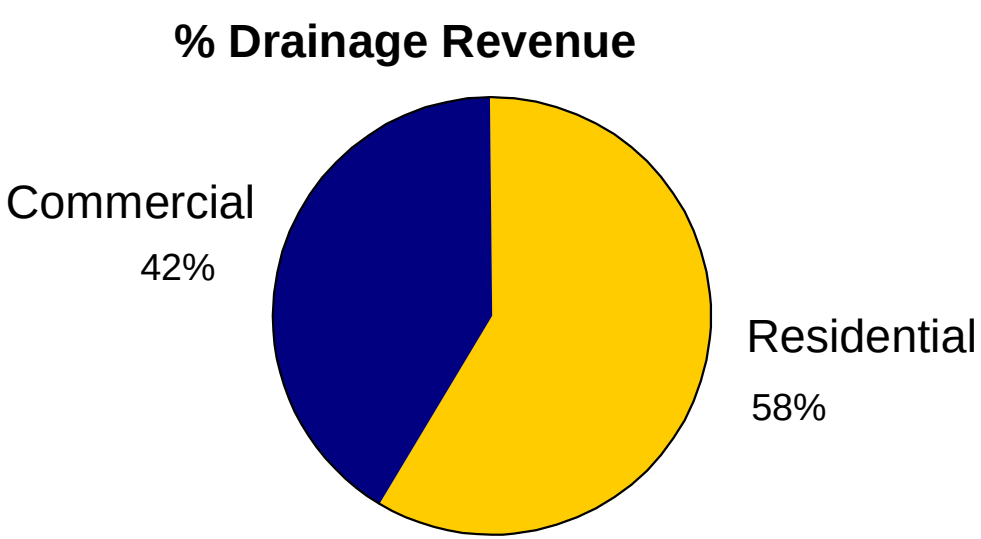
Main Drainage Prices

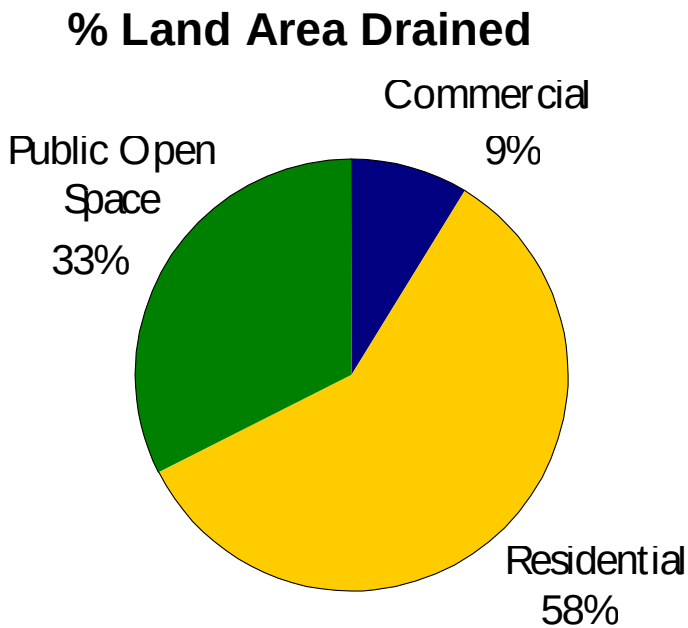
Charges apply within main drainage districts

Rate in $ GRV

Residential	0.574 c
Vacant Land	0.648 c
Non-residential	0.691 c
Minimum Charge	$50.20
Headworks	$294 per SRE

Main Drainage Revenue
$24m





Issues

Uniform charges apply to all main drainage catchments

Charges only paid by those within main drainage catchments

Provides benefits to those who use public open space (roads, parks, rivers, lakes)

Developed vs undeveloped land

Cost of collection vs equity and efficiency

Alternative Charging Methodology

Area based charge

Different charges by catchment

Modification of charges for on-site retention

Drainage Forum

Managing Drainage in the Swan-Canning Catchment –
Institutional Arrangement Options

Dr W.J. Cox
CHAIRMAN
ENVIRONMENTAL PROTECTION AUTHORITY

Institutional Arrangements - Options

Desired Outcome

- Nutrient input to the Swan-Canning Rivers down to levels to maintain river health (includes fringing vegetation)

Guiding Principles

- Nutrient management as part of total water cycle management
- Community ownership of problem and solution
- Separate planning/regulator and operator functions
- Standards set for receiving environment(s)
- User pays/beneficiary pays
- Accountability for outcome(s) including monitoring and reporting

Option 1 : Current Responsibility Matrix - Simplified

Who	Strategic Planning		Construction		Management		Impact	
	W	N	W	N	W	N	W	N
DOE			-	-	-	-	-	-
WAPC			-	-	-	-	-	-
Developer	-	-			-	-	-	-
Community	-	-	-	-	-	-		
Local Govt	-	-	-	-		-		
WC	-	-		-		-	-	-
SRT	-	-	-	-	-		-	-

Who is accountable for quantity of water and nutrients

reaching river?

Option 2 : Evolution of Current Model

Who	Strategic Planning & Regulation		Construction		Management		Impact	
	W	N	W	N	W	N	W	N
DOE		 *	-	-	-	-	-	-
VAPC			-	-	-	-	-	-
Community	-	-	-	-	-	-		
Local Govt	-	-	-	-				
WC	-	-					-	-
SRT	-	-	-	-	-	-	-	-

- DOE to license discharge to river from drains.
- Local Government and Water Authority to manage water and nutrient discharge to main drains and river.
- Reduces the long term role of Swan River Trust in managing impact of nutrients.
- Accountability focuses on Water Corporation and Local Government

Option 3 : Single Agency Model – Water Cycle Management

Who	Strategic Planning	Construction	Management	Impact
	W & N	W & N	W & N	W & N
Agency				-
WAPC				
Developer	-		-	-
Local Govt	-	-	-	
WC	-	-	-	-
SRT	-	-	-	-

Weakness is where the standard setter and the operator are the same agency and accountability is internalised

Option 4 : Single Agency Model – Management Only

Who	Strategic Planning & Regulation	Construction	Management	Impact
	W & N	W & N	W & N	W & N
DOE	🗐	-	-	-
WAPC	🗐	-	-	-
Developer	-	🗐	-	-
Community	-	-	-	🗐
Agency	-	🗐	🗐	-
Local Govt	-	-	-	🗐
WC	-	-	-	-
SRT	-	-	-	-

- DOE is regulator.
- Agency could be Water Corporation, Swan River Trust or new agency.
- Single agency accountable for discharge to river.

Assessment Against Guiding Principles

Principle	Option 1	Option 2	Option 3	Option 4
Total Water Cycle	No	Yes	Yes	Yes
Community Ownership	Some	Some	Some	Some
Separate Regulator and Operator	Yes	Yes	No	Yes
Standards Set	No	Yes	Yes	Yes
User/Beneficiary Pays	No	No	No	Yes
Accountability	No	Some	No	Yes

- Option 4 could also be achieved in Options 2 and 3

Conclusions

- Existing arrangements are untenable.
- Need to focus on Total Water Cycle management.
- Institutional change by itself will not address issue.
- Institutional change, plus standard setting, plus user pays/beneficiary pays, plus change in community behaviours.
- Single operating agency has advantages.

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Understanding the System: Planning for Urban Development



Presentation to

Drainage Forum: Drainage Management in the Swan-Canning Catchment

24 November 2003

Government of Western Australia

OVERVIEW

1. Sustainability – The decision making context and how planning seeks to achieve sustainable outcomes

2. The Land Use Planning Framework – What are the key elements of the planning system and how planning addresses drainage issues

3. The Issues - What are the key issues for the planning system in dealing with drainage at a catchment level

4. Water Sensitive Urban Design Case Study - Example of what planning is doing to incorporate Water Sensitive Urban Design into land use planning

SUSTAINABILITY

- ***Thee STATE SUSTAINABILITY STRATEGY (September 2003) has set the agenda for future development.***

- ***A prime objective of the land use planning process is to seek sustainable outcomes, an objective already in the STATE PLANNING STRATEGY (1997).***

SUSTAINABLE OUTCOMES THROUGH PLANNING

- *To achieve sustainable outcomes, the planning process needs to:*
  - *consider a range of social, economic and environmental matters (including issues relating to water);*
  - *provide policy guidance on best practice and design;*
  - *promote a whole of government approach;*
  - *base its decision making on the best available information; and*
  - *where necessary enter into trade offs in order to achieve a balanced or desired outcome.*

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TOWARDS THE FUTURE

The State Government directions for Stormwater and Drainage Management are:

To use water resources more sustainably by considering water as an asset and within the context of the total water cycle.

To employ a holistic approach to water resource management where elements such as stormwater, drainage, nutrient management, WSUD, protection of water resources, water efficiency, recycling and reuse are subsets of the "bigger picture".

LAND USE PLANNING FRAMEWORK

State Planning Strategy (1997) and Statement of Planning Policy No. 1 – State Planning Framework (May 2000):

- ***Provides central framework and context for decision-making on land use and development in WA.***
- ***Informs WAPC, local government and others on aspects of State level planning policy which are to be taken into account/given effect.***
- ***Aims to integrate decision-making across all spheres of planning.***

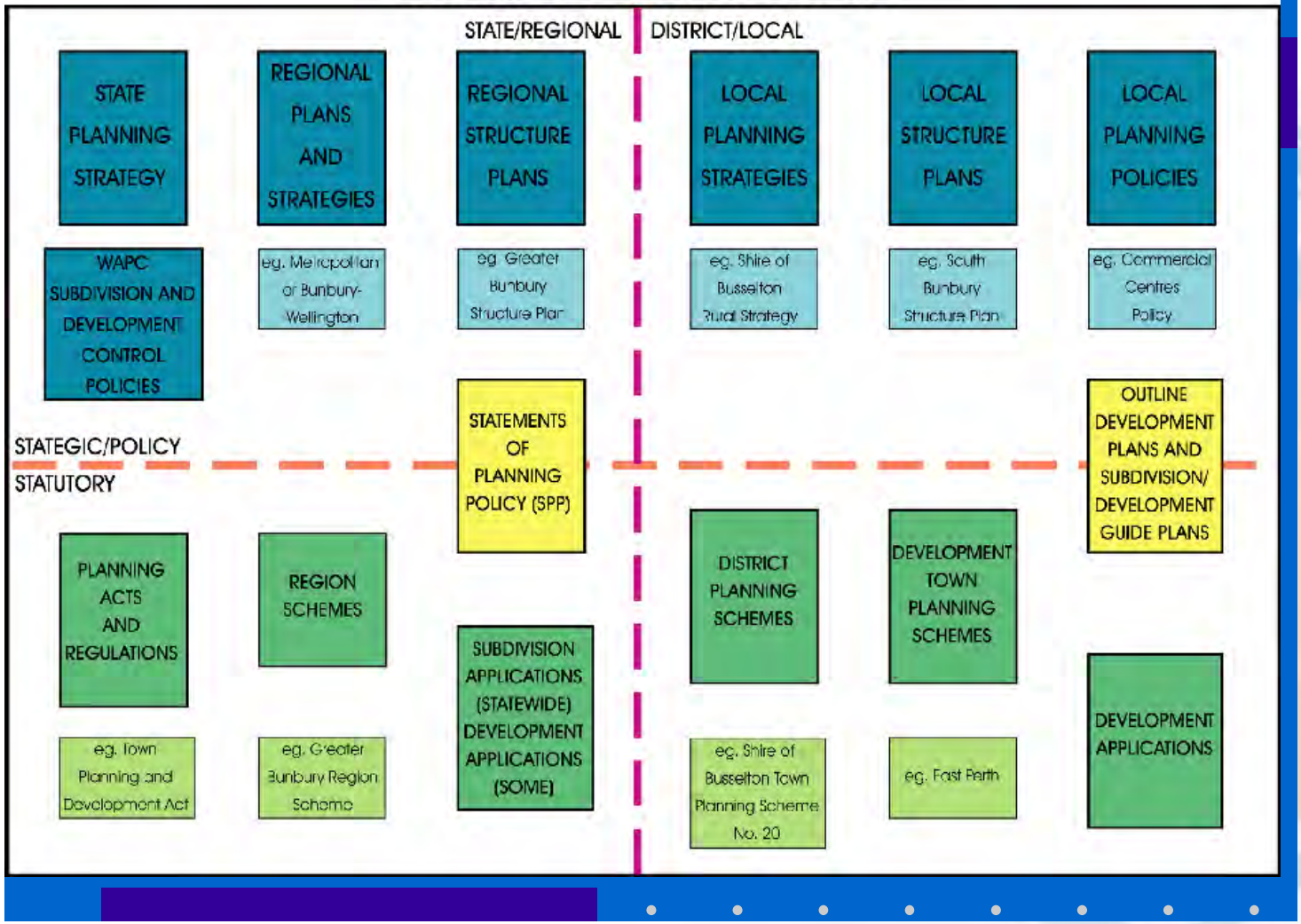
LAND USE PLANNING FRAMEWORK

State Planning Strategy (1997) and Statement of Planning Policy No. 1 – State Planning Framework (May 2000) primarily:

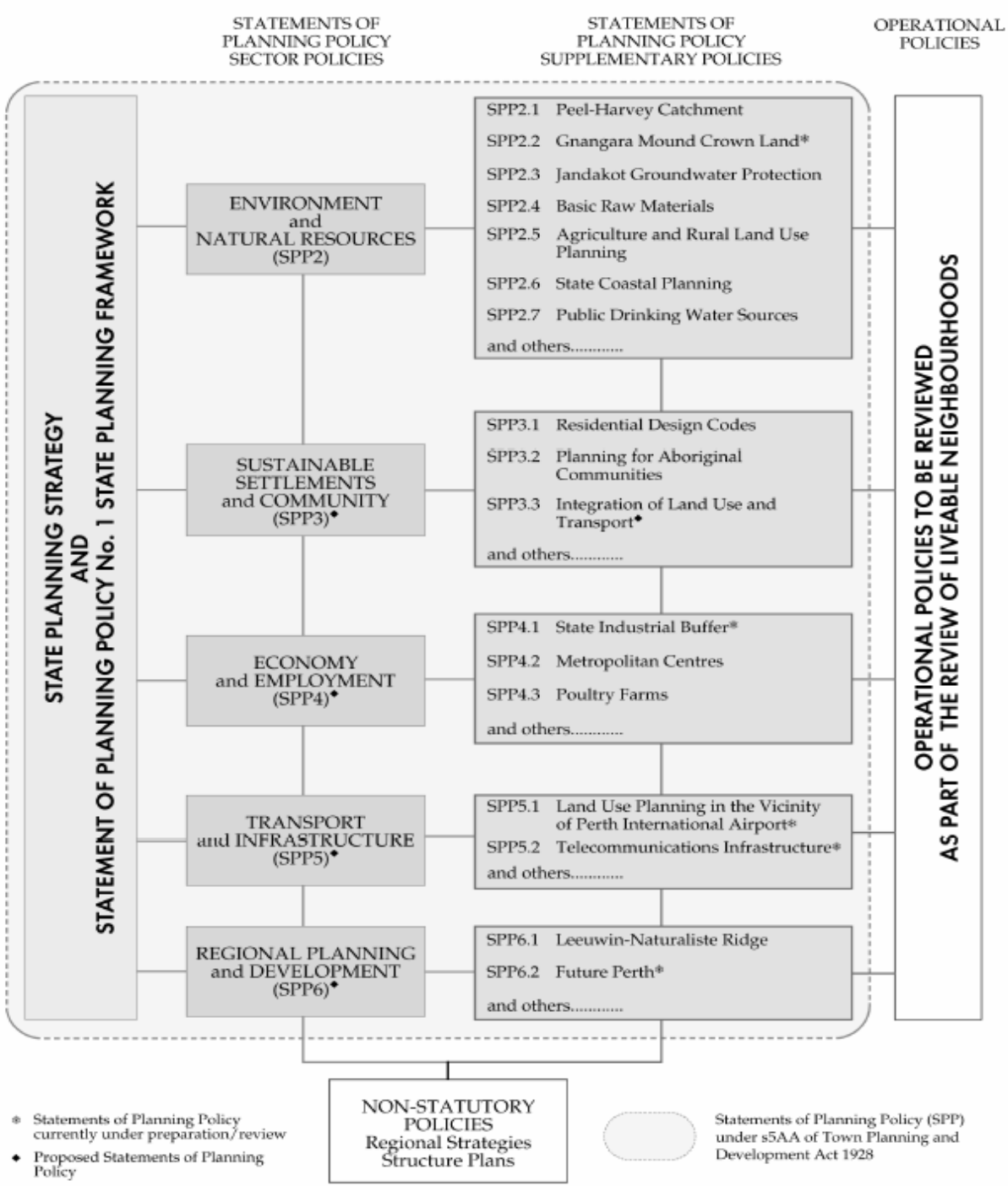
- ***Set out general principles for land use planning and development relating to Environment, Community, Economy, Infrastructure and Regional Development.***
- ***Establish hierarchical framework of STATUTORY and STRATEGIC POLICIES.***

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LAND USE PLANNING FRAMEWORK



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PLANNING PERSPECTIVE ON DRAINAGE

- *Need for holistic approach – drainage is one component of total water resource management.*
- *Trade-offs between competing demands may be necessary to achieve balanced outcomes.*
- *Planning system provides specific opportunities to address issues relating to drainage.*
- *Planning mechanisms one component of suite of legislative and administrative arrangements for drainage management.*
- *Planning relies on technical information available to it (eg provided by other agencies) at the time of making decisions.*

HOW PLANNING ADDRESSES DRAINAGE ISSUES

- *State Planning Strategy*
- *Statement of Planning Policy No. 2 – Environment and Natural Resources*
- *Proposed Statement of Planning Policy – Water Resources*
- *Planning Bulletin No. 61 – Stormwater Management*
- *Liveable Neighbourhoods*
- *Other Initiatives*

STATE PLANNING STRATEGY

State Planning Strategy provides strategic guidance on the WAPC's position in respect to conserving and protecting the quality of water resources. Actions identified include:

- *promoting Water Sensitive Urban Design (WSUD) in urban subdivisions and local structure plans;*
- *promoting integrated catchment management (ICM); and*
- *encouraging greater use of recycled waste water.*

SPP NO. 2 – ENVIRONMENT & NATURAL RESOURCES

SPP No. 2 contains Water Resources Policy Measures:

Planning Strategies, Schemes and decision-making should –

consider mechanisms to protect, manage, conserve and enhance (inter alia) waterways and estuaries; and

encourage urban water management through WSUD approaches that better manage stormwater quality and quantity through:

- ***reducing the impact of stormwater flows to streams, wetlands and coastal waters; and***
- ***controlling or removing pollutants and nutrients so as to improve water quality, retain habitats, conserve water and provide for recreational opportunities and conservation functions through multiple use drainage systems.***

PROPOSED SPP – WATER RESOURCES

Proposed Water Resources SPP aims to:

- ***use land use planning to promote and contribute to using our water resources more sustainably; and***
- ***seek the protection of the State's significant water resources through land use planning.***

Will include policies which relate to:

- ***use of total water cycle management principles within new developments;***
- ***promoting WSUD principles in all types of new development; and***
- ***recognition of the need to consider catchment planning when planning and designing for new areas, particularly through structure planning.***

PLANNING BULLETIN NO. 61 – URBAN STORMWATER MANAGEMENT

- *Outlines WAPC current position and practice and considerations re: USM.*
- *Applies to new residential subdivisions.*
- *Summarises relevant aspects of existing policies including:*

  Operational policies (e.g. DC 2.3 – POS in residential areas – multiple use of POS; stormwater management facilities) &

  Liveable Neighbourhoods relating to USM.
- *Flags WAPC intention to use the LN policy to review existing policies and merge into comprehensive policy to guide structure planning and subdivision.*

LIVEABLE NEIGHBOURHOODS

- *Assessment tool for structure plans and subdivisions for new urban development.*
- *Promotes integrated approach to designing future communities.*
- *Contains 6 elements to facilitate sustainable development.*
- *Element 4 – POS credits for shared drainage/POS facilities.*
- *Element 5 – WSUD approaches to UWM including:*

  prevention of flood damage; addressing stormwater quality & quantity; stormwater discharge not to degrade receiving waters; maximising opportunities for local on-site storage; multiple use systems; cost efficiency.

OTHER INITIATIVES

WAPC also dealing with urban water management issues through:

- ***Participation in Working Group reviewing Manual for Managing Urban Stormwater Quality in WA;***
- ***Preparation of strategic plans eg Southern River/Forrestdale/Brookdale/Wungong District Structure Plan and supporting the Urban Water Management Strategy for the same area (and associated MOU); and***
- ***Membership (through DPI) on Drainage Reform Group.***

WHEN CAN PLANNING INTERVENE?

- *Scenario A: Existing situation & no change proposed. Absence of trigger to achieve changes through statutory planning implementation mechanisms.*
- *Scenario B: Redevelopment of substantial areas (brownfield). Some opportunities for retrofitting but cost may be a limitation.*
- *Scenario C: Infill development (brownfield). Generally connection to existing service or limited retrofitting. Scale of proposal unlikely to warrant broadscale retrofitting.*
- *Scenario D: New development of substantial area (greenfield). New infrastructure provision.*

ISSUES FOR PLANNING

- *Not always possible to optimise drainage outcomes as must balance many factors.*
- *Planning system only provides opportunities to impose requirements at certain stages of the statutory process e.g. when land use change/rezoning is proposed or a specific subdivision or development application is made.*
- *Statutory conditions must be defensible, that is relevant and reasonable in the context of the proposal. Desirable drainage measures may be unduly onerous.*
- *Accurate environmental baseline data may not be available to assist in design/assessment of structure plans and subdivisions.*
- *Cooperation of developers to be innovative and lead by example.*

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ISSUES FOR PLANNING (2)

- *Need for coordinated/consistent advice from DPI, DoE, local governments and other relevant government agencies. Could be facilitated by developing partnerships eg Commonwealth re: Australian Rainfall Quality National Standard Manual.*

- *Development may impact on adjacent areas.*
  Need to consider implications in context of catchment.
  Recognised in new policies (SPP No. 2 – Environment and Natural Resources & proposed SPP – Water Resources) but there will be lag in implementation.

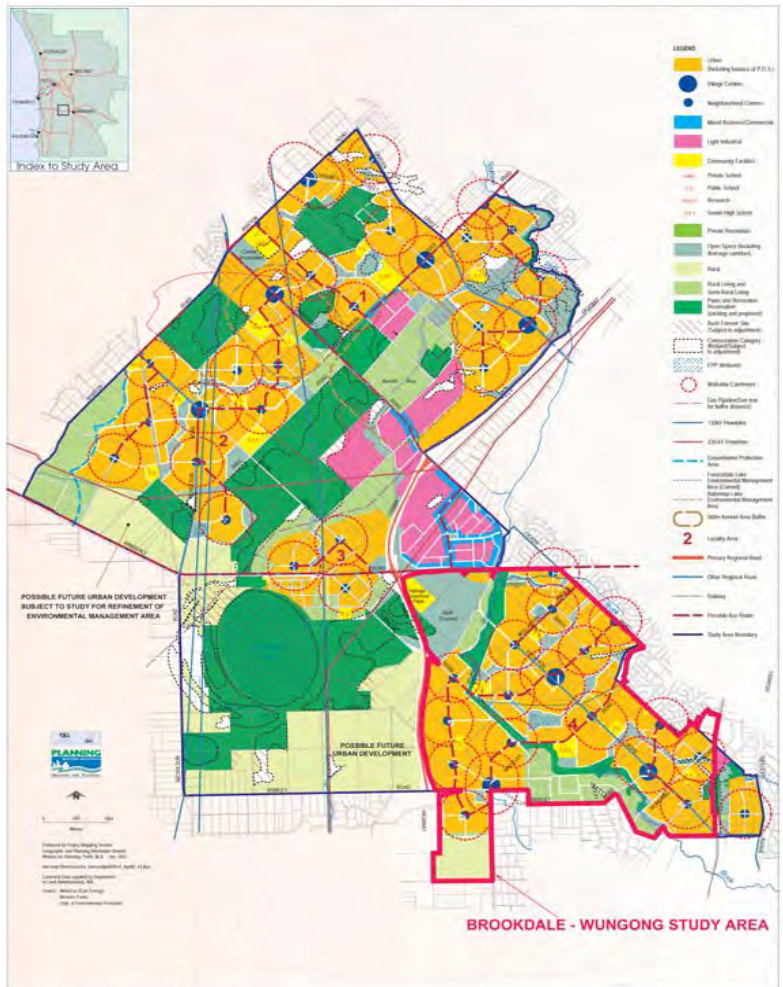
- *Need to prepare overall water resource management plan to ensure all water related issues are dealt with in an integrated and coordinated manner and how this interrelates with land use planning.*

ISSUES FOR PLANNING (3)

- *Removal of polluting land use does not address issue of stored nutrients.*
- *Mismatch in catchment boundaries and local government administrative boundaries (on which planning scheme coverage based).*
- *Education required to modify behaviour.*

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WSUD CASE STUDY



Southern River/Forrestdale/Brookdale/Wungong
District Structure Plan

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WSUD CASE STUDY

Land use planning implications for the case study:

- ***the regional planning for the site includes a regional strategy and appropriate zonings and reservations in the MRS, including a significant portion of the study area zoned Urban Deferred;***

- ***principles for water resource and sustainable stormwater management are well established, the challenge is to investigate and apply suitable and innovative best practice implementation measures to structure plans, subdivision design and water resource management plans;***

- ***the need to collect relevant environmental data to enable best practice design is crucial, particularly as it is acknowledged that drainage in this area will influence subdivision design. A review of the background information for the study area reveals much of this work is yet to be completed including lack of groundwater information, flood management discrepancies and the need for water quality modelling;***

WSUD CASE STUDY

- *Land use planning implications for the case study (cont.):*

  - *Given the uncertainties in respect of baseline data, design work should not be undertaken until this information has been completed and agreement reached with the relevant authorities as to suitability and accuracy of this data;*

  - *How will contemporary stormwater and WSUD principles apply to the study area, for example, how effective will dealing with disposal of stormwater at source be in an area with a high water table?;*

  - *Principles should be applied in a wider context, not just concentrate on residential areas but all components of development (eg. Commercial areas);*

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WSUD CASE STUDY

- *Land use planning implications for the case study (cont.):*

  - *Can trade offs achieve affordable cost effective housing and produce a vibrant attractive sustainable community? Given the environmental constraints of the area and its location, cost - effective methods in dealing with stormwater disposal will be a fundamental consideration if viable development is to occur;*

  - *What are the wider strategic considerations and implications as a result of development of the study area for the Canning Catchment given the plan to revitalise the Wungong River in the Swan-Canning Cleanup Program, Caring for the Canning and the draft Riverplan?; and*

  - *How can development work with and facilitate the recommendations of these reports – what are the implications for environmental flows and nutrient export ?*

WSUD CASE STUDY: LESSONS

- *Planning for water management in new land developments in the urban areas is improving, with arrangements in place for stormwater strategies to be developed and factored into Structure Plans. However, the resources invested in strategic stormwater management planning at whole catchment scale is inadequate.*
- *Opportunities for strategic planning to influence urban water management in new land developments is confined to major changes in urban land use.*
- *Further urban development is moving into more difficult bio-physical environments – principally the more low-lying areas of the Swan Coastal Plain.*

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CONCLUDING REMARKS

- *Land use planning is becoming increasingly responsive to urban water management issues.*
- *A holistic approach is required to deal with urban water management issues, preferably in a water resource management context.*
- *Urban water management, especially its stormwater and drainage components, has considerable room for improvement so that new benchmarks are set for others to follow.*
- *As development pressures increase to accommodate our future communities on land with increasingly complex environmental constraints, more innovative solutions will need to be developed.*

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Understanding the System: Planning for Urban Development



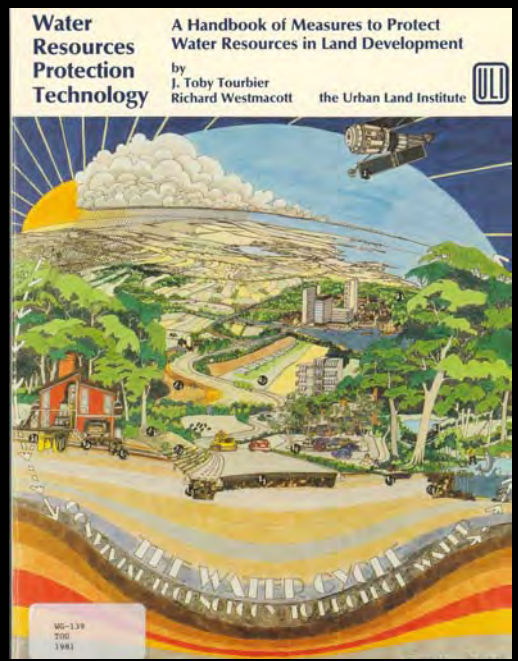
Drainage Management Forum, Swan-Canning Catchment

Technical / Engineering Solutions

PARSONS BRINCKERHOFF

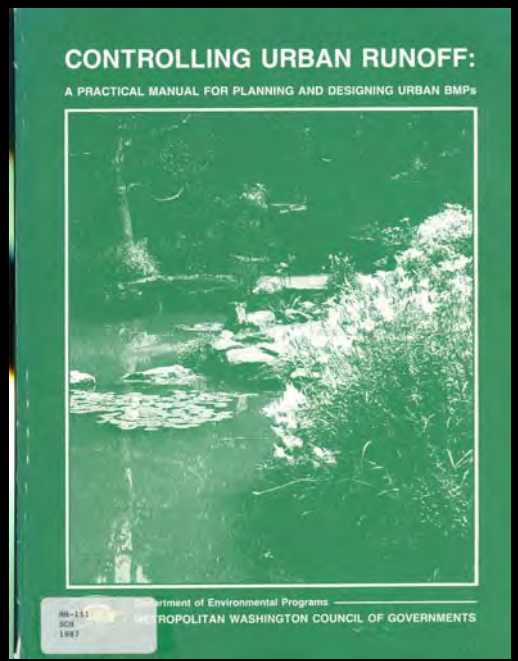
International *National* *WA*

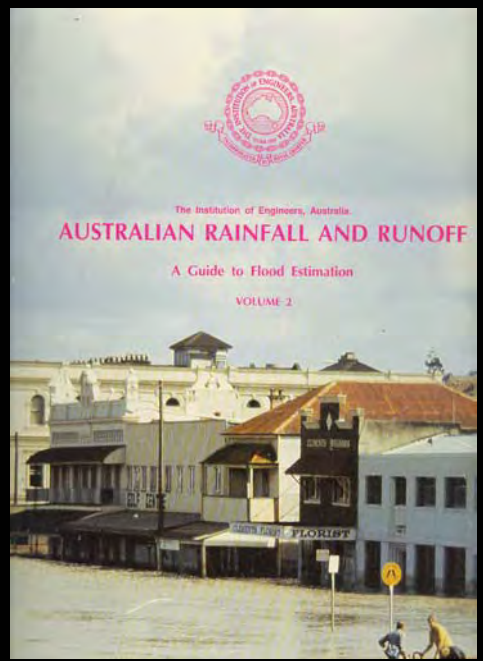
1981



International *National* *WA*

1987



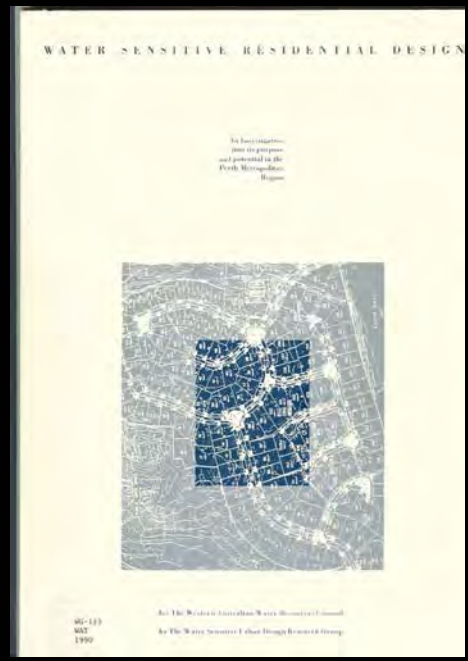


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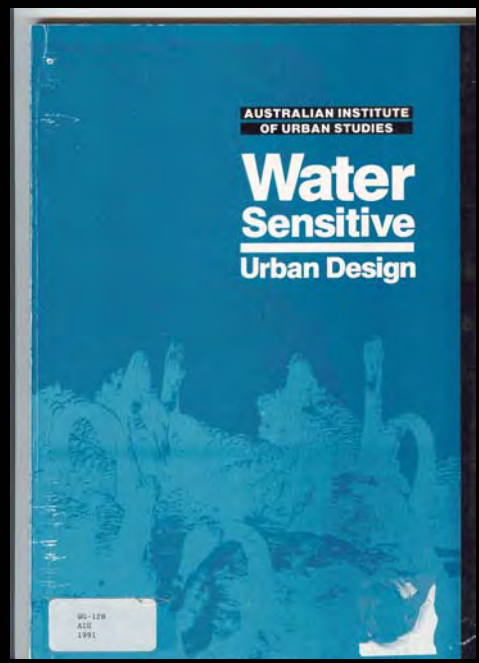
1990



International *National* *WA*

1991

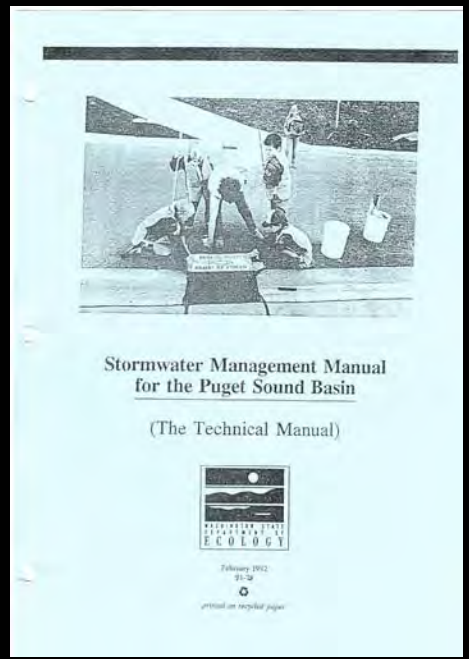




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International *National* *WA*

1992



Stormwater Management Manual
for the Puget Sound Basin

(The Technical Manual)

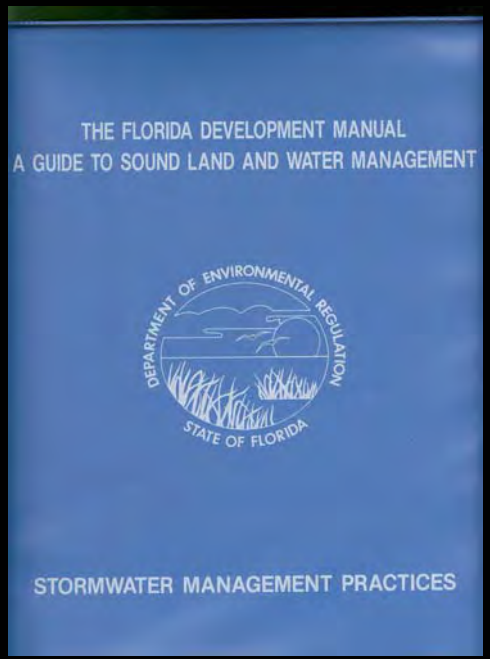
ECOLOGY

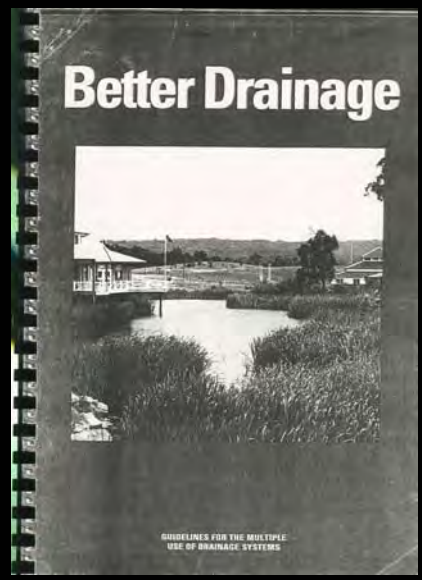
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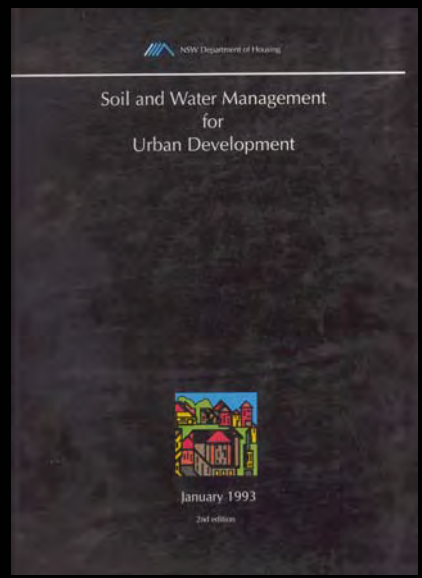
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1993







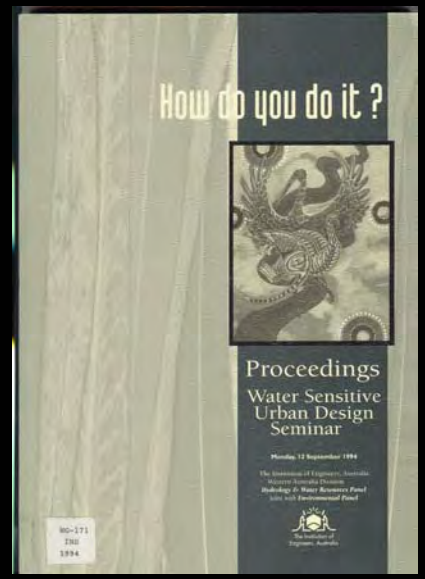
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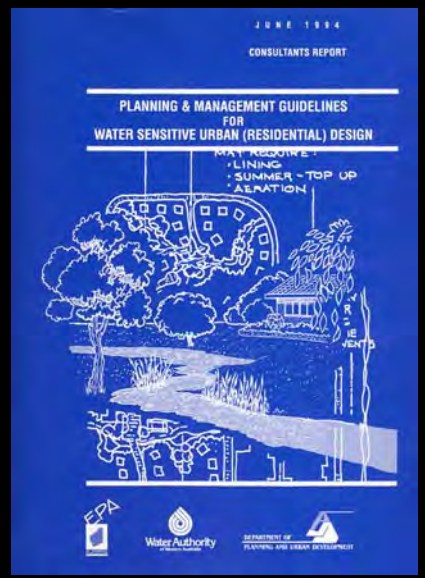
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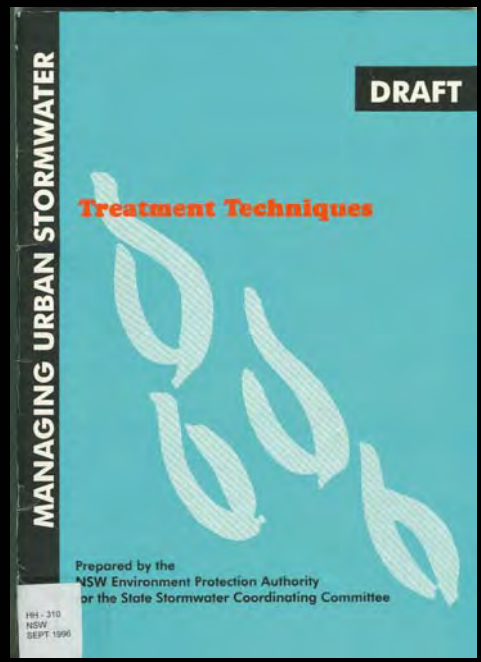




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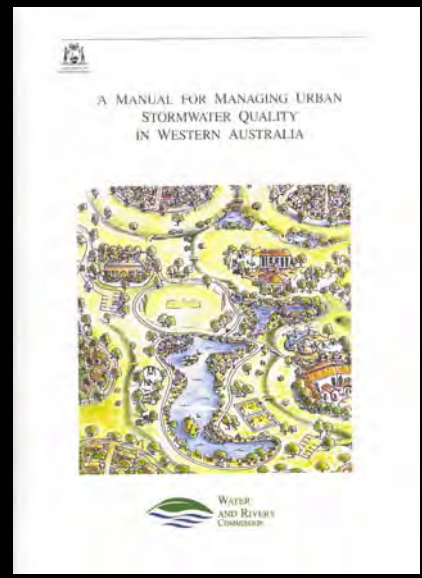
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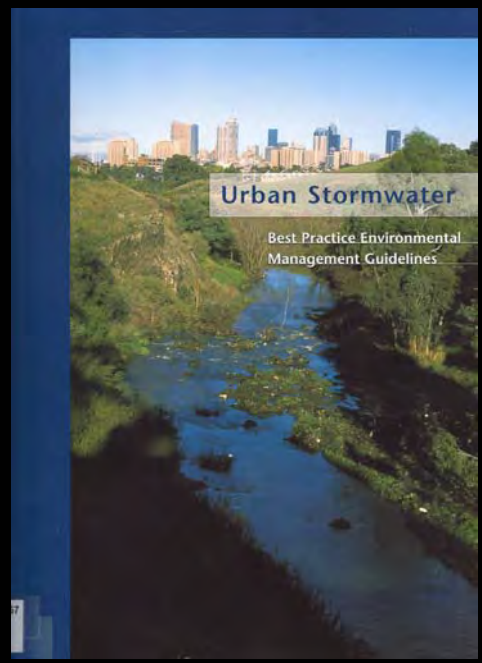
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International National WA

1999

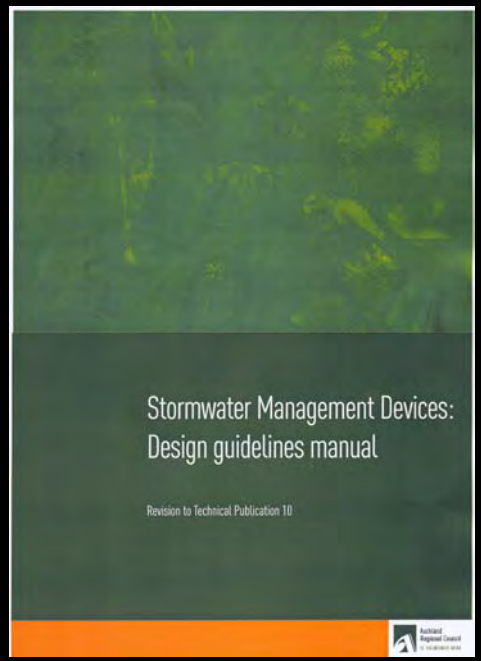


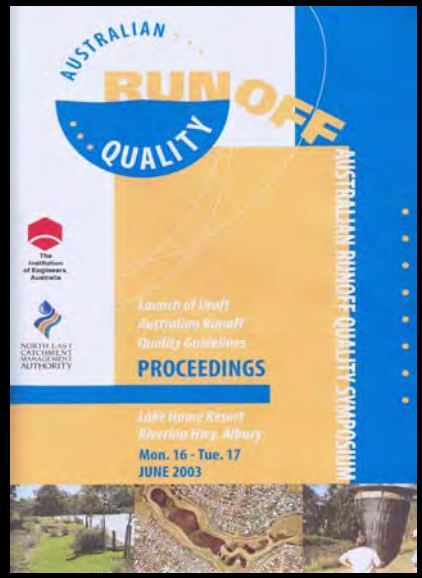
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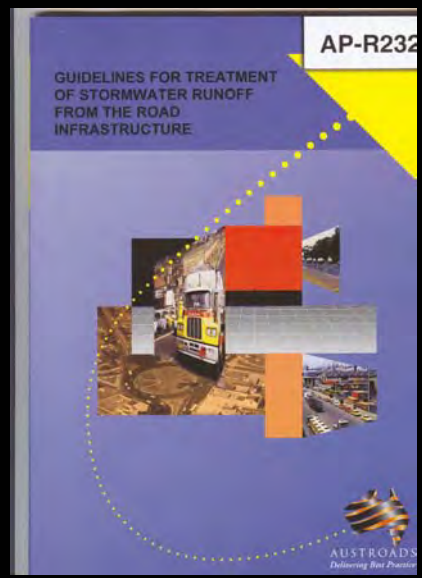
National

WA

2003







	International	National	WA
2004		NSW EPA Managing Urban Stormwater; Urban Design	DoE Stormwater Quality Management Manual Update
		Melbourne Water WSUD -Engineering design	

PARSONS BRINCKERHOFF



Australian Runoff Quality

Authorship Team

Editor-in-chief:

- Assoc Prof Tony Wong [***Monash University/CRC for Catchment Hydrology/Ecological Engineering Pty Ltd***]

- Dr Robin Allison [***Melbourne Water/Ecological Engineering Pty Ltd***]
- Assoc Prof John Argue [***University of South Australia***]
- Dr Peter Breen [***Ecological Engineering Pty Ltd***]
- Dr Peter Coombes [***University of Newcastle***]
- Hugh Duncan [***Melbourne Water/CRC for Catchment Hydrology***]
- Marino Evangelisti [***Parsons Brinckerhoff***]
- Dr Tim Fletcher [***Monash University/CRC for Catchment Hydrology***]
- Ian Lawrence [***CRC for Freshwater Ecology***]
- Tony McAlister [***WBM Oceanics Pty Ltd***]
- Dr Grace Mitchell [***CSIRO***]
- Dr Mike Mouritz [***WA Department of Planning & Infrastructure***]
- David Pezzaniti [***University of South Australia***]
- Dr Brett Phillips [***Cardno Willings Pty Ltd***]

The National Committee on Water Engineering has commenced a project to publish *Australian Runoff Quality* aimed at providing an overview of the current best practice in the management of urban stormwater quality in Australia and guidelines to the following:-

- procedures for the estimation of a range of urban stormwater contaminants
- design of stormwater quality improvement measures
- procedure for the estimation of performance of stormwater quality improvement measures
- development of an integrated urban water cycle management strategy

Table of Contents

1. Introduction
2. Urban Stormwater Pollutants, Processes and Pathways
3. Estimation of Catchment Pollutant Event Mean Concentration
4. Water Sensitive Urban Design
5. Roofwater, Stormwater and Greywater Reuse
6. Water Quality Criteria
7. Gross Pollutant and Sediment Traps
8. Hydrocarbon Management
9. Buffer Strips, Vegetated Swales and Bioretention Systems
10. Infiltration Systems
11. Constructed Wetlands and Ponds
12. Urban Waterways
13. Modelling Urban Stormwater Management Systems
14. References and Recommended Reading

Overview of Chapters

- Chapter 1 Introduction [***Tony Wong***]
  - An overview of the content of the document, their inter-relationship
  - Brief outline of the principles of Ecologically Sustainable Development, Water Sensitive Urban Design & Integrated Urban Water Cycle Management.
- Chapter 2 Urban Stormwater Pollutants, Processes and Pathways [***Peter Breen & Ian Lawrence***]
  - Major Urban Water and Stormwater Management Issues
  - Stormwater Pollutant and their Characteristics
  - Pollutant Mobilisation and Transport Pathways
  - Implications for Stormwater Management

Overview of Chapters (cont.)

- Chapter 3 Urban Stormwater Pollutant Concentrations and Loads [***Hugh Duncan***]
  - Presents an analysis of published stormwater quality data of 508 sites and 21 stormwater quality
  - Presents pollutant concentration vs land use and catchment characteristics
- Chapter 4 Water Sensitive Urban Design [***Mike Mouritz, Marino Evangelisti & Tony McAlister***]
  - Concept and Policy Framework
  - WSUD Principles, Aims and Objectives
  - Best Practices Hierarchy and Integration
  - Planning and Design Tools
  - WSUD in Practice

Overview of Chapters (cont.)

- Chapter 5 Roofwater, Stormwater and Greywater Reuse [***Peter Coombes, Grace Mitchell & Peter Breen***]
  - Overview of reuse techniques for roofwater, stormwater and greywater
  - Selecting techniques for a given site
  - Financial and Economic Considerations
  - Guidelines and Regulations

- Chapter 6 Water Quality Criteria [***Ian Lawrence & Brett Phillips***]
  - Assessing receiving waterway values and relating to impact of stormwater pollution
  - Identifying dominant pollutant pathways and transformation
  - Establishing sustainable pollutant loads and concentrations
  - Relationship with National Water Quality Management Strategy and ANZEEC/ARMCANZ Guidelines for Fresh and Marine Water Quality

Overview of Chapters (cont.)

- Chapter 7 Gross Pollutants and Sediment Traps [***Robin Allison & David Pezzaniti***]
  - GPT – mainly proprietary products
  - Guidelines on specifying and selecting a GPT or sediment trap
  - Some basic steps in sizing sediment traps

- Chapter 8 Hydrocarbon Management [***Brett Phillips & Ian Lawrence***]
  - Overview of management strategies
  - Source control techniques
  - Selection of appropriate measures

Overview of Chapters (cont.)

- Chapter 9 Buffer Strips, Vegetated Swales and Bioretention Systems [***Tim Fletcher, Tony Wong & Peter Breen***]
  - Overview of application of vegetated stormwater conveyance systems
  - Functional operation, design principles and expected performance
  - Some basic steps in sizing systems

- Chapter 10 Infiltration Systems [***John Argue & David Pezzaniti***]
  - Background theory of Infiltration Systems
  - Design Procedures
  - Other design issues requiring attention

Overview of Chapters (cont.)

- Chapter 11 Constructed Wetlands and Ponds [***Peter Breen, Tony Wong & Ian Lawrence***]
  - Pond and Wetland values; Differences between Ponds and Wetlands
  - Overview of Design Issues and Considerations
  - Treatment processes and expected performance
  - Some basic steps in sizing constructed wetlands and ponds

- Chapter 12 Urban Waterways [***Ian Lawrence & Peter Breen***]
  - Overview of types of urban waterways
  - Factors influencing ecosystem health of urban waterways
  - Opportunities for rehabilitating urban waterways

Overview of Chapters (cont.)

- Chapter 13 Modelling Urban Water Systems [***Tony McAlister, Grace Mitchell, Tim Fletcher & Brett Phillips***]
  - Underlying philosophy associated with modelling
  - Review of inherent assumptions in models
  - Discussion on spatial and temporal “scale” of modelling
  - Guidance on appropriate application of models
  - Discussion on data requirements
  - Overview of typical models currently in use in Australian practice

- Chapter 14 References and Recommended Readings

swan catchment council

The catchment perspective

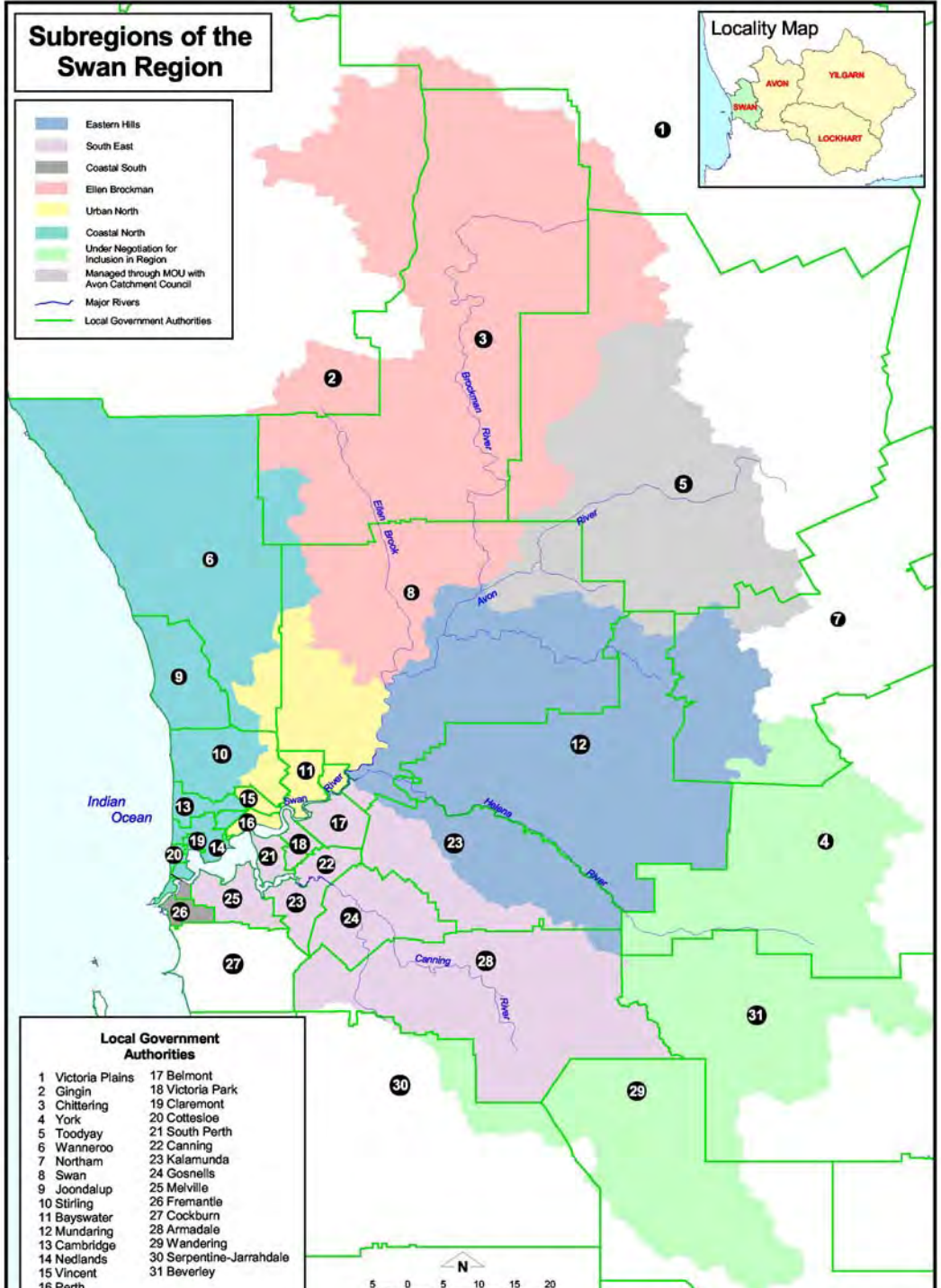
Sue Metcalf, Chair, Swan Catchment Council










Subregions of the Swan Region
Eastern Hills
South East
Coastal South
Ellen Brockman
Urban North
Coastal North
Under Negotiation for Inclusion in Region
Managed through MOU with Avon Catchment Council
Major Rivers
Local Government Authorities
Locality Map
YILGARN
AVON
SWAN
LOCKHART
Brockman River
Ellen Brook
Avon River
Swan River
Helena River
Canning River
Indian Ocean
Local Government Authorities
1 Victoria Plains
2 Gingin
3 Chittering
4 York
5 Toodyay
6 Wanneroo
7 Northam
8 Swan
9 Joondalup
10 Stirling
11 Bayswater
12 Mundaring
13 Cambridge
14 Nedlands
15 Vincent
16 Perth
17 Belmont
18 Victoria Park
19 Claremont
20 Cottesloe
21 South Perth
22 Canning
23 Kalamunda
24 Gosnells
25 Melville
26 Fremantle
27 Cockburn
28 Armadale
29 Wandering
30 Serpentine-Jarrahdale
31 Beverley
N
5 0 5 10 15 20



Meeting SCCP nitrogen targets

Tributary	1998	1999	2000	2001	2002
Ellen Brook					
Mills Street Main Drain					
Bannister Creek					
Bayswater Main Drain					
Southern River					
Bickley Brook					
Bennett Brook					
Yule Brook					
Blackadder Creek					
Canning River					
Helena River					
South Belmont Main Drain					
Avon River					
Susannah Brook					
Jane Brook					
Short-term target met (%)	80	80	80	87	93
Long-term target met (%)	20	20	27	33	40

Tributary fails both long and short-term targets

Tributary meets short-term targets but fails long-term target

Tributary meets both short-term and long-term targets

Meeting SCCP phosphorous targets

Tributary	1998	1999	2000	2001	2002
Ellen Brook					
Mills Street Main Drain					
Southern River					
South Belmont Main Drain					
Bannister Creek					
Yule Brook					
Bayswater Main Drain					
Bickley Brook					
Blackadder Creek					
Jane Brook					
Avon River					
Bennett Brook					
Canning River					
Helena River					
Susannah Brook					
Short-term target met (%)	80	87	87	93	93
Long-term target met (%)	67	67	67	67	67

Tributary fails both long and short-term targets

Tributary meets short-term targets but fails long-term target

Tributary meets both short-term and long-term targets



Drainage catchment perspective

- The land and water are connected
- The people are connected to the land and water
- To change the water quality the land management must be improved
- To improve the land management there are a number of options

Swan Avon
INTEGRATED CATCHMENT MANAGEMENT

swan catchment council

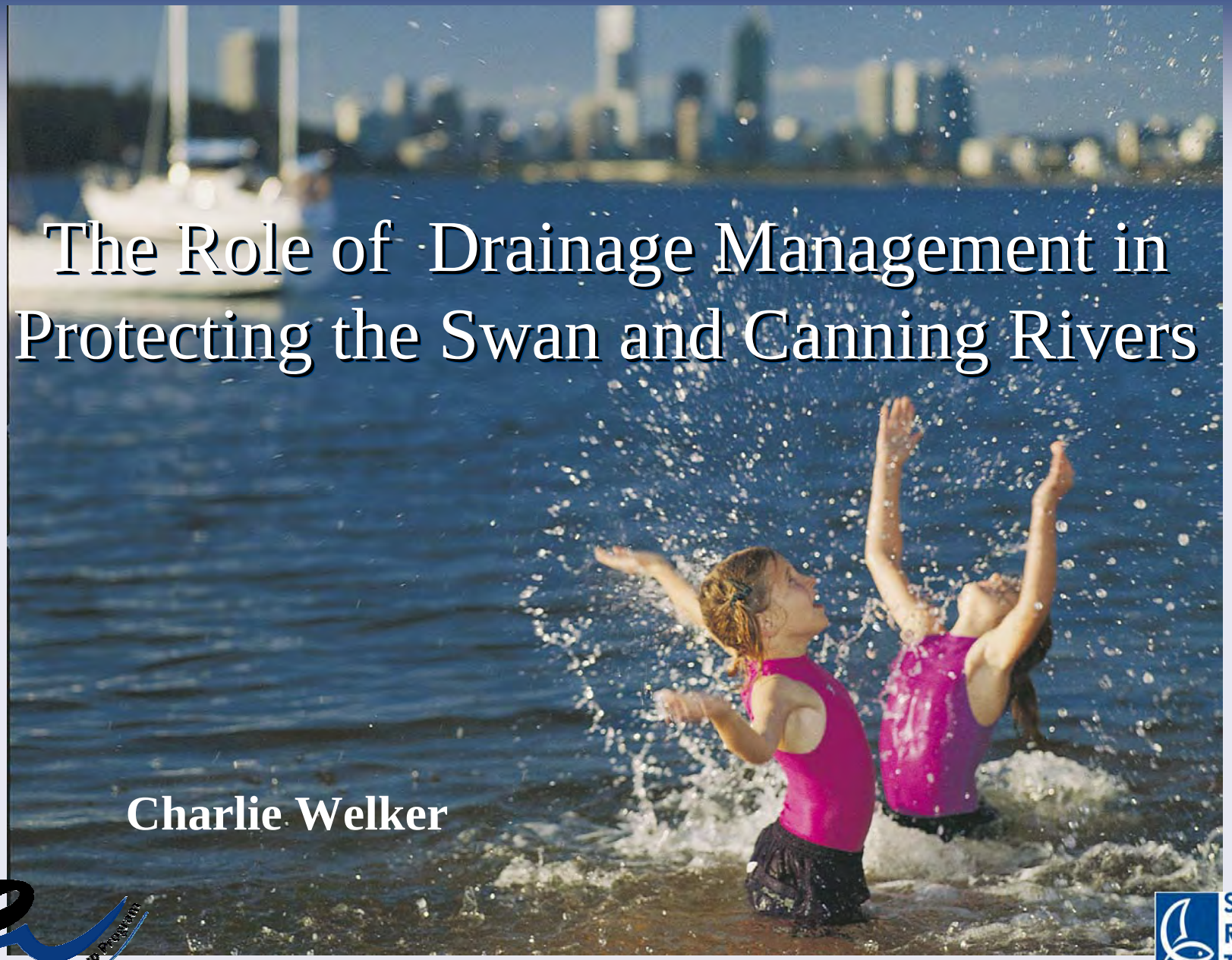
Land management options

- education
- rehabilitation
- engineering
- regulation
- incentives

- appropriate recognition of land capability and suitability for development

Swan Avon INTEGRATED CATCHMENT MANAGEMENT

swan catchment council



The Role of Drainage Management in Protecting the Swan and Canning Rivers

Charlie Welker

Swan-Canning Cleanup Program

SWAN RIVER TRUST

The Role of Drainage Management in Protecting the Swan and Canning Rivers

Values and status of the system

- **Premier's nomination for the Western Australian Heritage Icons 2004 project**
- **Second only to Kings Park as a heritage icon (*West Australian* survey)**
- **Included in register of Western Australian Endangered Places 2003 (WA National Trust)**
- **Listed site under the Aboriginal Heritage Act**
- **Regarded as the soul of Perth**

Swan-Canning Cleanup Program

SWAN RIVER TRUST

The Role of Drainage Management in Protecting the Swan and Canning Rivers

Indicates

- **The regard the community has for the River**
- **The level of its concern over its future**
- **Deep spiritual and cultural associations for the Nyungah and those who have grown up in it, on it and around it**
- **Concerns about whether it is safe to fish and swim in it, sail, row or canoe on it, or whether it is pleasant to sit or walk alongside.**

Swan-Canning Cleanup Program

SWAN RIVER TRUST

The Role of Drainage Management in Protecting the Swan and Canning Rivers

Indicates

- **The community and Swan River Trust consider current incidence, levels and impact of algal blooms are unacceptable**

- **Reduction of nutrient levels to limit the frequency and extent of algal blooms is recognised as having a critical role in protecting the ecological function of the rivers and ensuring their amenity continues to be available to the community.**

Swan-Canning Cleanup Program

SWAN RIVER TRUST

The Role of Drainage Management in Protecting the Swan and Canning Rivers

Swan Canning Cleanup Program

- Initiated in 1994 to develop an action plan to reduce the impact of algal blooms.

- The SCCP Action Plan, adopted in 1999, established five goals that address the environmental, social and economic issues of sustainable management of the rivers and their catchments.

The Role of Drainage Management in Protecting the Swan and Canning Rivers

SCCP Action Plan Gaols - Waterway

- ***Public Health and Amenity:*** **Algal blooms are kept at a level that is not a threat to public health and amenity and are not a nuisance to the community. Toxic algal blooms are kept to a minimum.**

- ***Ecological Function:*** **Water quality in the Swan-Canning system is suitable for maintaining a healthy ecosystem. People can swim and catch fish at any time.**

Swan-Canning Cleanup Program

SWAN RIVER TRUST

The Role of Drainage Management in Protecting the Swan and Canning Rivers

SCCP Action Plan Gaols - Catchments

- ***Catchments and Targets:*** Contaminants in stream runoff leaving the catchments are within set targets. Rural catchments are managed to be productive and profitable and are affordable places to live.
- ***New Urban and Industrial Areas:*** New areas are designed so that discharges have reduced contaminant levels and meet set targets before entering the rivers, while they still remain attractive and affordable places to live and productive and profitable places to work.
- ***Older Urban and Industrial Areas:*** Older urban and industrial areas are modified over time to reduce contaminant levels so that drainage discharges meet set targets before entering the rivers.

Swan-Canning Cleanup Program

SWAN RIVER TRUST

The Role of Drainage Management in Protecting the Swan and Canning Rivers

SCCP Action Plan Recommendations for Management of Drainage

- Rehabilitate drains and streams to restore environmental function and reduce sediment and nutrient loads.
- Map the drainage system and identify those most urgently requiring intervention.
- Trial constructed wetlands, gross pollutant traps, sediment remediation techniques and floodplain agroforestry woodlots as ways of removing nutrients and other contaminants.
- Integrate stream and drain restoration provisions into catchment and farm management plans and town planning schemes.

Swan-Canning Cleanup Program

SWAN RIVER TRUST

The Role of Drainage Management in Protecting the Swan and Canning Rivers

SCCP Action Plan Recommendations for Management of Drainage

- **Develop drain management and maintenance standards and practises to minimise transport of nutrients and other contaminants.**
- **Establish environmental flow regimes for impounded tributaries.**
- **Develop district drainage management plans.**
- **Apply Water Sensitive Urban Design principles to new developments and drainage systems and to the modification of existing systems.**
- **Investigate the potential for licensing main drains as a means of controlling nutrients entering rivers.**

Swan-Canning Cleanup Program

SWAN RIVER TRUST

The Role of Drainage Management in Protecting the Swan and Canning Rivers

Swan and Canning Rivers Environmental Protection Policy

- The improper management of drainage is an activity that can degrade environmental values of the rivers and therefore contrary to the objectives of the policy
- It requires:

  Development of best management practises for the control of drainage.

  Development of strategies to prevent litter entering the rivers.

  Review of the existing drainage system to identify opportunities for their enhancement to minimise impact of their design and operation on the environmental values of the rivers

Swan-Canning Cleanup Program

SWAN RIVER TRUST

The Role of Drainage Management in Protecting the Swan and Canning Rivers

The Challenge

- **Drainage management plays a critical role in the urban landscape. By managing groundwater levels and stormwater it protects people, property and infrastructure from flooding.**
- **The challenge is to expand the role of drainage management to deal with these expectations of its broader place in environmental management.**
- **What opportunities management of drainage may provide, particularly for the management of water quality, and the governance arrangements required to make best use of these opportunities is the central task of this forum.**

Swan-Canning Cleanup Program

SWAN RIVER TRUST

The Role of Drainage Management in Protecting the Swan and Canning Rivers

Need to Consider

- Drainage as part of the water cycle
- Drainage water as a water source
- Addressing all components of the drainage system
- Controlling water quality entering drainage systems
- Improving water quality within and from the drainage system
- Managing flow for environmental benefit
- Drainage systems as part of broader urban and environmental amenity
- Asset management and maintenance
- Performance standards and measurement
- Costs and funding models
- Equity and assignment of responsibility
- Administrative requirements and governance model
- Legislative arrangements.

Swan-Canning Cleanup Program

SWAN RIVER TRUST


help
keep our rivers
healthy
1800 062 549

Australian Research Centre for Water in Society

Understanding the System
Where does the community fit?

Blair E. Nancarrow

for the Drainage Management Forum Swan/Canning Catchment
November 2003

Does the Community Care?

- YES
  - People care about their waterways
  - This is consistent nationally
  - The Swan River is an Icon
- What does this mean ……. and what can we expect from the community?

Environmental Values

- Major criteria for setting water quality standards
  - cleanliness (health)
  - protection of the environment/ecosystem
  - suitable for human activities
- "Purity" is important to about one-third of people

Environmental Values

- Water quality is substantially restricting people's recreational activities on/in rivers
  - activities associated with greatest personal contact – health concerns

Environmental Values

- Little community support for uses/activities which have the potential for pollution or exploitation of rivers
  - some support if life-related uses/activities
  - only about one-quarter support the disposal of drainage water into rivers
  - only about one-fifth support the disposal of treated wastewater into rivers

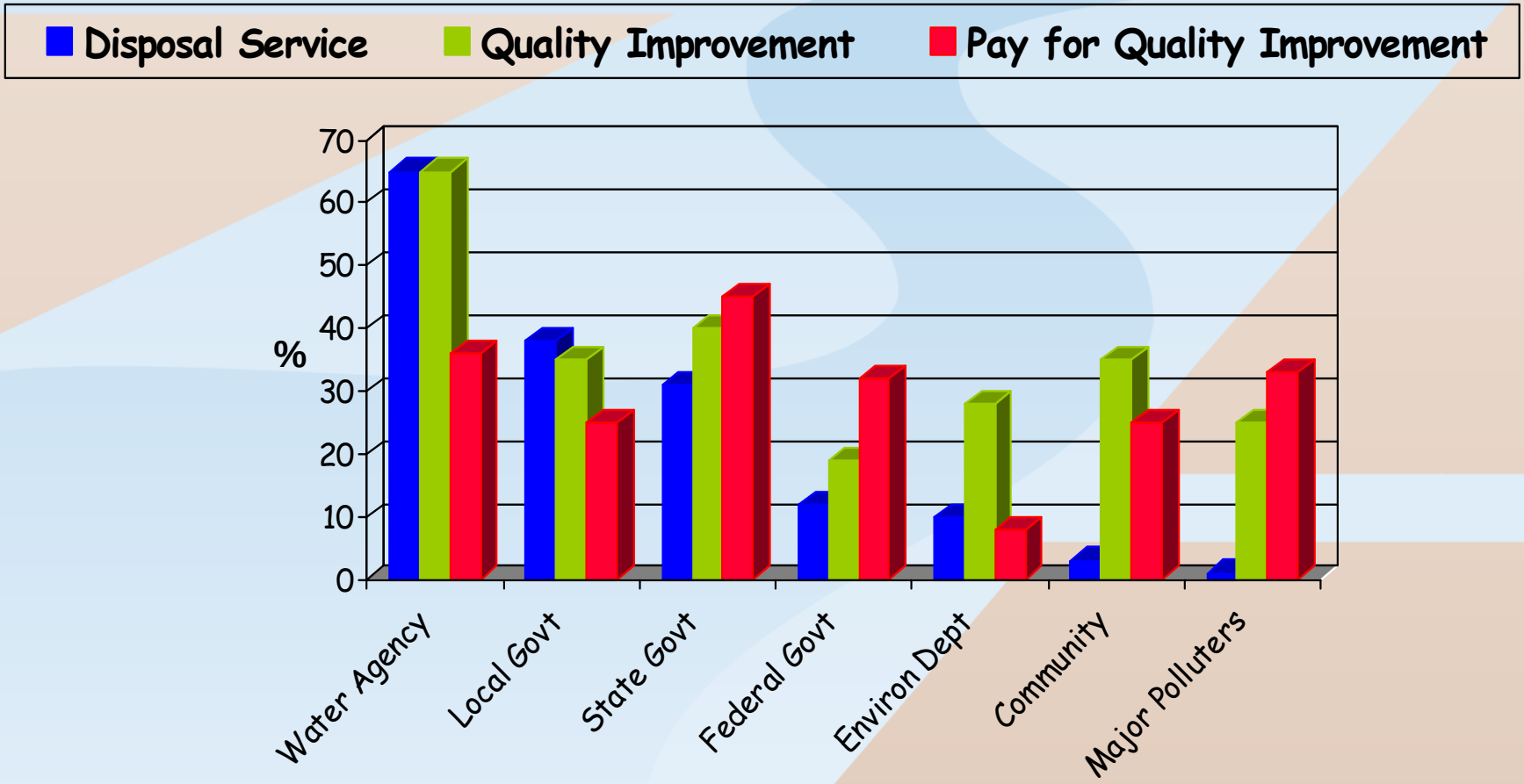
How do People Judge Water Quality?

- perceived as being in a natural state or life supporting
- "natural"?
  - physically observable indicators
    - colour; clarity; foam; scum; rubbish

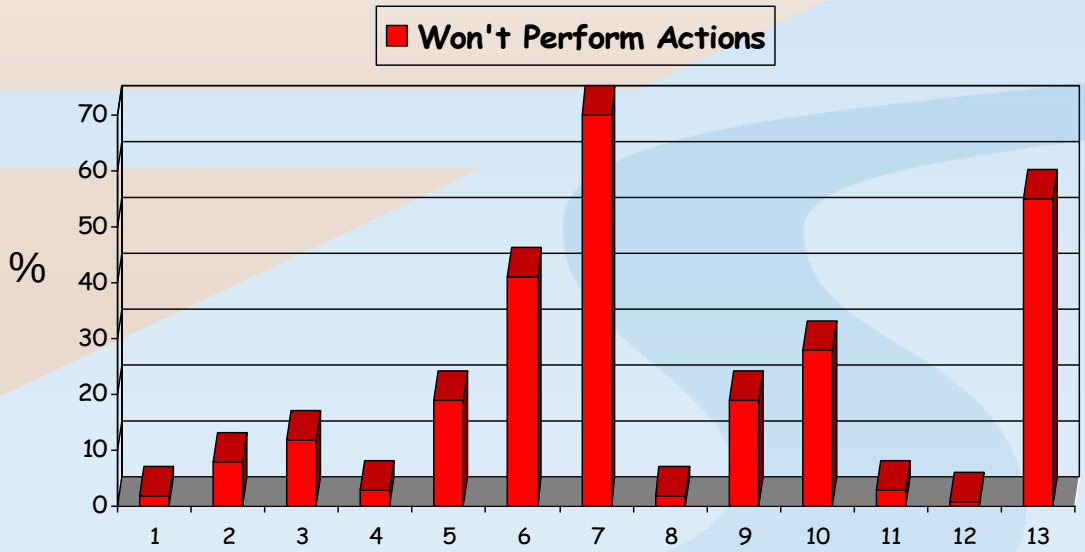
Manage Quantity or Quality?

- In stormwater management, most people believe the management of ***quality*** to be ***more than twice as important*** than the management of ***quantity***
  - no difference between people who live near or far from rivers
  - no difference associated with experience of floods

Who Should be Responsible?



Potential for Community Action



1. Pick up litter from verge outside home
2. Pick up litter from gutter outside home
3. Sweep leaves/dirt from gutter outside home
4. Sweep and not hose paved/concreted areas
5. Wash car on grass
6. Install rainwater tank
7. Remove paved/concreted areas from yard
8. Reduce fertiliser use
9. Pick up animal pooh from verge
10. Take plastic bag when walking dog (only dog owners)
11. Ensure no oil leaks in car
12. Don't put things down stormwater grates
13. Join a stormwater community action group

Predictors of Potential Community Action

- Attitudes
  - "good citizen" & "responsibility towards the environment" more likely to agree to community action
  - "no worries" and "fact of life" less likely to agree to community action

What Didn't Predict Potential Community Action

- Knowledge of the pollutants of stormwater
- Potential recreational benefits
- Willingness-to-pay for quality improvements
- Perceptions of the responsibility of the polluters for quality improvement

Catchment Management Experiment

- Action group
- Information targeting attitudinal dimensions as well as facts
- Newsletters
- Behavioural monitoring
- Change measurement surveys
- Willingness to pay for catchment specific solutions

What Happened?

- Visibility of the drainage system and prior knowledge had no effect on neighbourhood action
- No measurable behavioural change even though people *reported* doing things

What Happened?

- There was no evidence of any systematic attitudinal change
- The attitudinal structure was continuously repeated over time
- The major attitudes continued to predict *reported* behaviour

What Happened?

- Increase in people reporting they were doing things
  - i.e. people were beginning to be aware that they *should be doing something*
    and in some cases knew *what* they should be doing.

What Happened?

- People remembered receiving information in the mail
  - to a lesser extent remembered the topics
- People noticed activities
- Saliency of stormwater increased
- Specific knowledge did not increase

What Happened?

- Support for community responsibility for quality improvements was maintained (including willingness to pay)
  - though willingness to pay measures would not have paid for specific catchment management options
- Very few people carried through their involvement intentions

What Happened?

- It is difficult for action groups to maintain motivation - given the long term nature of stormwater management and the lack of immediate results

- People have lives and commitments which impact on time available for voluntary action

What Does it Mean?

- There was an increase in awareness
- Awareness leads to attitudinal change which in turn leads to behavioural change
- The good intentions are there …. but it will take some time for behavioural change
- Community expectations for environmental improvement will have to be managed

WATER AND RIVERS COMMISSION

Understanding the System - Institutional Arrangements (Urban)

Verity Allan, Chairman

Water and Rivers Commission Board

Institutional Arrangements

Organisation	Roles
Water & Rivers Commission	Strategic Drainage Planning; Floodplain management; Arterial Drainage Scheme
Swan River Trust	Protection & management of S-C system; S-C EPP; S-C Clean Up program
Water Corporation	Drainage Manager
WA Planning Commission	Planning; Subdivision and DA control; SPP's
Office of Water Regulation	Licences service providers (drainage managers)
Health Department	Controls health
Local Government Authorities	Local drainage managers
Swan Catchment Council/ ROC's	Possible direction setting - catchment protection/ Possible drainage manager
EPA	EPP's – Riverplan, EIA process

Water & Rivers Commission

- Established under Water and Rivers Act 1995
- Board of Management
- Recent changes to Board Composition
- Changes in 2004 – Water Resources Management Council



Bannister Creek

Urban Drainage Functions

Functions: water resources conservation, protection and management:

- Planning & administration of arterial drainage & declaration of drainage courses

  (Metropolitan Water Authority Act 1982)

- By-laws for prevention of pollution in catchment areas or water reserves, or underground water pollution control areas;
- Licencing wells in public water supply areas

  (*Metropolitan Water Supply, Sewerage and Drainage Act 1909)*

Functions (2)

- Licencing or directions as to use of surface waters; and
- Licencing artesian and non-artesian wells.

(*Rights in Water and Irrigation Act 1914)*

- Conservation - waterways and adjoining land in management areas

(*Waterways Conservation Act 1976)*

Functions (3)

- Advice to Minister on policy;
- Assessing resources;
- Planning;
- Promoting efficient use;
- Providing assistance to projects;
- Developing plans; advice on flood management;
- Research; and
- Publishing information

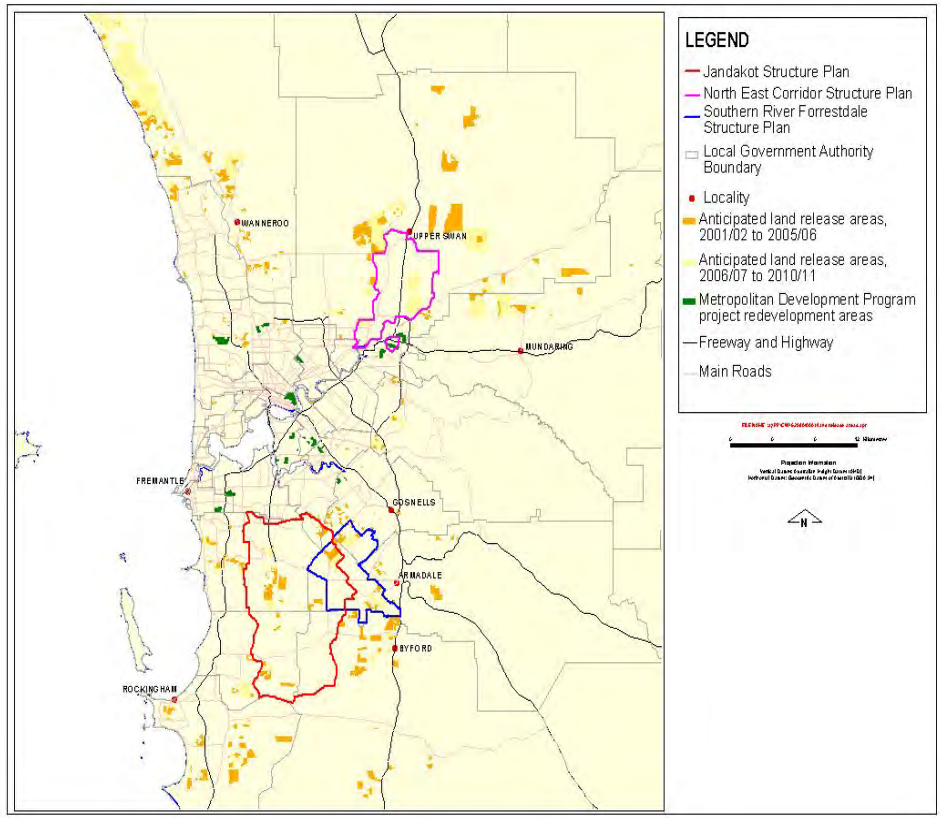


Ascot Waters

Urban Drainage Reform

In Perth WRC's roles are addressed in two key areas

- Strategic Drainage Planning
- Flood Plain Management



Institutional Issues

- Lack of Resources
  - To cover costs/fulfill roles
- Changes needed to institutional arrangements – which way?
- How do key agencies relate?
- How do they relate to developers?
- Quantity and Quality – holistic catchment approach



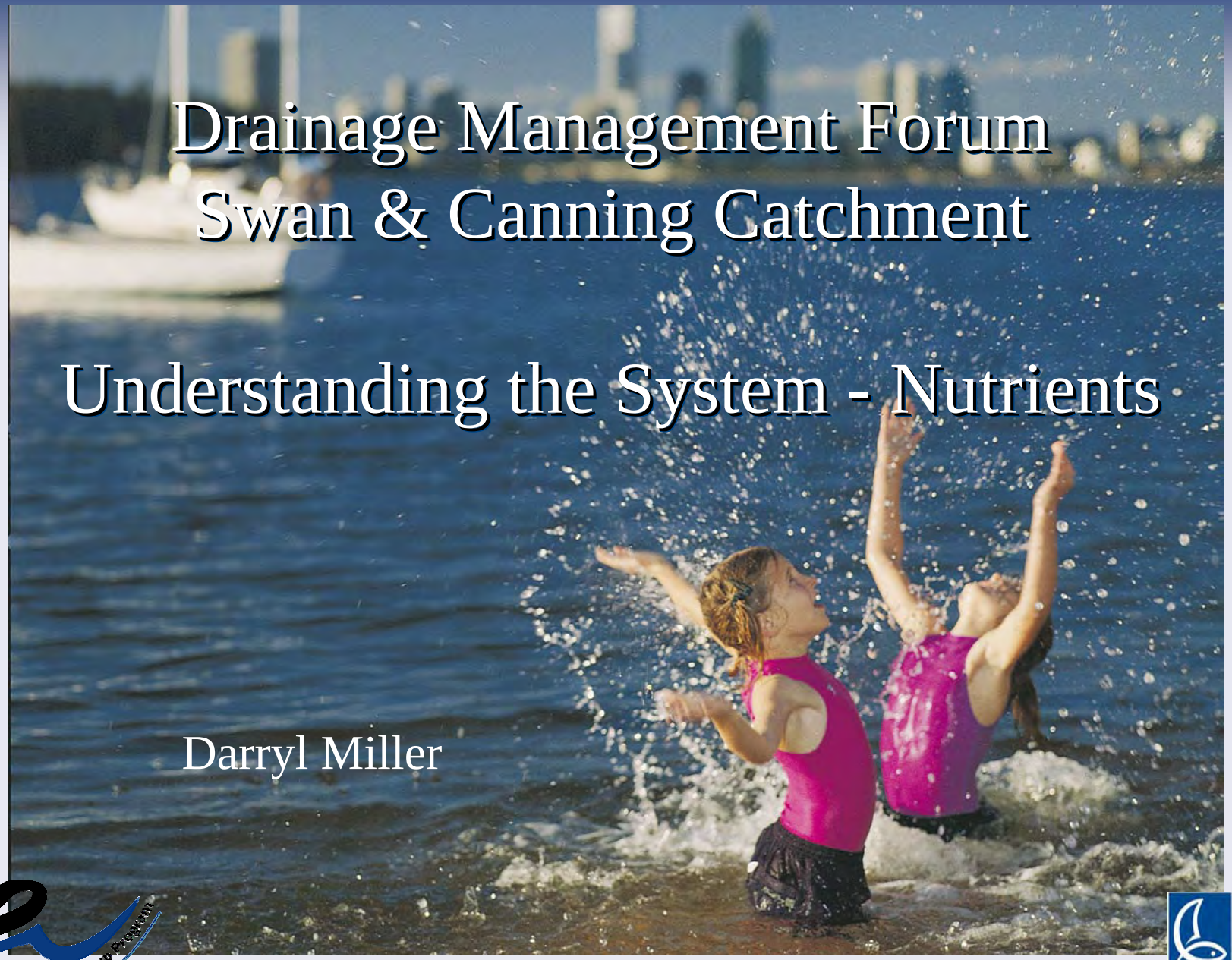
Jane Brook Estate

General Agreement

- Holistic catchment wide approach
- Institutional change
- Need for certainty
- Leadership in planning/management
- Need for shared vision
- Shift from ‘flood control’ to ‘quality control’
- Review of funding
- Information sharing



Bannister Creek



Drainage Management Forum
Swan & Canning Catchment

Understanding the System - Nutrients

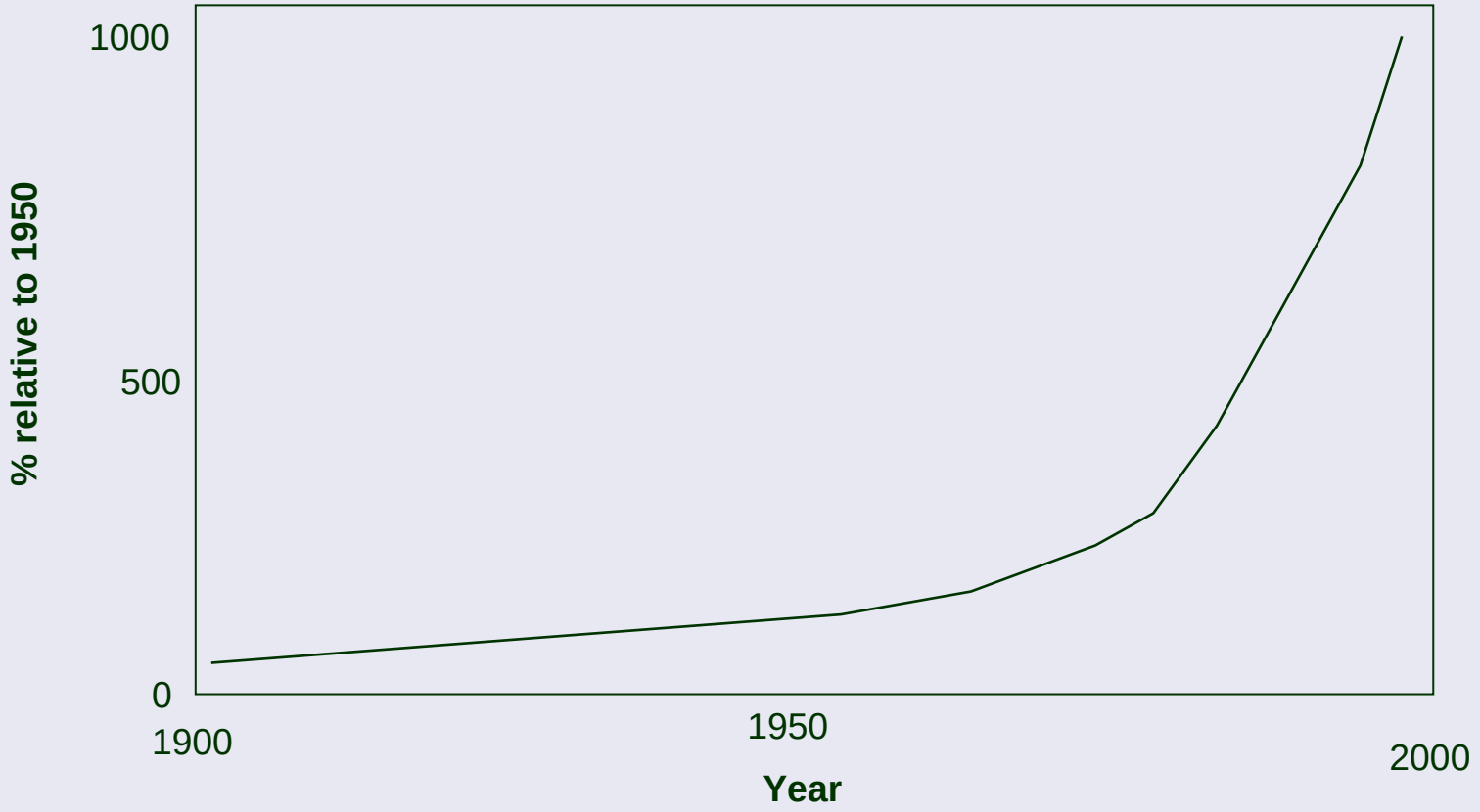
Darryl Miller

Swan-Canning Cleanup Program

SWAN RIVER TRUST

Understanding the System - Nutrients

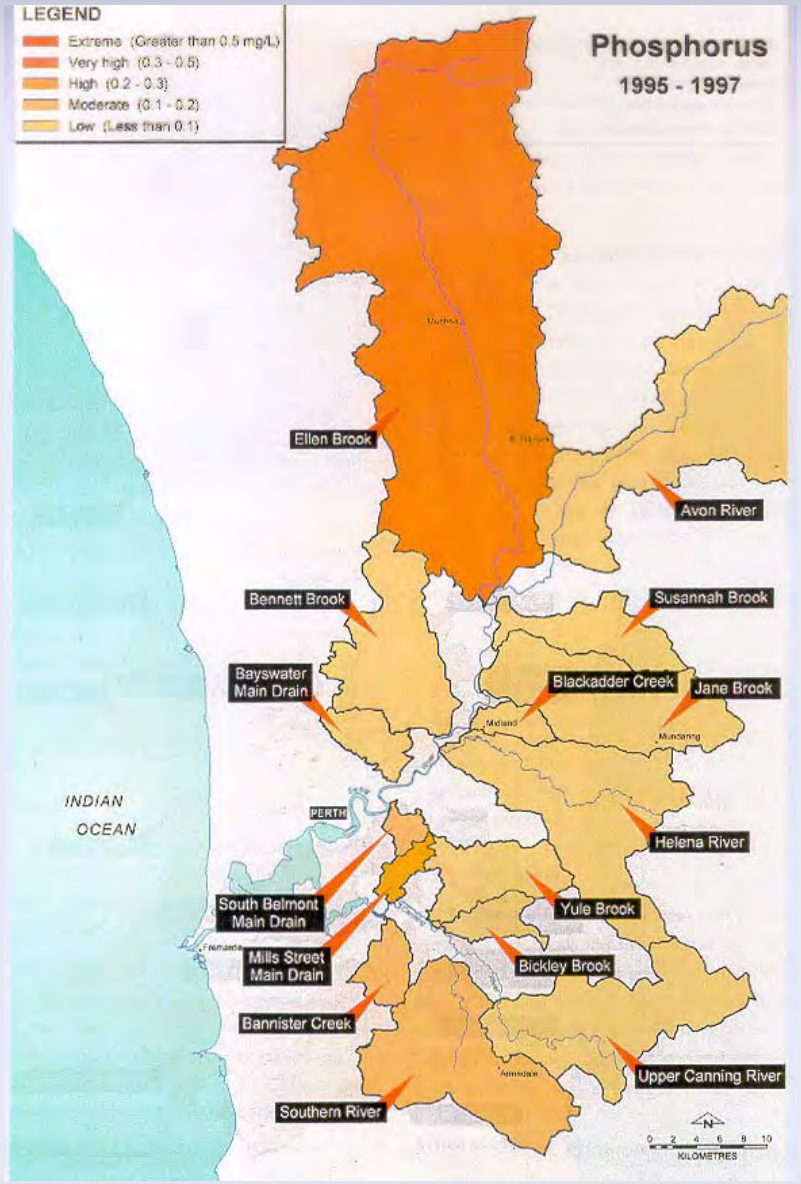
Increase in phosphorus levels in sediment cores from the Swan-Canning estuary



Swan-Canning Cleanup Program

SWAN RIVER TRUST

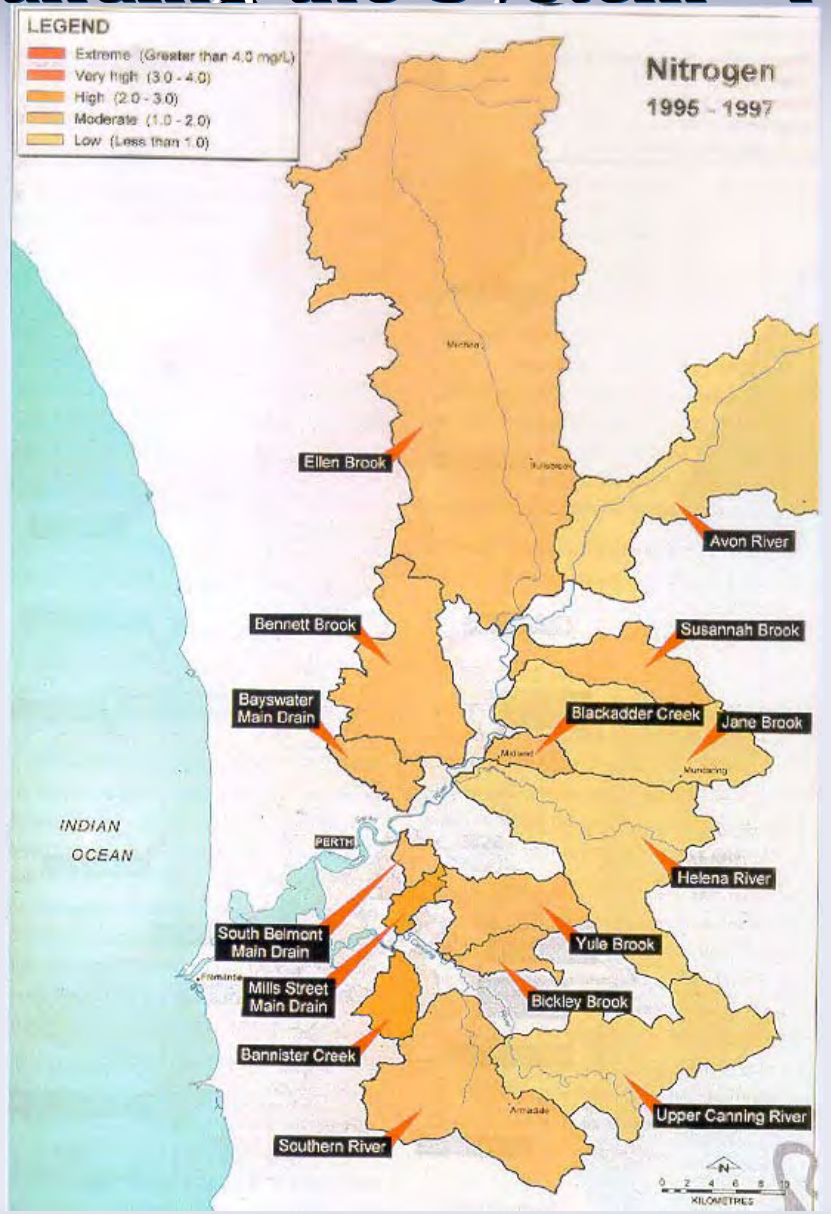
Understanding the System - Nutrients



Swan-Canning Cleanup Program

SWAN RIVER TRUST

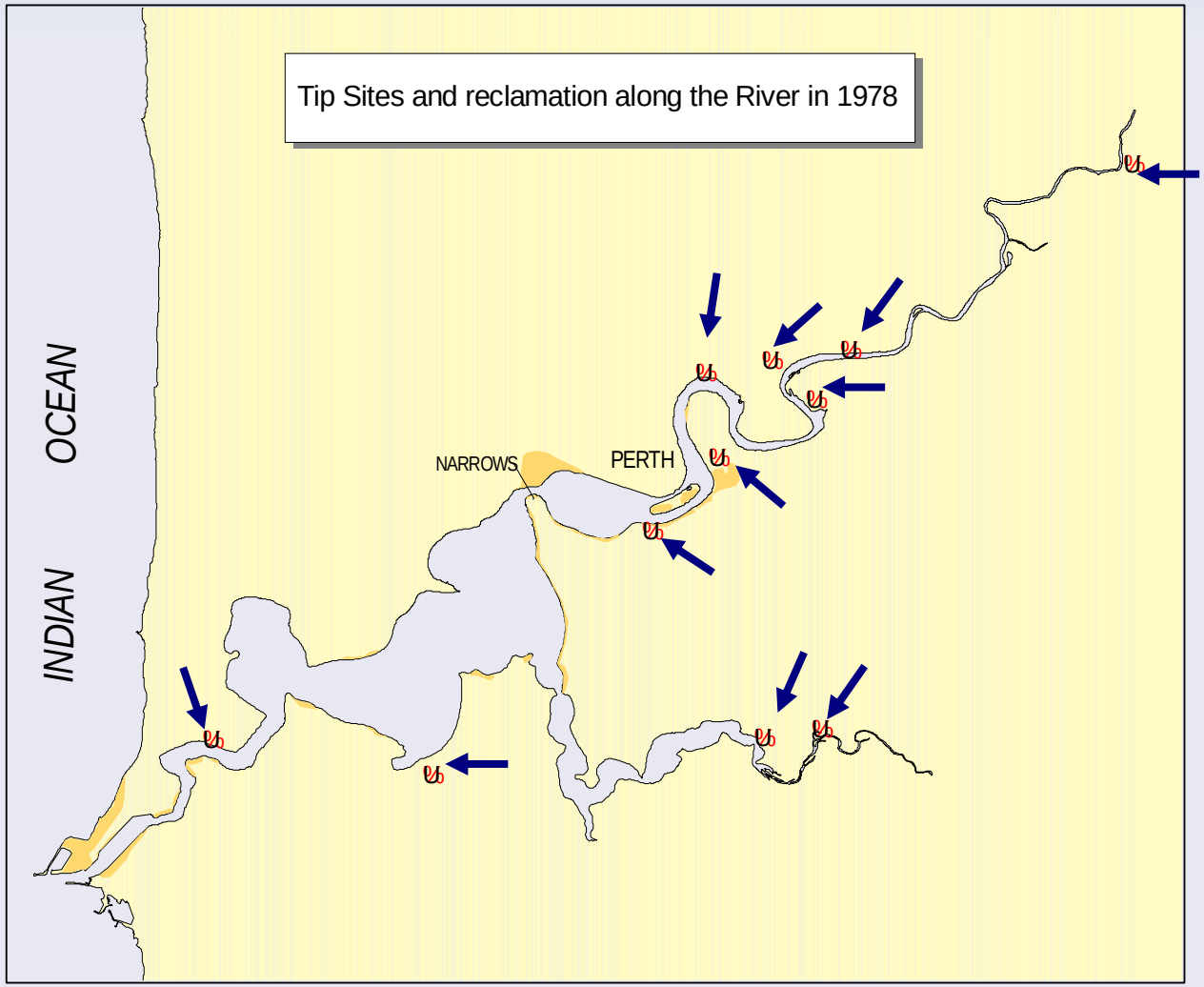
Understanding the System - Nutrients



Swan-Canning Cleanup Program

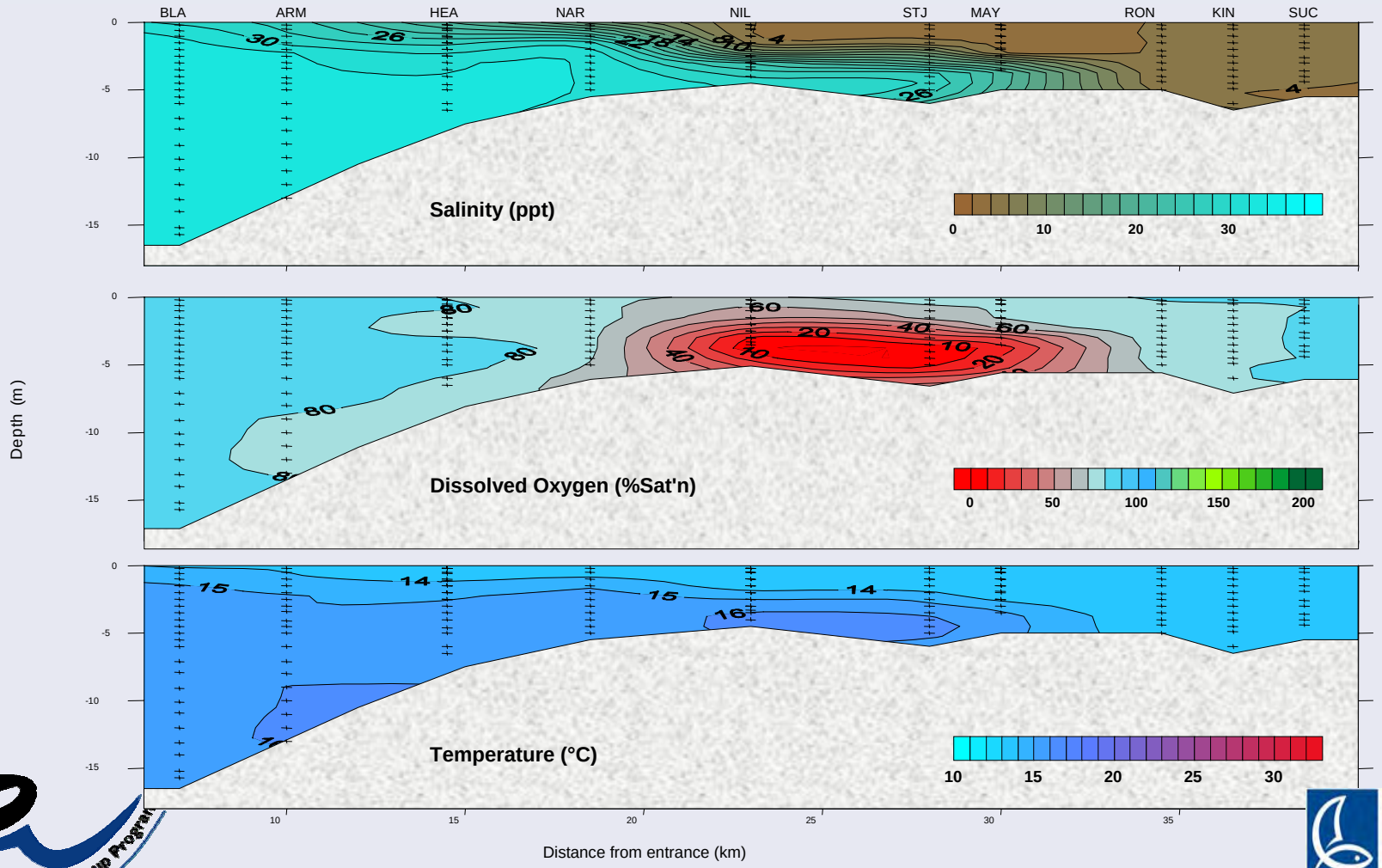
SWAN RIVER TRUST

Understanding the System - Nutrients



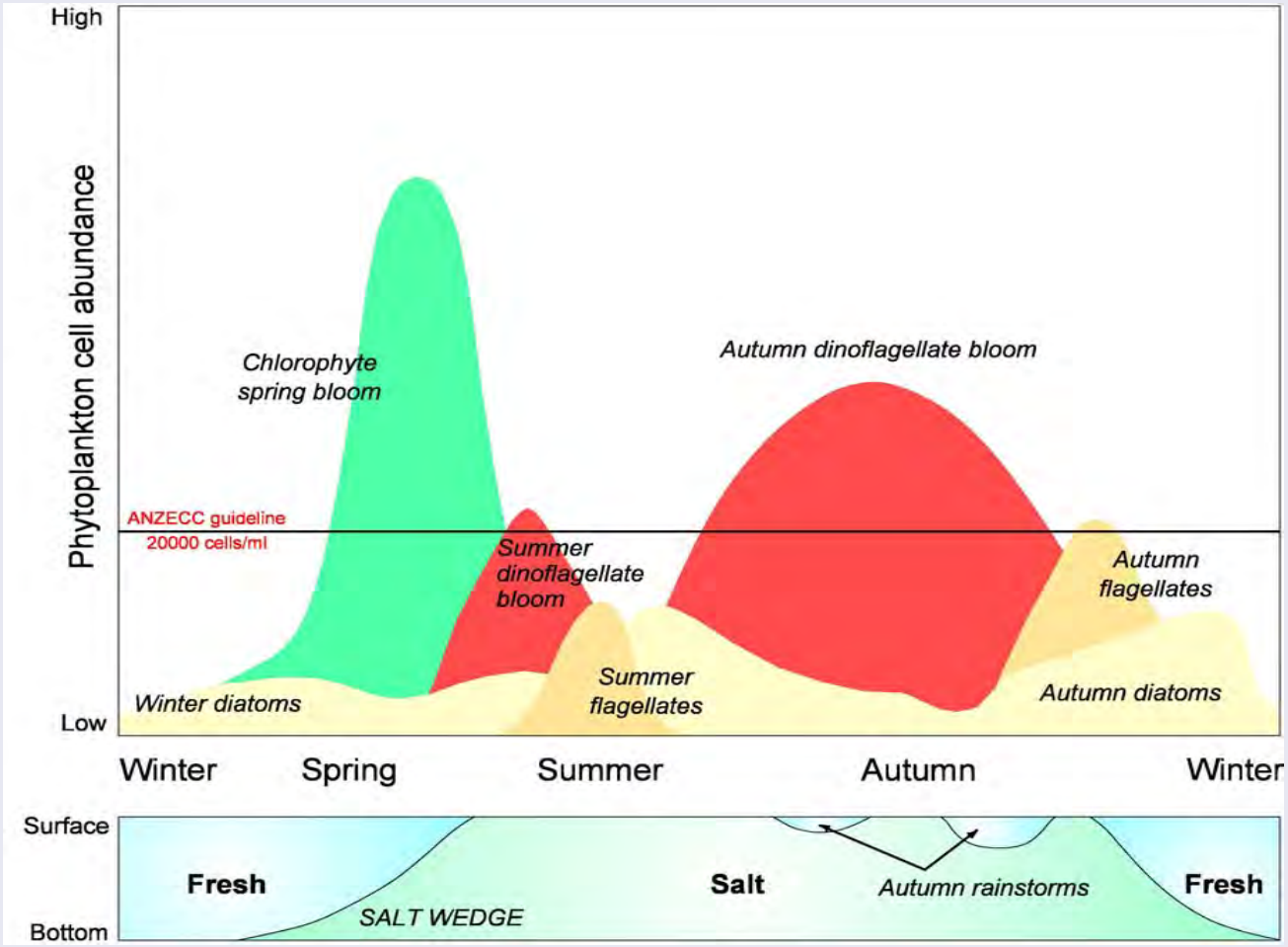
Understanding the System - Nutrients

Swan River Estuary - Physico-chemical Profile - 30 June 2003



Understanding the System - Nutrients

Swan and Canning Rivers
Algal Succession



Understanding the System - Nutrients



Microcystis bloom February 2000

Swan-Canning Cleanup Program

SWAN RIVER TRUST

Understanding the System - Nutrients



Fish deaths *Karlodinium* bloom May 2003

Nitrogen Trends Phosphorus Trends

Tributary	1998	1999	2000	2001	2002
Ellen Brook	(10) 29	(11) 29	(12) 32	(12) 30	(12) 30
Mills Street Main Drain	(11) 19	(11) 16	(12) 15	(12) 11	(12) 29
Bannister Creek	(11) 12	(11) 8	(12) 26	(12) 25	(12) 27
Southern River	(7) 15	(11) 17	(12) 16	(12) 17	(12) 19
Bickley Brook	(7) 14	(11) 21	(12) 22	(12) 19	(12) 17
Beaton Brook	(21) 8	(21) 8	(21) 4	(21) 7	(21) 11
Bennett Brook	(20) 3	(21) 8	(21) 11	(21) 12	(22) 10
Jane Brook	(14) 6	(21) 9	(21) 5	(21) 6	(21) 6
Blackadder Creek	(14) 2	(20) 3	(21) 1	(21) 2	(21) 2
Canning River	(13) 0	(19) 0	(20) 1	(19) 2	(19) 2
Helena River	(20) 3	(20) 2	(21) 1	(21) 0	(21) 0
South Belmont Main Drain	(14) 5	(21) 5	(21) 2	(21) 0	(21) 0
Avon River	(21) 0	(21) 0	(21) 0	(21) 0	(22) 0
Susannah Brook	(19) 0	(19) 0	(20) 0	(20) 0	(20) 0
Jane Brook	(12) 0	(18) 0	(19) 0	(19) 0	(18) 0
Short-term target met (%)	80	87	87	93	93
Long-term target met (%)	20	20	27	27	33

	Tributary fails both long and short-term targets
	Tributary meets short-term target but fails long term target
	Tributary meets both short-term and long term targets

Understanding the System - Nutrients





Swan-Canning Cleanup Program

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Understanding the System - Nutrients



Understanding the System - Nutrients

CRITICAL TASKS

- Reduce nutrient loss from urban and agricultural land
- Reduce nutrient levels in streams and drains
- Ensure growth does not increase nutrient levels
- Reduce availability of nutrients in the rivers

Swan-Canning Cleanup Program

SWAN RIVER TRUST

Understanding the System - Nutrients



Understanding the System – Who Pays? Drainage Forum – Swan-Canning Catchment

Presented by
Cliff Frewing
24 November 2003

Understanding the System – Who Pays?

- Local Government rating
- Why local government - why not Water Corporation?
- Who would pay?
- Direct benefit principle
- What is the basis of the calculation?
- Consultation with LG
- State-LG government consultation agreement
- Implementation costs
- What are the rules for remitting the levy?
- What fees would be paid to local government?
- What changes in legislation would be necessary?
- Does proposal have support of both political parties?
- What is time frame?
- The local government rates notice
- FESA levy

URBAN DEVELOPMENT INSTITUTE OF AUSTRALIA WA

DRAINAGE MANAGEMENT FORUM

INDUSTRY CONTEXT

- In 2001 existing residences 564,919
- Annual demand new residences 13,000
- New residences 2.3% of existing stock-a small element of the overall problem
- Importance of solving urban water issues in existing developed areas is clear.

DRAFT POLICY POSITION

- Provide a consistent and co-ordinated approach across all levels of government.
- Recognise the need for sustainable cost effective solutions which maximise social, economic and environmental benefits, whilst at the same time being practical to implement and maintain.
- Provide a flexible, performance based approach to water management, which recognises that site-specific solutions are required depending upon the unique characteristics of each development site rather than the application of generic policies.
- Recognise the requirements of the community in terms of urban lifestyle preferences.
- Ensure that all stakeholders are accountable and contribute to solving the problem

Flexible performance based approach

- Primary objective is removal of nutrients and contaminants from storm-water to protect receiving water bodies – policy should never lose sight of this
- UDIA concerned that exclusive focus on infiltration and “living streams” not necessarily technically sound and does not deliver best urban design outcome.
- Contaminant infiltration in shallow Bassendean sands only delaying contaminant entry to receiving water bodies
- Source control supported but also need to incorporate “in stream” contaminant removal
- Retrofitting of existing catchments critically important – existing developed catchments is where most of the contaminant loads originate.

CONSTRUCTED WETLANDS IN NEW RESIDENTIAL ESTATES

- Prohibition on new permanent wetlands not supported
- Community desire for urban wetlands is very clear – very high demand for land with proximity/views over water
- Well designed constructed wetlands provide landscape amenity and community benefit
- New vegetated habitat and permanent water provide environmental benefit
- Nutrient and contaminant removal achievable – requires application of process design techniques
- Evaporative losses a very small issue-little difference to irrigation of grassed playing fields
- Good initial design the key to minimisation of future management problems with
- Good water quality through minimising contaminant inputs, mixing and aeration, shading, adequate depth and size, optimised biological contact – these techniques are known



BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS


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CONSISTENT AND COORDINATED APPROACH

- UDIA has been involved in 11 separate drainage reform initiatives over the last 2 years
- UDIA is a willing participant but concerned about coordination between reviews and achievement of a consistent outcome
- Inconsistencies between State and local government policy on civil design/urban water management approach- create design problems and delay issue of approvals.

COORDINATION of URBAN WATER MANAGEMENT POLICY

- WAPC best suited to coordinate
- Triple bottom line/sustainability approach
- Department of Environment focus on environmental element of TBL
- Quality urban design outcomes require a broader view
- “Enquiry be design” template for policy development – WAPC has experience
- UDIA members keen to participate and provide the benefit of significant experience and design skills

Water Quality: Policy Instruments

Neil Gunningham

and

Darren Sinclair

Australian National University

Potential Targets for Pollution Policy include:

- Large (industrial) point source pollution
- Pollution from households and urban streets etc
- Light industry
- Small point-source pollution (agriculture)
- Rural non-point source pollution

Non-Point Source Pollution from agriculture: policy challenges

- Many different contributors to NPSP, spread over a large geographical area
- NPSP very difficult to measure and track to its source
- Impact of agricultural practices varies greatly between properties and areas
- Agricultural enterprises limited awareness, knowledge, resources, and resistant to regulation

Past Policy: domestic and international

- Heavy reliance on information and education
- Heavy reliance on voluntarism

Limitations:

-voluntarism only likely to be effective where primary producer has enlightened self-interest

-many voluntary initiatives fail outright when these conditions not satisfied

20 percent of the population will comply with any regulation, 5 percent will attempt to evade it, and the remaining 75 percent will go along with it as long as the 5 percent were caught and punished

Key Issues

Who to target?

- the impacter
- drain managers
- others

Regulatory Options

- General environmental duty
- Mandatory BMPs
- Mandatory buffer zones
- Nutrient sensitive zones where fertiliser use licenced and nutrient management plan
- Licence drain managers
- Mandatory land use change

Policy goals

- Effective
- Efficient
- Equitable
- Politically acceptable

Economic Instruments

- Subsidies: auctioned grants for voluntary improvement of environmental practices
- Impacter pays: BMP incentives charges
- Emission offsets to limit future urban non-point emissions
- Tradeable permits on nutrient loads where practicable

A sequenced approach?

- Information, education
- Voluntary measures reinforced by subsidies
- Underpinned by regulation
- A two track approach (those without accredited farm plans require license

If targets not met then

- purchase of land based on offset system
- phasing out of agricultural production of land in nutrient sensitive areas;

Beyond Voluntarism" Towards an Optimal Policy Mix

- Information and education strategies
- Voluntarism
- Self-regulation
- Economic Instruments
- Command and Control Regulation

Reconfiguring Environmental Regulation

- Where necessary, build in a regulatory underpinning
- Government as facilitator, catalyst and activator
- Design financially attractive mixes
- Institutional mixes: harnessing third parties

Licensing Drain Managers

- Convert non-point to point sources
- Impose targets/emission charges and give incentives to reduce pollution
- Enable trading between drainage managers

BUT

Main drains not the cause of the pollution

Equity issues

Transactions costs: difficulty identifying non-point sources

Light Industry: the Policy Challenge

- Lack of resources
- Lack of environmental awareness/expertise
- Lack of exposure to public scrutiny
- Sheer numbers of enterprises (making inspection largely impractical)

Existing Institutional Arrangements, Regulatory and Policy Approaches

- Focus of DOE almost exclusively on large premises requiring licence
- Resource limitations: other powers under legislation but very rarely used
- environmental codes of practice (3 to date)
- Local government can only enforce EP Act when authority is delegated to it

Cleaner Production Program

- Simplified environmental management practices aim to prevent pollution at source
- Aim of win-win outcomes
- Disappointing response from light industry:

-too complicated

-lack of incentive for voluntary participation

Policy Instruments

- **Information and education**: -simple but effective messages, industry specific, third parties (customers, suppliers, professionals) to reinforce message.
- **Positive Incentives**: Where practicable, provide targeted subsidies for environmental audit and technological assistance.
- **Regulation**

- self-inspection and self-audit;
- inspection and enforcement;
- neighbourhood environmental improvement plans

Self-inspection and self-audit

-
- • Develop a self-audit check-list specific to key industry sectors.
- • Keep it simple (eg to four water pollution issues in each sector, limit three pages).
- • Arrange for collection and collation of completed check-lists.
- • Provide oversight through peer review, randomised audits by regulators.
- Threaten inspections for those they do not complete and return self-audit check-lists.

Inspection and Enforcement

- Extend the power to issue infringement notices (on the spot fines) to local gov
- Extend the power to issue pollution abatement notices to local government,

Neighbourhood Environment Improvement Plans

- Empower local communities to develop geographically based environmental improvement plans.
- Engage light industry at the local level (such as industrial zone) through their participation in environmental improvement plans.

Institutional Arrangements

- DoE to take greater role?
- ‘second best’ solutions: extended local government role
- Funding support
- Training
- Leadership

Water Corporation

- Capacity to treat industrial wastewater
- Encourages light industry to discharge to sewer (requires industrial waste permit)
- Capacity to impose penalties for breach of permit conditions
- Some discharge to sewer without permit (no inspection program)

Agricultural Point source pollution

- Cumulatively substantial pollution load
- Practicable to impose controls (measurable outputs, technological capacity to improve)
- Cost effective to impose controls
- Limitations to the effectiveness of voluntarism

  -win wins vs win-lose

Policy options

- Sector specific codes of practice/ BMPs/ EMS
- regulatory underpinning: performance-based, prescriptive or process based?
- the role of licences
- Government – industry partnerships: Incentives and two track regulation

Best Management Practices

- The ‘best’ methods of farming in terms of sustainable production
- Can be combined with Environmental Management Systems
- May be best option where costs of monitoring/ calculating performance targets are very high
- Ensure BMPs can provide inputs to farm plans
- Underpin by regulation (eg BMPs must exceed general environmental duty, be independently accredited, and continuously improving)

General Principles guiding the selection of policy mixes

- Information and education necessary but rarely sufficient to achieve preferred environmental outcomes
- Use complementary combinations of policy instruments to compensate for the deficiencies of stand alone instruments
- Use reinforcement and pull-push combinations for optimal results
- Order the introduction of instruments for optimal effect

The Perth Community Perspective on Drainage

Findings of Qualitative Research -
Three Focus Groups with Perth Residents

Drainage Management Forum

29 March 2004



market equity
research and strategy

Julie Beeck
Managing Director
Market Equity

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market equity

The Swan – Canning Rivers are:

- Highly valued by all
  - Lifestyle
  - Icon
  - Perth's Identity





- Taken for granted by most

"The average person doesn't really stop and think where it all comes from."

- Understood by very few as a drainage system

"I'm just realising sitting here how very ignorant I am of the things that impact the health of the river."

Education is starting from a low base of knowledge

Awareness and Knowledge are Based on Observations

Current Users are most concerned about the health of the river

(BOATING, FISHING, RIVER SPORTS)

CONCERNED BY WHAT THEY SEE:

- Litter
- Erosion of banks
- Industrial waste and colour clarity of water

Surrounding residents and visitors to the river banks see the river in good health

UNCONCERNED BY WHAT THEY SEE:

- Looks healthy
- No odour issues
- Wildlife is apparent

Some residents base their impressions on historical experiences or instincts

"We used to swim as kids and often got ear-aches."

"I just don't trust the water is clean enough to eat the fish."

Algae blooms are known and considered serious, but so far have been fixed

The Community's Views



Beyond what they observe, the community's views are also influenced by what they don't hear

"If there was a problem we'd hear about it."

Awareness of What Impacts the Health of the River

Visible or known impacts are:



Climate - low rainfall and flow



Recreational Use

Farming





Industry



Pesticides - used on the river



Fertilizers

There is low knowledge of controls or measures in place to manage the river.

market equity

Reactions to proposed funding models

"Polluter Pays"

- ✓ Encourages positive behaviour - stop the problem getting worse
- ✓ Fair system - those responsible should fix it
- ✓ Could raise consumer awareness through increased prices/charges
- **X Would it raise sufficient funds?**
- **X Could put some people / clubs out of business**
- **X (Big) industry may 'get away with it' - a 'licence' to continue polluting**

"Beneficiary Pays"

- ✓ More evenly distributed
- ✓ Everyone is responsible so cost should be shared (minority view)
- ✓ More likely to raise enough funds for us to keep the benefits of the River
- **X "Another slug on the community" (resent having to pick up the tab again)**
- **X Feels like another tax**
- **X Not everyone benefits equally (outer suburb people)**

market equity

Reactions to Funding Options

Is it a problem to be solved?

OR

An asset to be protected?

Problem

Polluter should pay

Protection

Combination of polluter and beneficiary pays

A dedicated levy is not popular:

- poor history of using levies to recover losses (GIO, WA Inc)

- seen as the community 'bearing another burden' for others' mistakes

Recommended Communication Priorities

THERE IS A STRONG CALL FOR COMMUNICATION, ONCE INTEREST IS SPARKED

1. Inform people of the actual health of the river (and the risks of doing nothing)
2. (AT THE SAME TIME) Communicate the plans, to ensure community support
3. Education program on how everyone can protect the river (esp. fertiliser use)
4. Information about how polluters are managed & addressed - public confidence



TONE: Positive, Responsible, Proactive and Involving.

The Perth Community Perspective on Drainage

Questions?

Drainage Management Forum

29 March 2004

Julie Beeck
Managing Director
Market Equity

market equity
research and strategy

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Department of Environment

Drainage Forum

Malcolm Robb *Aquatic Science Branch,*
Water and Rivers Commission

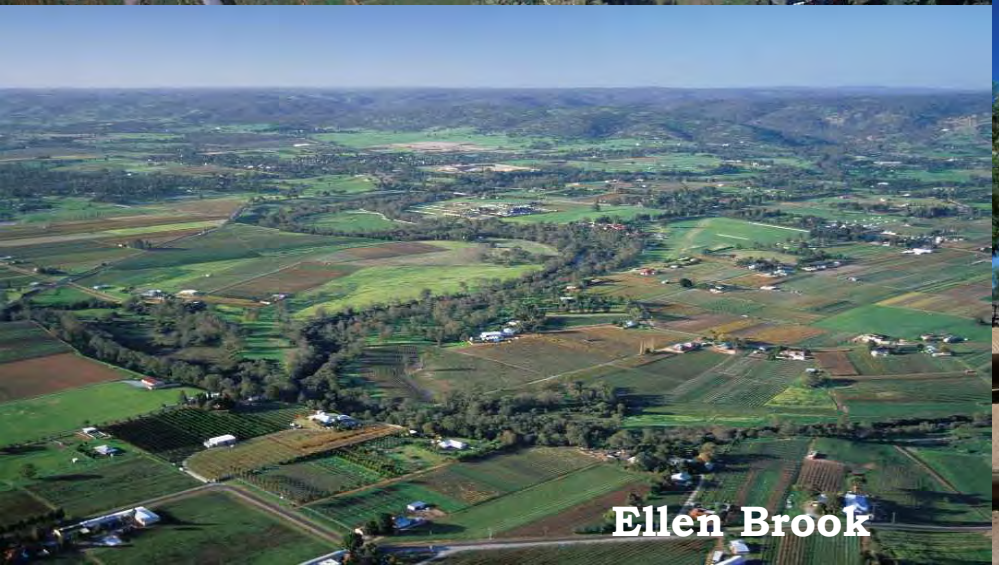


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Land Use


Blackadder


Bennett Brook


Ellen Brook


Helena River

Department of Environment

Historical Land Use SCCP Program



Spatial data essential for catchment modelling

- Export Coefficient calculations of nutrient loss WIN CMSS
- Process based models LASCAM which includes groundwater
- CRC Catchment Hydrology for TIME framework
- MUSIC etc

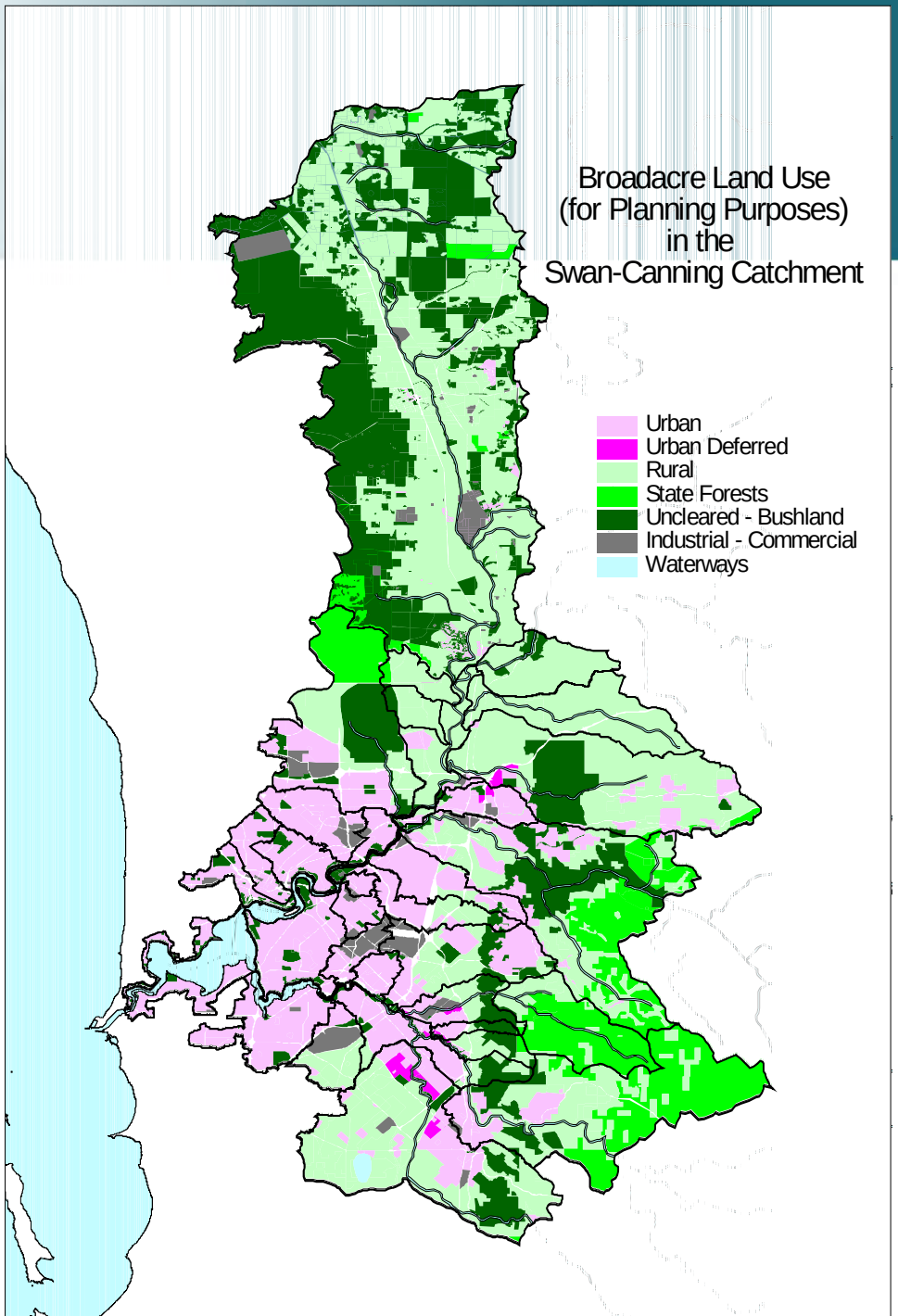
Hardest data sets to obtain - 1998, esp. historical

- Avon - sourced from Land Monitor using the Deep Rooted Vegetation Mask
- Ellen Brook from North East Corridor Strategy
- Other - MRS from hard copy and converted to GIS for Southern River and Mill St Drain (now aerial photos)
- MRS is proposed not current so impose the urban footprint
  - 64, 74, 84 with assumptions
  - 95, 2000, 2002 Street directory

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Broad acre Landuse





MRS 1998

NE Corridor Extension Strategy

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Historical Land Use Current and Future Effort



Capturing Point Sources from internal and external data sets - ongoing

- Many are not spatial and need conversion
- Many contradictions need reconciling
- Mapped data from all data sets to examine priority catchments wrt to point sources

Next Steps

- Combine land use and point source with hydrology through selected models
- Calibrate and validate with monitoring data
- Model nutrient production based on land use on sub-catchment basis
- Generate estimates of required load reductions

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Historical Land Use Conclusions



Land use Information serves many purposes

- different classification schemes have been established
- many are not appropriate for use in the environmental management of surface and groundwater
- do not necessarily encompass the wide range of potentially polluting activities.

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Historical Land Use Conclusions



Priority catchments- Point Sources

- Mills Street Main Drain, South Belmont and Bannister Creek based on the number, density and type of industry
- CBD and Yule Brook also having a high density and risk of potentially polluting industries.
- also noted as having potentially high nutrient concentrations

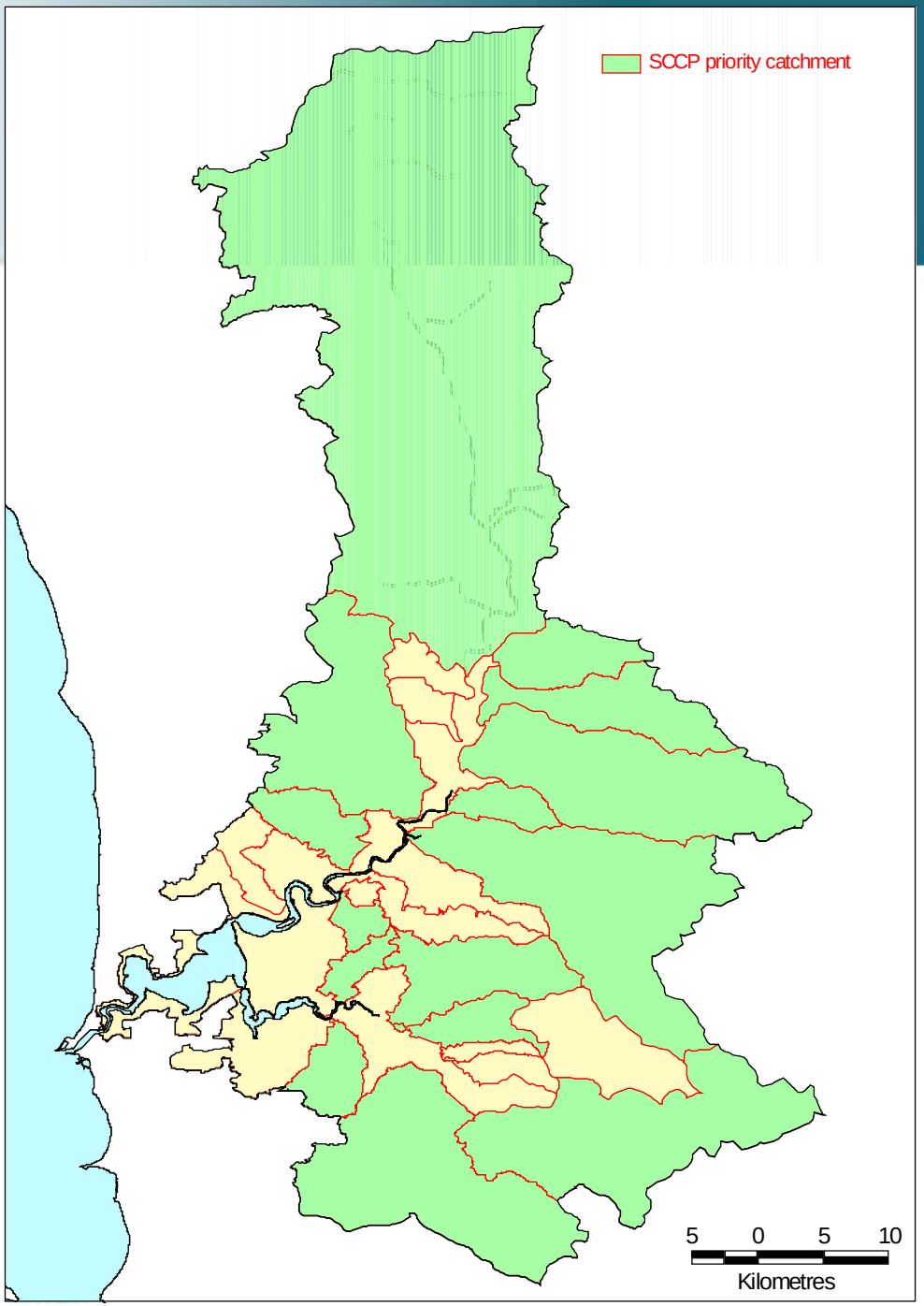
Priority catchments- Diffuse Sources

- Ellen Brook and Southern River have the highest nutrient concentrations with these being derived from diffuse sources.

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Landuse

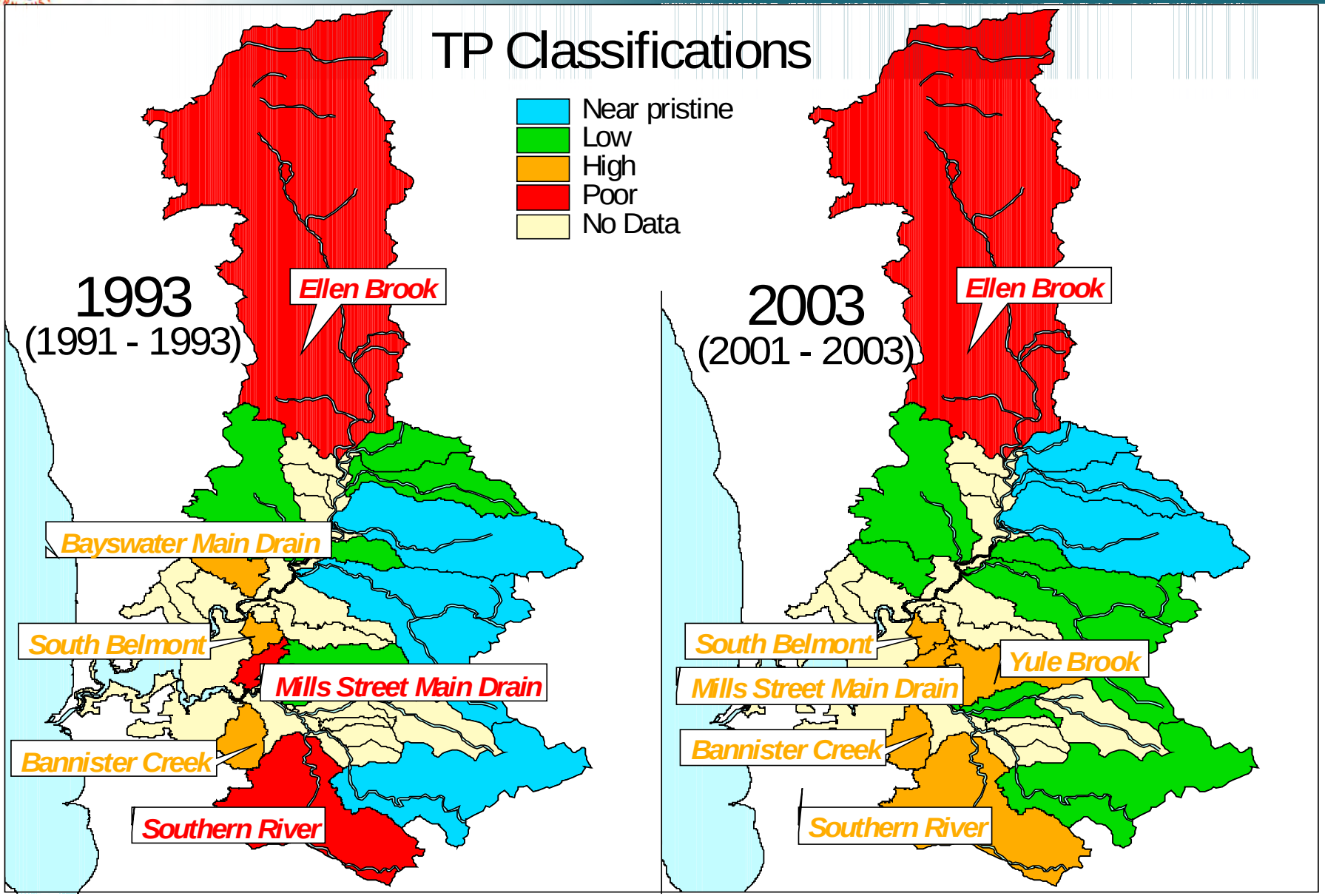




SCCP Priority Catchments

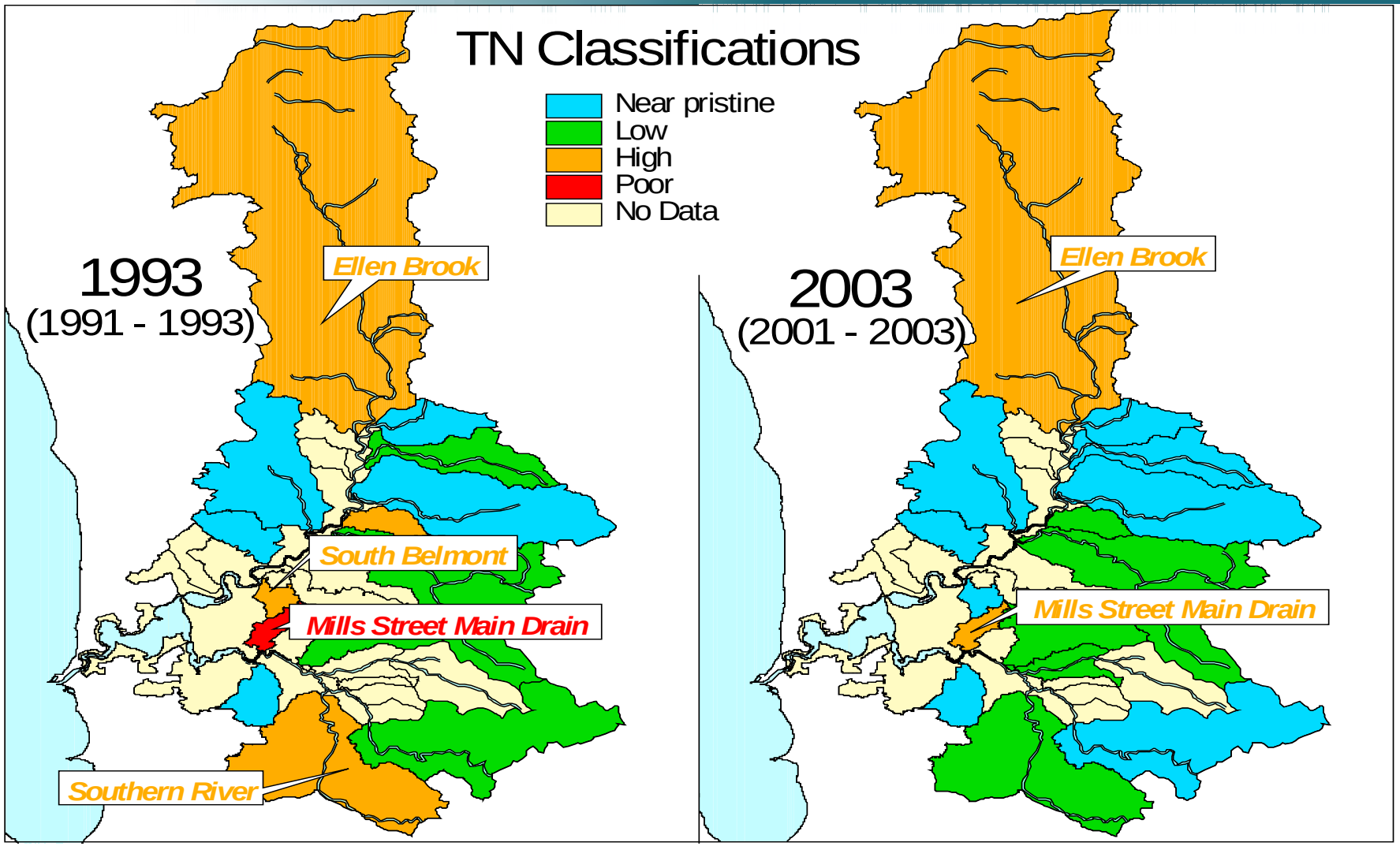
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Nutrient Status



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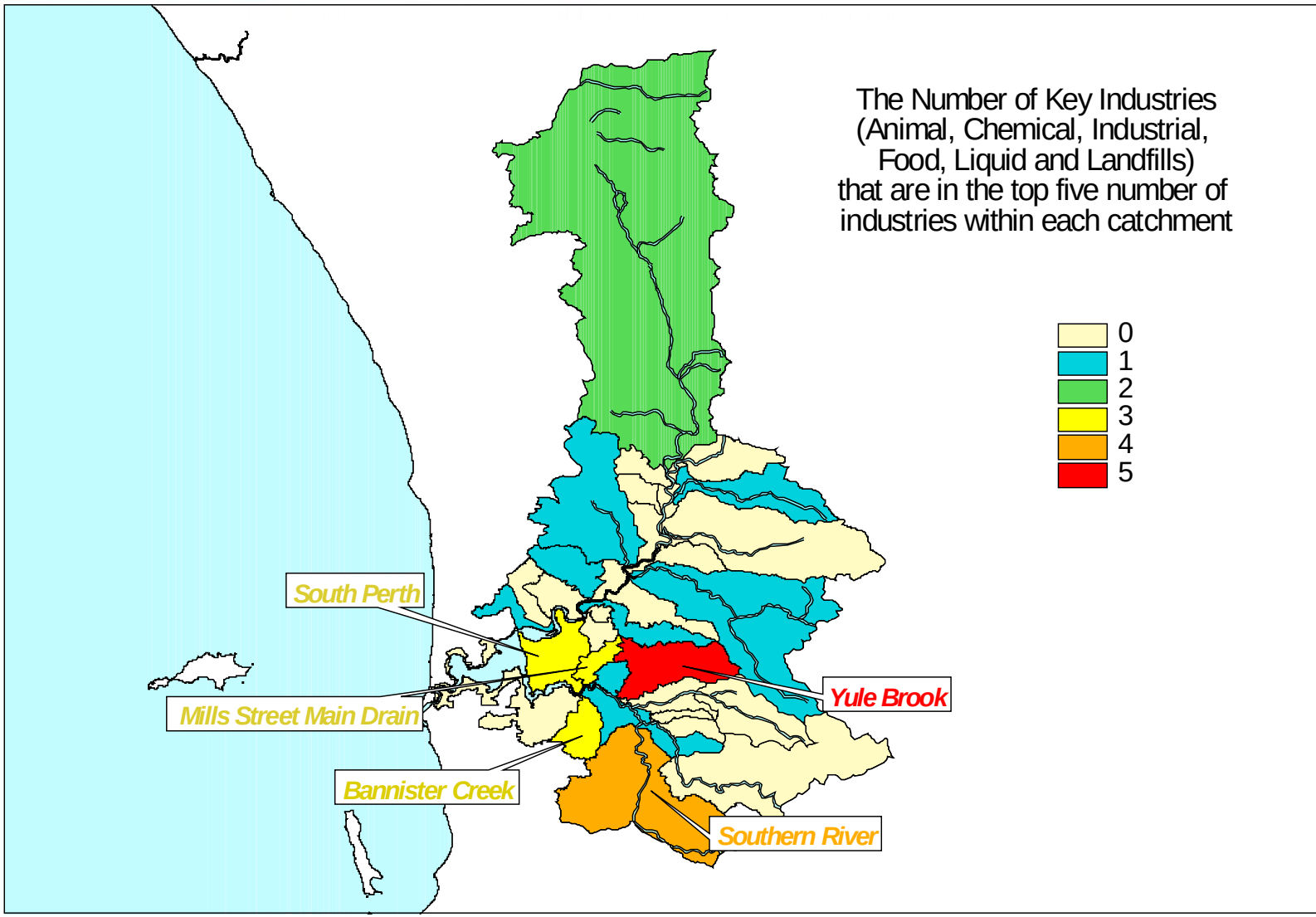
Nutrient Status



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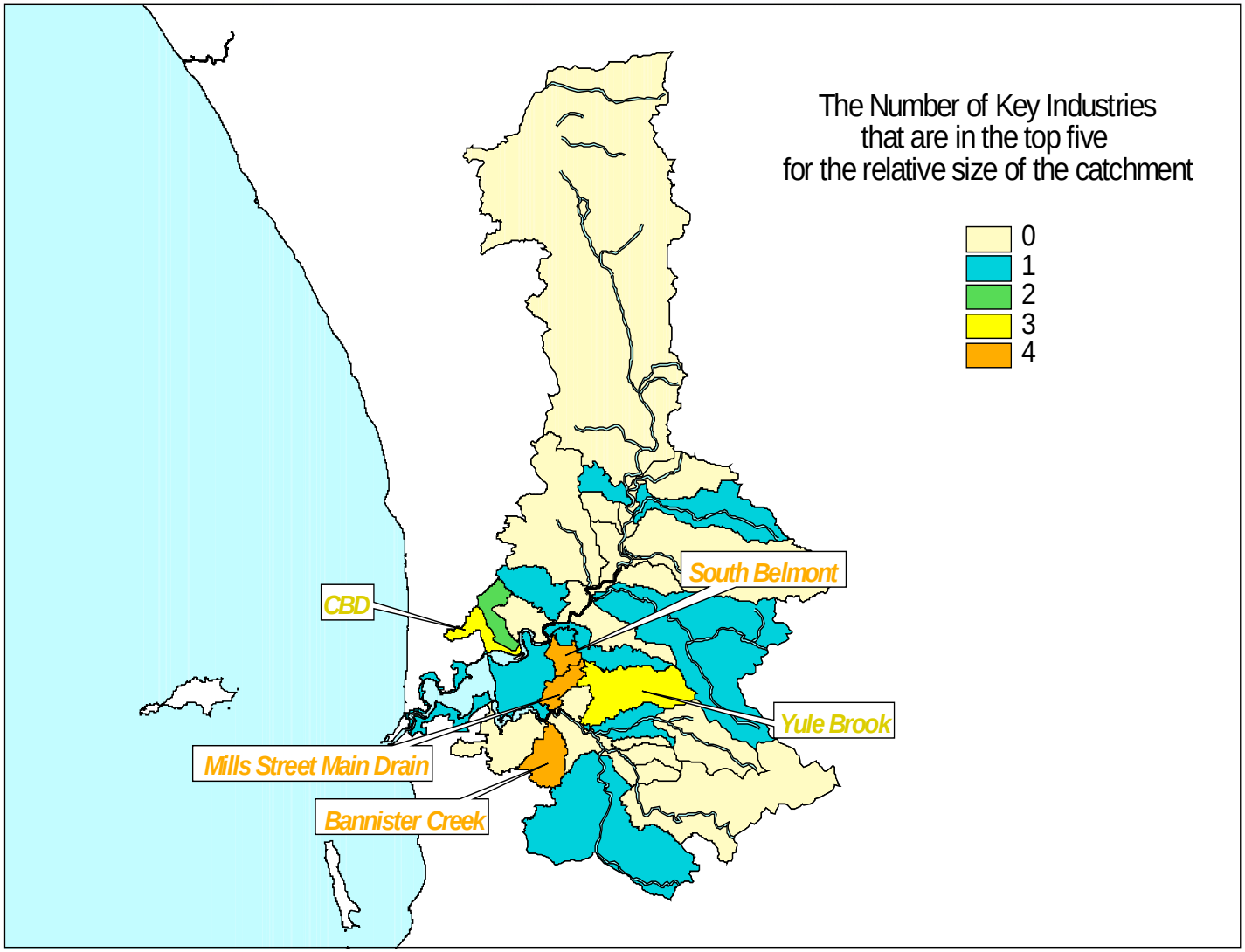
Historical Land Use
Key Industries





Historical Land Use
Key Industries

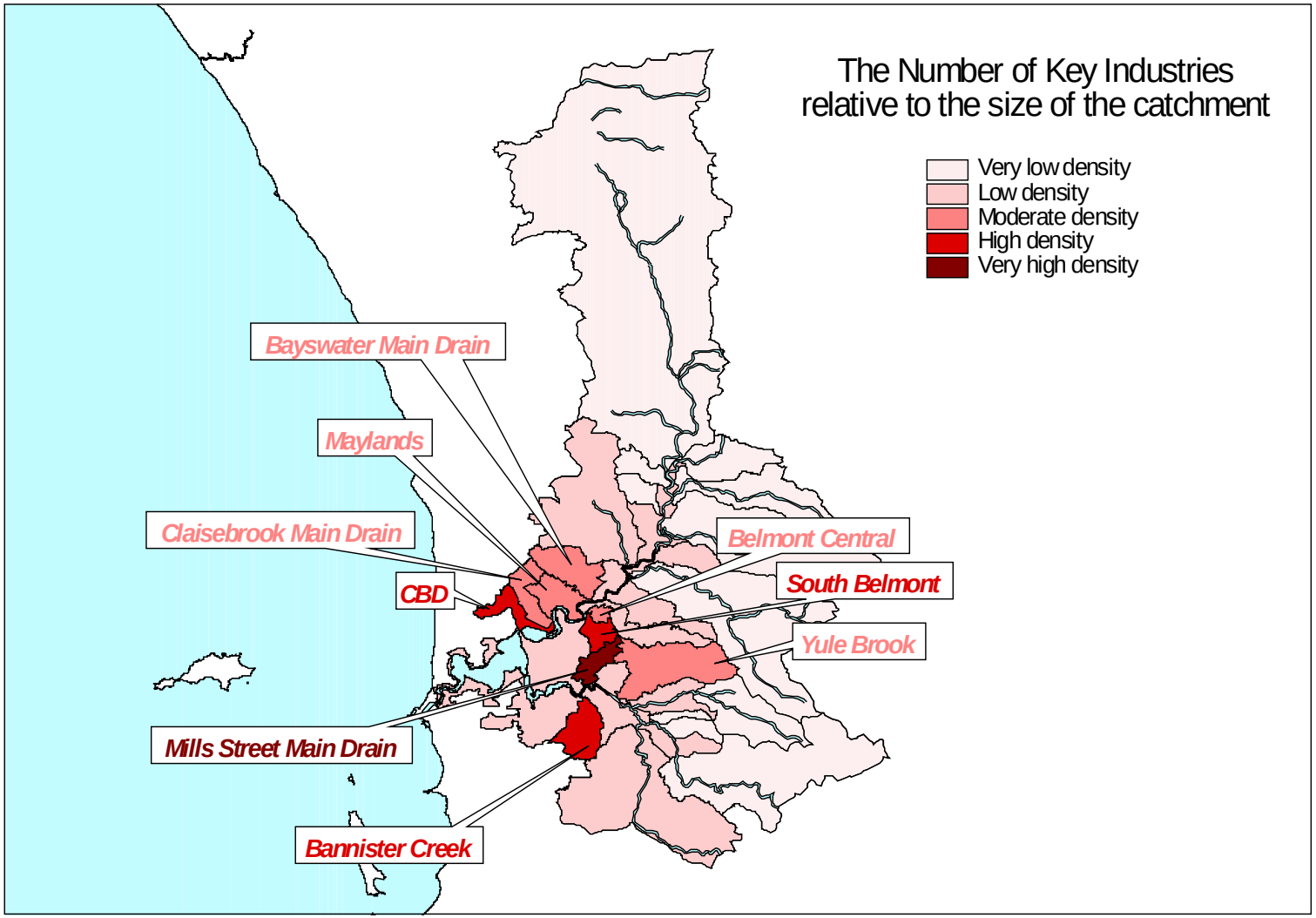




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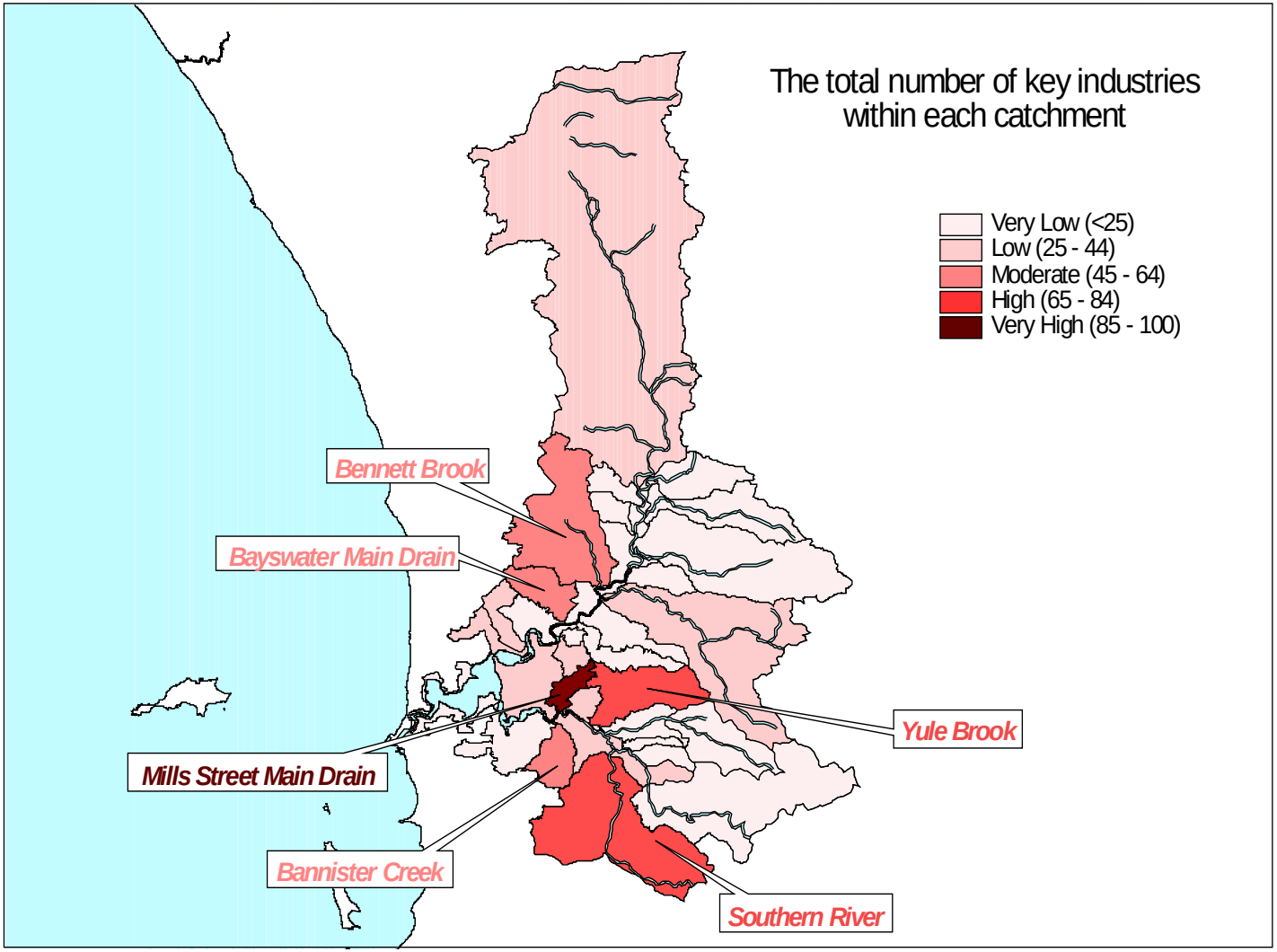
Historical Land Use





Historical Land Use

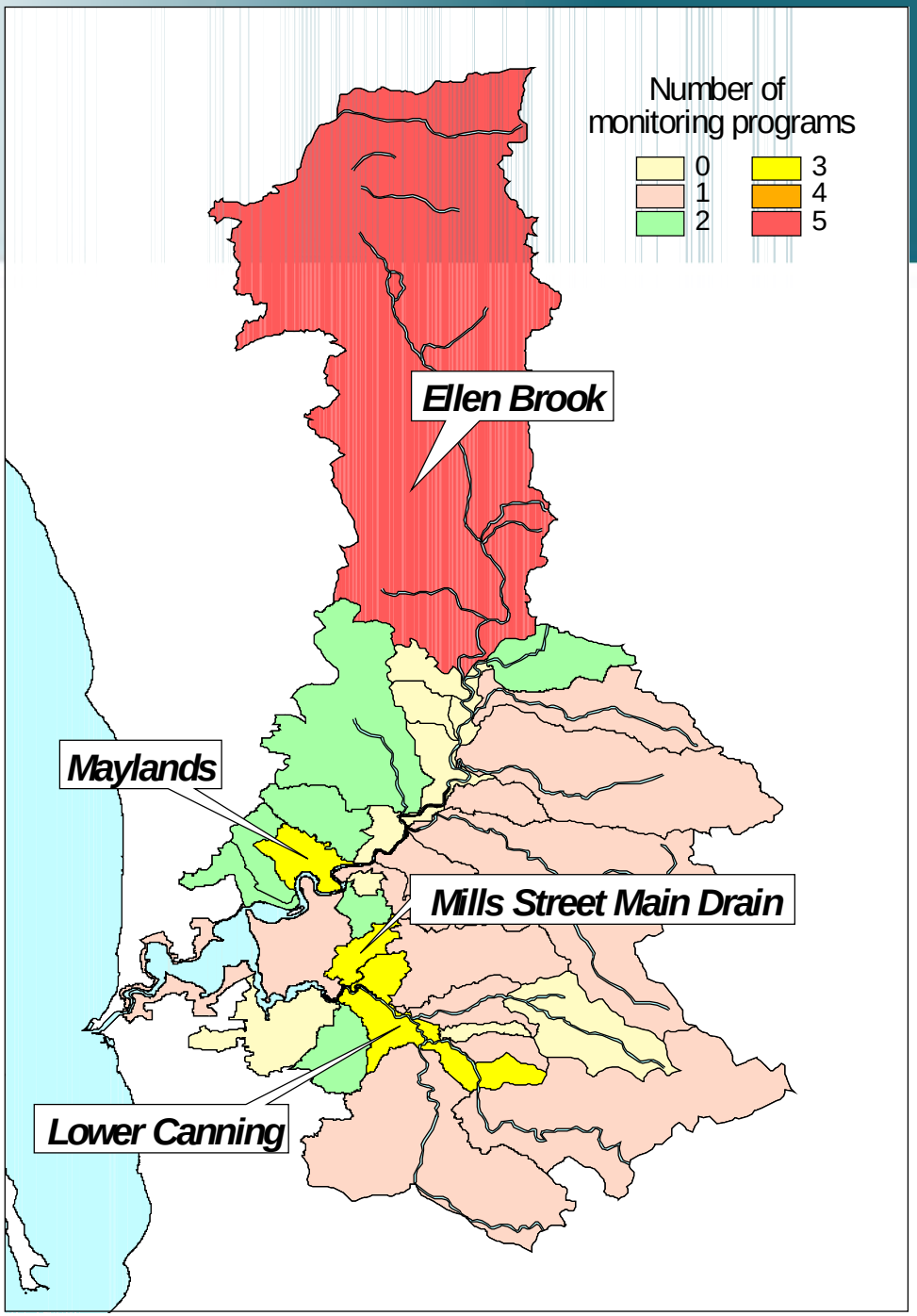




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Historical Land Use





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Historical Land Use Recommendations



- Continue to capture, standardise and reclassify data sets relating to historic and current land use into a spatial format.
- Promote the inclusion of standardised premise locations in data sets enabling them to be spatially defined.
- Ground truth the key data sets including land use type and location of potentially polluting industries.
- Interview knowledgeable individuals to identify additional historical sites that may be contributing to current diffuse contamination sources.

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Historical Land Use Recommendations



- Undertake sampling and analysis programs in identified high-risk catchments to further refine understanding of sources.
- Incorporate spatial data sets into existing decision support models for the purpose of identifying appropriate management actions.
- Continue development of Decision Support Models including MUSIC

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Historical Land Use
Thanks and Questions?



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Target Setting in the Swan Canning



Context

Existing Targets

Future Directions

Jane Brook

Department of Environment

Target Setting in the Swan Canning



What is a target?

- A target is simply something to aim for and therefore can take a number of forms.
- Milestones and benchmarks constitute targets, for example.
- Targets by their very nature require some form of measurement of performance against that target, otherwise the setting of a target has little practical purpose.
- Performance against targets or milestones provides the tools to evaluate success or otherwise of the activity or programs.

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Target Setting Target Languages



- NAP/NHT2 - Swan Regional Strategy
- Swan Canning EPP - Riverplan
- SCCP Catchment and Estuarine Targets

- Regulatory - License Conditions

- ANZECC NWQMS
- EPA Reporting Framework for NRM

- Performance Objectives or Criteria
  - for BMP development

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Target Setting NAP/NHT2



Aspirational targets (>50 years)

- vision statements of the overall goals or outcomes of the management program.

Resource condition targets (10-20 years),

- which are quantifiable outcome-based targets relating to desired changes in natural resource condition.

Management action targets,**milestones**(0-5 years)

- targets linked to specific actions, such as the number of kilometres of riparian zone revegetated, or the proportion of development in a catchment incorporating water sensitive urban design.

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Target Setting Riverplan



Environmental Values (EV)

- particular values or uses that are conducive to a healthy ecosystem and also provide public benefit' . The explicit assumption is that 'management of the human of the human oriented uses will be achieved by protecting the ecologically based values.'

Environmental Quality Objectives' (EQO)

- 'goals which, when achieved, will allow the environmental values to be supported'

Environmental Quality Criteria (EQC)

- represent the nominated acceptable levels for a specific indicator. They are nearly always numerical and represent a nominated level that has yet to be met for an environmental objective to be achieved'.

Department of Environment

Target Setting SCCP



SCCP Objectives - Action Plan

- Broadly equivalent to Aspirational Targets

SCCP Water Quality Targets

- Catchment TN and TP in mg/L
- Estuary Chl a, DO, TN and TP
- Equivalent to resource condition targets
- Broadly similar to EQO's

Management Action Targets

- Not set for the SCCP

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Target Languages



NRM Style Targets -NAP/NHT2

- Devloped through consensus within Swan Regional Strategy partnerships
- Not based on blame
- Non Statutory
- Reflect measures of improvement

EPP Style Targets

- Not usually consensus (except EV's)
- Statutory
- Remedial actions required
- Risk based in derivation (EQC's)
- Reflect measures of deterioration

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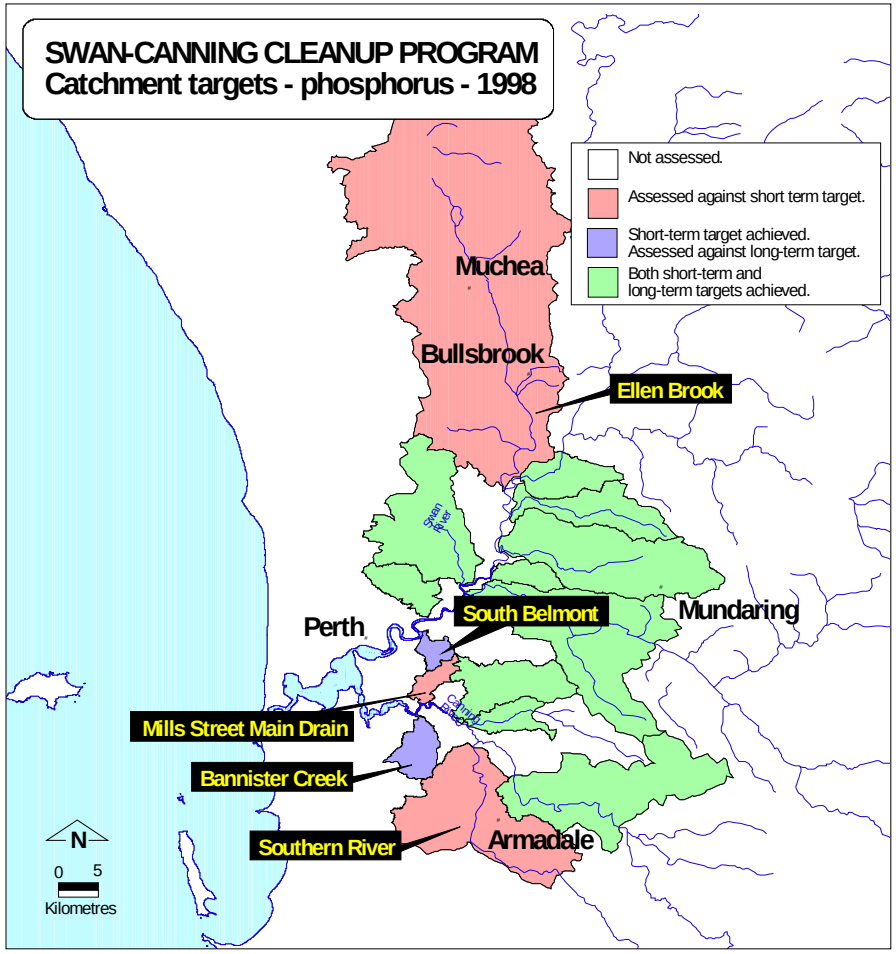
Target Setting Resource Condition

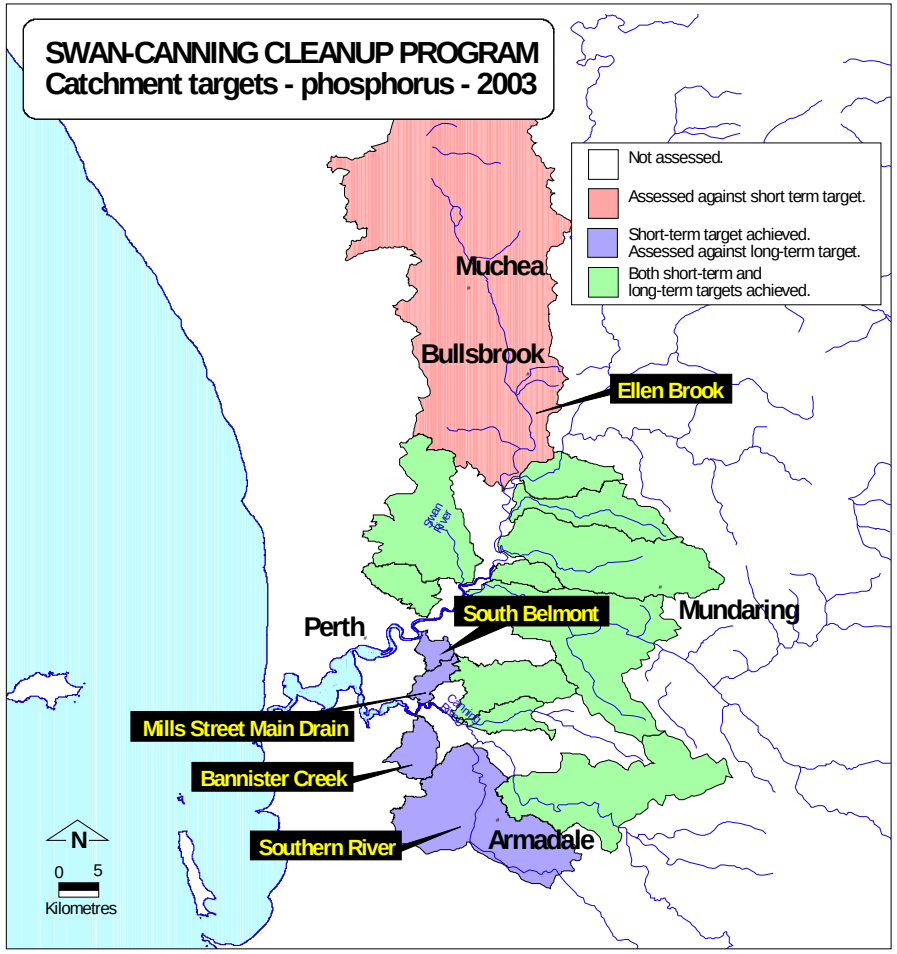


- Identify the problem
- Define the problem in terms of attributes that can be measured - current condition
- Select Indicators
- System and Process Understanding
- Long term data - monitoring data
- Describe desired future condition
- Establish compliance testing scheme
- Estimate ability to detect change
  - Understand scale of intervention
  - Identify natural vs intervention

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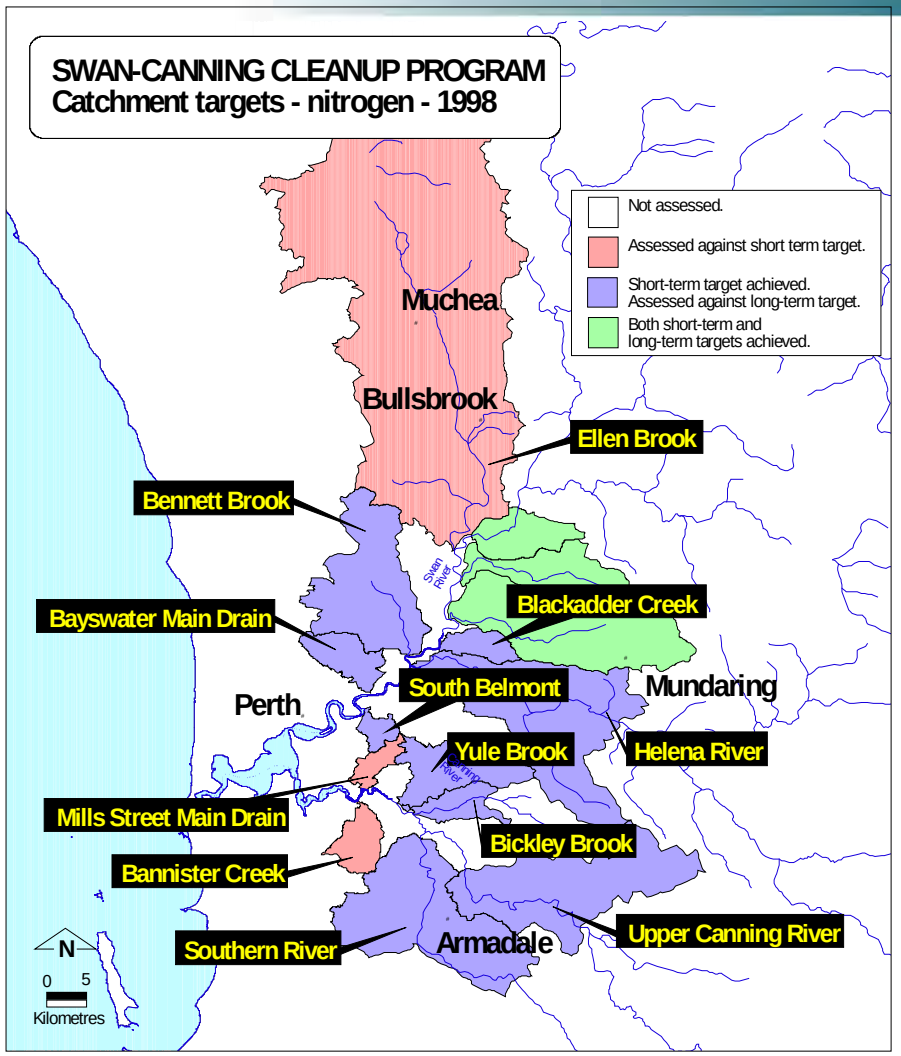
SCCP Targets Phosphorus

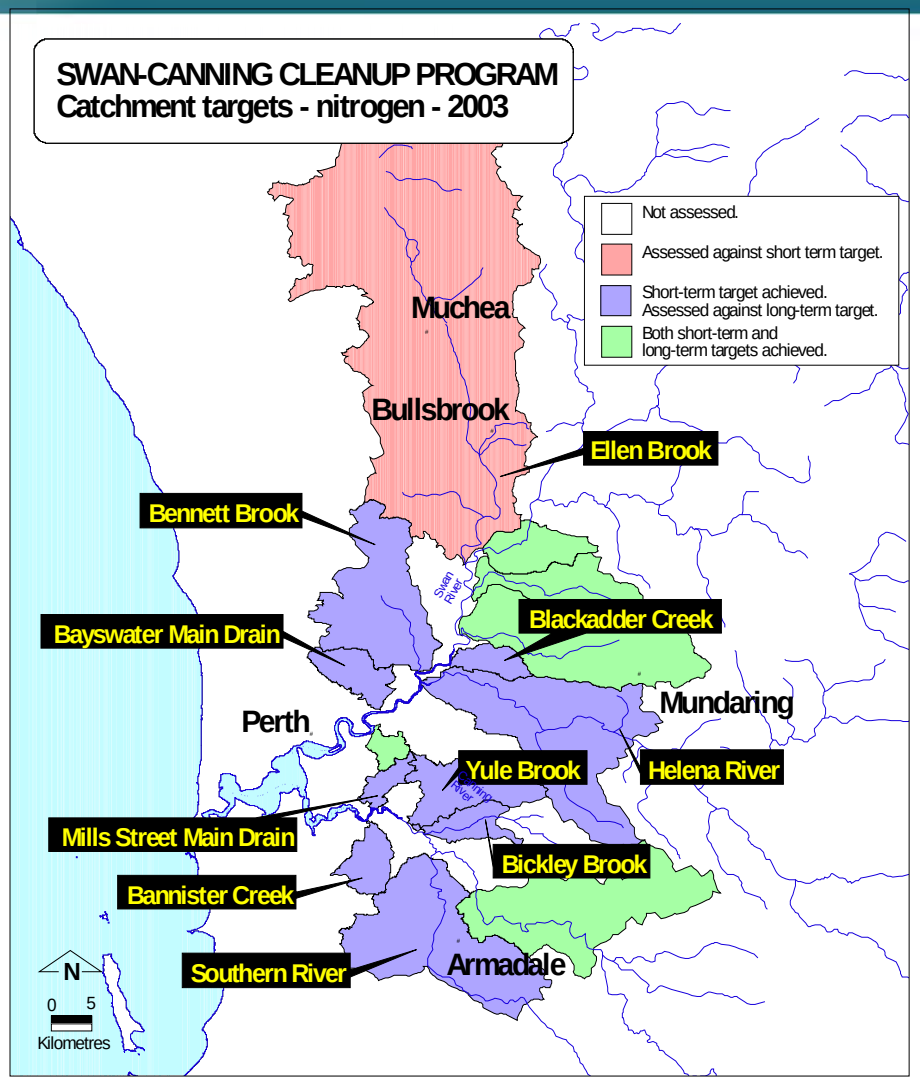




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SCCP Targets Nitrogen





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Target Setting SCCP



Management objective	Potential measures or indicators	Indicator for numerical SCCP targets	Method
Reduce nutrient inputs from the catchment	Nitrogen (TN, DIN) Phosphorus (TP, DIP)	TN TP	1. Fortnightly sampling at 15 catchment sites 2. Concentration based target
Reduce frequency of algal blooms	Phytoplankton cell counts No. of recorded blooms Chlorophyll *a* *In situ* fluorescence	Chlorophyll *a*	3. Weekly sampling at fixed and randomly selected sites 4. Surface samples 5. Set by estuary basin
Reduce potentially toxic blooms in the Canning	No. of blooms of gazetted toxic species	Targets not set	• Weekly sampling, and • Opportunistic sampling • Phytoplankton ID and cell counts
Reduce anoxic periods in the Swan	Dissolved oxygen concentration	Dissolved oxygen (% saturation)	• Weekly sampling of surface waters
Reduce nutrients which feed algal growth in the estuary	Nitrogen (TN, DIN) Phosphorus (TP, DIP)	TN TP	• Weekly sampling • Concentration based target • Set by estuary basin

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Target setting Conclusions



- Number of target languages and needs among stakeholders in drainage management
- Identification of the needs of all stakeholders is important to reduce confusion and duplication.
- Target setting in the Swan-Canning will be governed by two main frameworks; the NAP/NHT2 driven Swan regional strategy and the Swan Canning Environmental Protection Policy driven Riverplan.
- The responsibility for target setting will depend on the ultimate governance arrangements for the Swan Canning.

Target setting Conclusions



- Additional target setting outside of the regional strategy and Riverplan may be unnecessary
  - reporting against targets is not always the most useful expenditure of money or the most effective form of communication to the community.

- For the SCCP, system wide water quality targets were established and have become indicators of overall performance for the SCCP.
- The process used in developing the Program targets has broader applications, especially for developing performance indicators for natural resource management programs.

- A target compliance system needs to be based on a sampling program designed around sound statistical reasoning.

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Target setting Recommendations



- Reconcile the target setting frameworks of the Swan region strategy and Riverplan to avoid confusion and duplication of effort.
- Determine the role and responsibility for regulatory approaches.
- Develop robust but simple and transparent methodologies for target development and reporting.

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Target setting Recommendations



- Undertake targeted investigations and well designed monitoring
  - to improve understanding so that models relating to targets and environmental health can be improved.
  - Numerical and decision support models will also require information gaps to be filled.
- Collate and understand all stakeholder needs for targets, design criteria and performance measures and assist in providing these.
- Only select numerical targets if a commitment can be made to appropriate compliance monitoring programs. In many cases non-numerical targets may be satisfactory.

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Target setting Recommendations for SCCP



- **Document all related management activities**
  - in terms of location, size, and intended influence on nutrient reduction and,
- **Quantify a selected number management actions**
  - so that efficacy, cost/benefit to purpose and contribution to achieving the targets can be determined.
- **Implement monitoring programs and develop targets** for:
  - ecosystem health,
  - non-nutrient contaminants and
  - incorporate human health indicators such as pathogens and faecal coliforms if considered appropriate
- **Develop web-based community reporting.**

Targets for Swan Canning

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Bennett Brook

Thanks for listening

Questions?

Department of Environment

Monitoring and Reporting











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Monitoring and Reporting



Good Monitoring is always good Science- Walter Boynton

The reverse is not always true

Long term data collection with consistent methods and protocols - trends over time

- Clearly defined information objectives
- Represent the problem in space, time (scale), variable
- Consistent, repeatable, well documented
- Recognised methods and protocols - collection, analysis
- Established data analysis and reporting

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Monitoring and Reporting



Current Effort

- Collated information on existing programs
- Similarities and differences -
- Synergies with objectives and needs
- Proposed collaborative and coordinated approach

Opportunity/ Need

- NHT Regional Strategy M and E framework
- SCCP program review
- SRT EPP implementation
- This forum and focus on drainage issues

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Monitoring and Reporting Conclusions



- Current monitoring programs
  - SCCP is the only system wide water quality monitoring program in the Swan and Canning
  - More than half of the local governments do not conduct water quality monitoring.
- Indicators / variables
  - Physical properties and nutrient concentrations are common to most monitoring programs.
  - Minimal monitoring of non-nutrient contaminants and direct drainage discharge into the estuary.
- Proposed monitoring / monitoring needs
  - Many proposed programs - continuation of existing
  - Local governments catchment management plans are likely to include monitoring programs.

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Monitoring and Reporting Conclusions



- **Methods and data management**
  - Minimal information on methods, data management and reporting/outputs for many of the existing or proposed monitoring programs.
  - Methods and data management used by local government monitoring programs varied, while catchment/community groups used consistent monitoring methods and data storage. (Waterwatch/ROB or SCCP)
- **Reporting**
  - The majority of monitoring program results are only reported within the organisation conducting the monitoring.
  - Not generally available to public or other potential users

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Monitoring and Reporting Conclusions



Overall Objectives

- State government, local government and community/catchment groups each have specific objectives for their existing and proposed monitoring programs,
- Considerable Overlap

Specific Objectives

- Baseline information on condition and trends,
- Determine the impact of threats,
- Assess the impact of management responses,
- Assess compliance against targets,
- Determine the suitability of use of the rivers for a particular purpose and,
- Raise public awareness.

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Monitoring and Reporting Recommendations



- Develop overall coordinated program
  - recognises considerable overlap in objectives and needs of existing and proposed programs.
- Ensure all monitoring and reporting in the Swan-Canning is consistent and compatible
  - to ensure local information needs are met along with state and national reporting requirements.
- Adopt consistent sampling and analysis methods
  - use consistent data management protocols and,
  - storage of data in a single, publicly available database to enable accessibility and comparison of results between monitoring programs.

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Monitoring and Reporting Recommendations



- **Promote inclusion of communication strategies**
  - in all monitoring programs to maximise the benefit of the water quality information collected.
- **Support the development of partnerships**
  - that will reduce monitoring duplication and,
  - improve monitoring data quality and consistency.
- **Expand SCCP estuary and catchment program**
  - to include non-nutrient contaminants and,
  - ecosystem health indicators.

Through Regional Strategy Development

Department of Environment

Monitoring and Reporting Future Work



- Case studies
  - SCCP Program
  - Cockburn Sound
  - Moreton Bay
- Proposed Approach
  - Collaborative program
- Existing Tools and systems

Monitoring and Reporting Case Study SCCP



- Weekly Estuarine Sampling - SRT vessels, SGA and ASB
  - Swan on Monday, Canning on Tuesday
- Catchment Sampling - SRT staff, ASB support
- Phytoplankton taxonomy and incident response -ASB
- Data management, quality assurance - ASB
- Data analysis - trends, fluxes, loads, targets, impacts
- Reporting - weekly and monthly -Health warnings
- Catchment and Estuary Target Compliance
- Web reporting - weekly CTD and observations
- River Science series
- Technical reports, Annual Report
- Support for related projects (modelling),
- Support to community monitoring efforts
- Event Response

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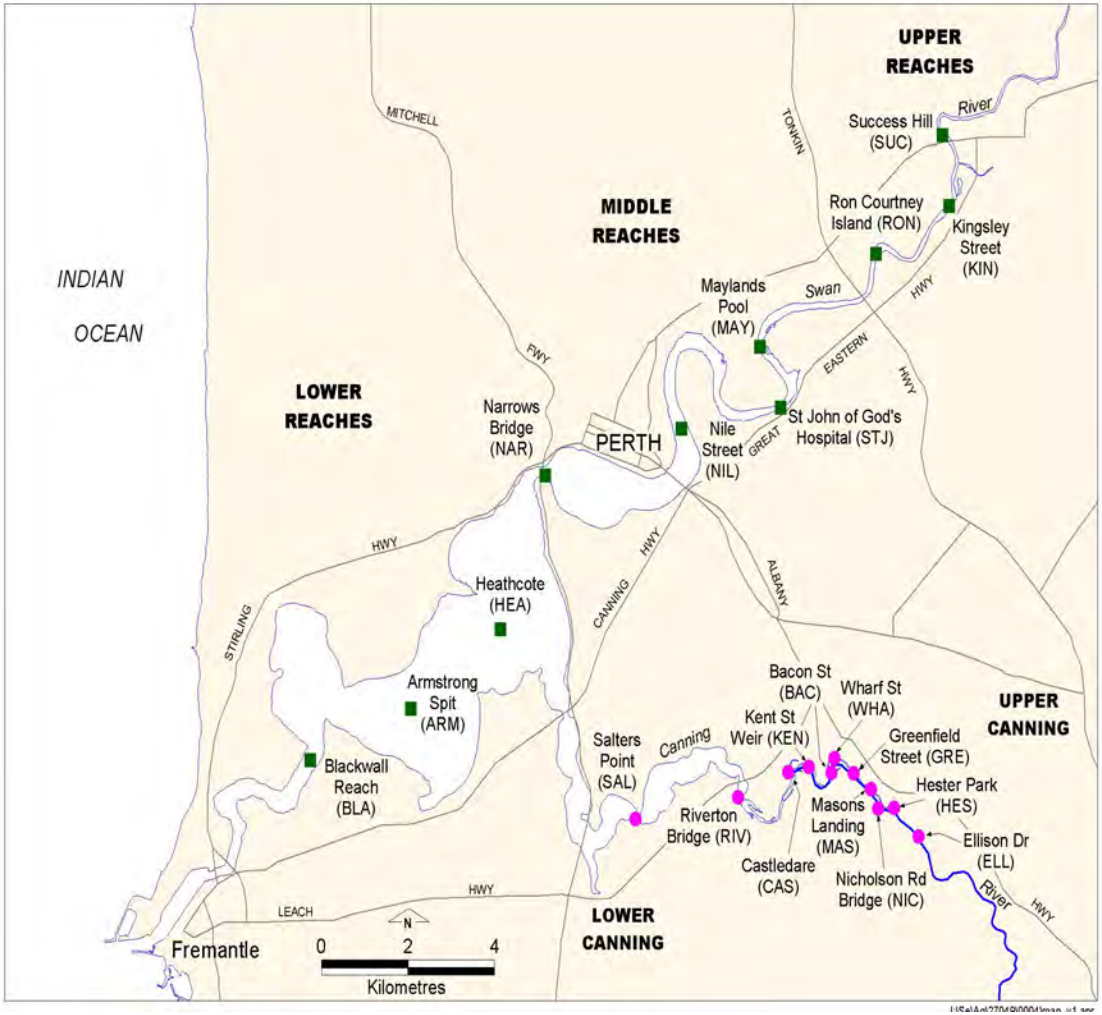
SCCP Monitoring Program Tasks



- Weekly Estuarine Sampling - SRT vessels, SGA and ASB -Swan on Monday, Canning on Tuesday
- Catchment Sampling - SRT staff, ASB support
- Phytoplankton taxonomy and incident response -ASB
- Data management, quality assurance - ASB
- Data analysis - trends, fluxes, loads, targets, impacts
- Reporting - weekly and monthly
- Web reporting - weekly CTD and observations
- River Science series
- Technical reports, Annual Report
- Support for related projects (modelling), community
- Event Response
- Channel 9 Algal Report

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SCCP Case Study Estuary Sampling



Weekly Sites

9 Swan

7 Canning +

4 Canning Bloom

CTD, Nutrients,

Phytoplankton, Fluorescence.

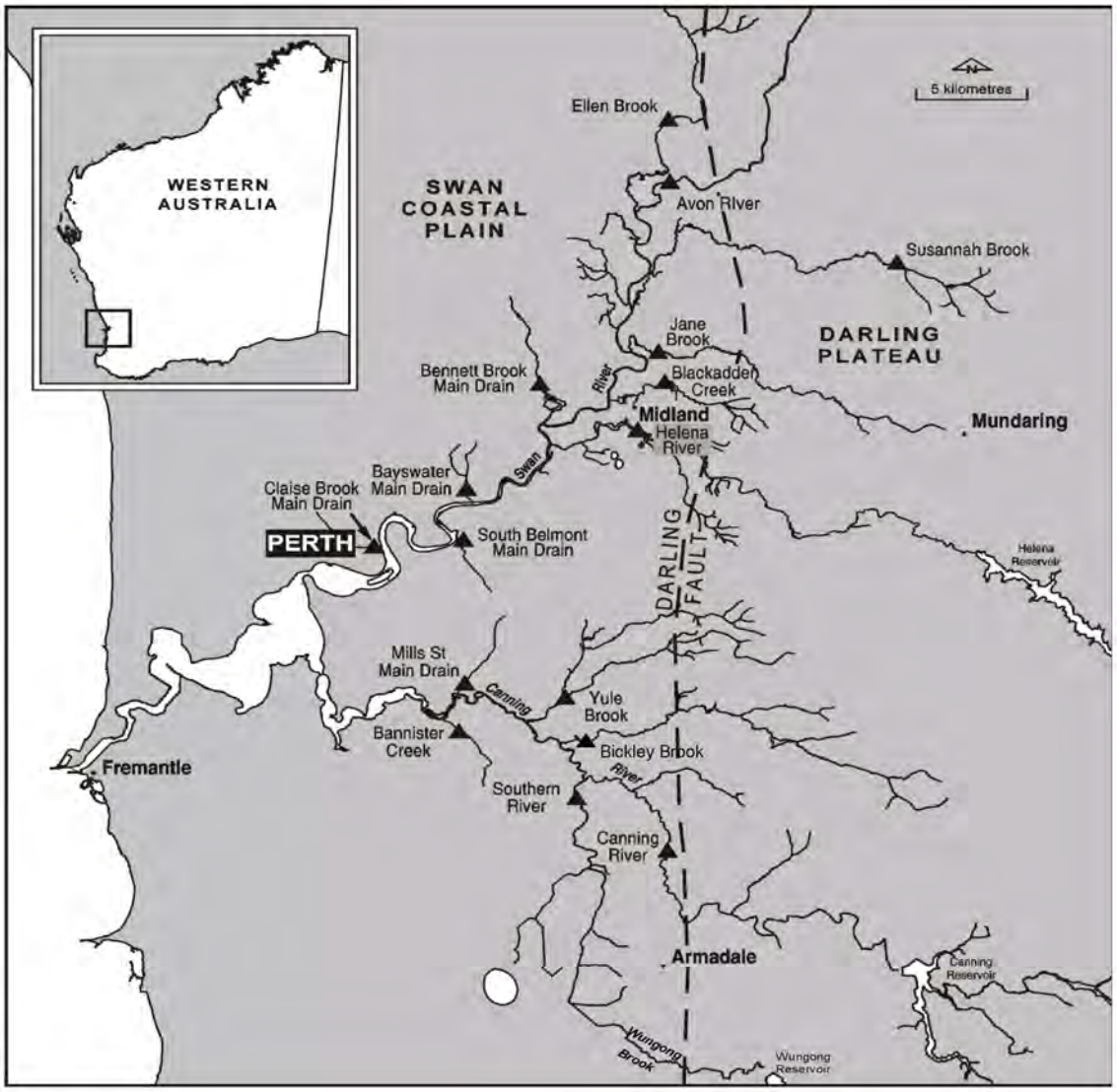
Event sampling

Fremantle Port

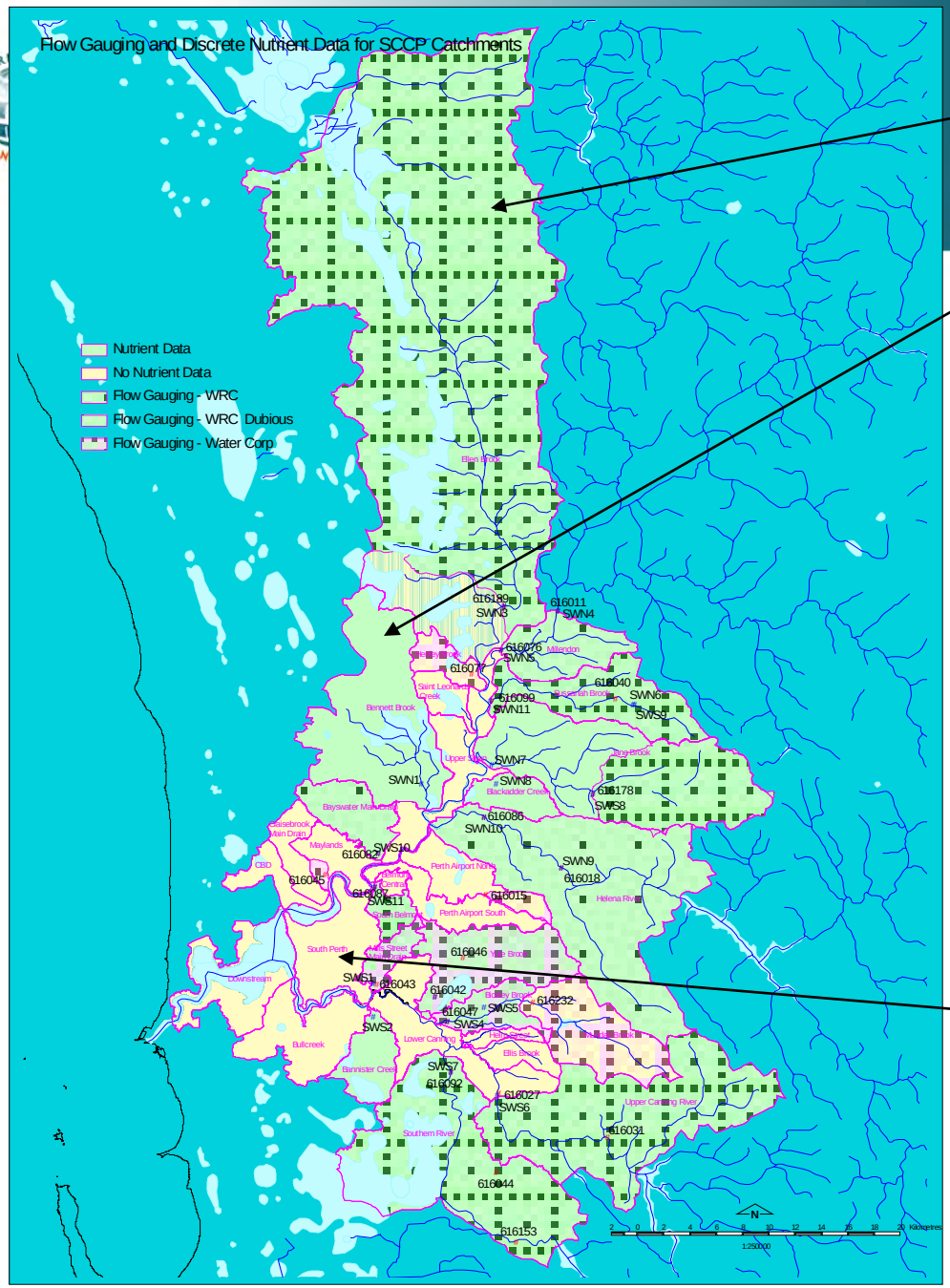
Target compliance

SCCP Case Study
Catchment Sampling

Department of Environment



- **Fortnightly sampling**
- **15 sites, bottom of catchment**
- **Temp, conductivity, nutrients, TSS**
- **SRT staff with ASB training and quality control**
- **SGA and WC run gauging stations and DM's**



Continuous

Discontinuous

6 sites SGA , 3 sites WC - continuous

6 WRC - poor or discontinuous

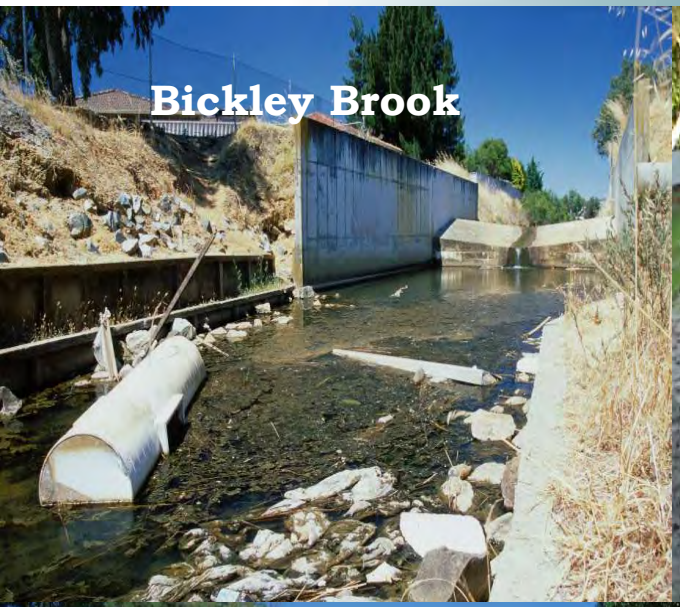
Upgrades, maintenance required

Capital vs operational

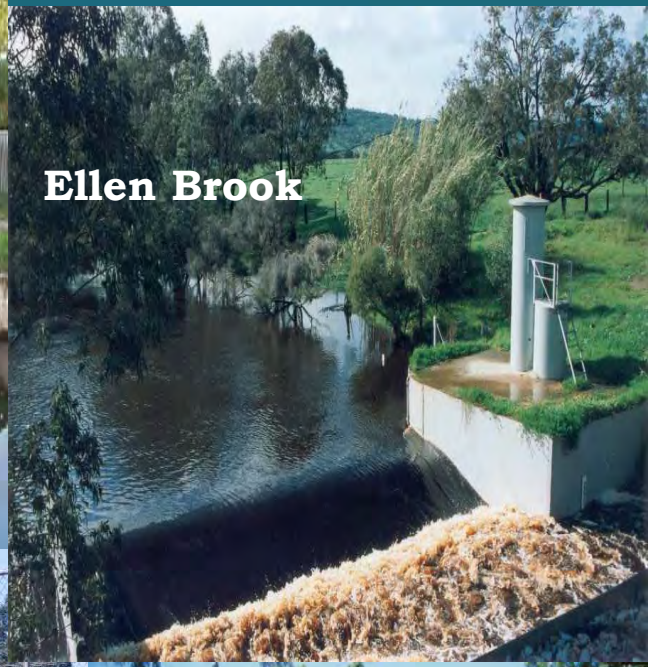
Ungauged

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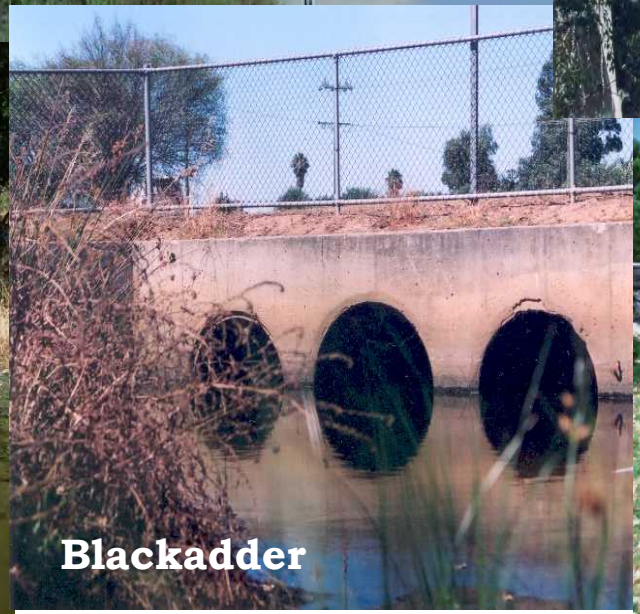
SCCP Case Study Catchment Sampling







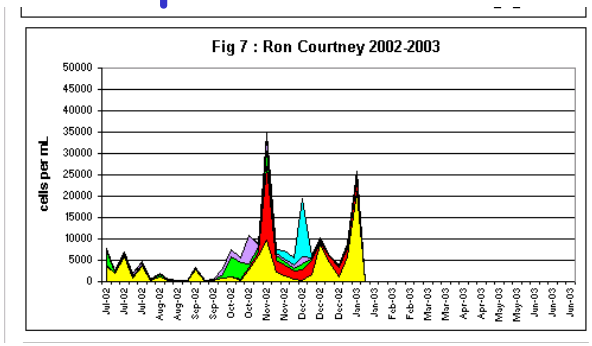






SCCP Case Study
Reporting the data

- SRT Weekly and monthly
  - Algal activity
- Web reporting weekly
  - Event details
  - salinity, DO, Temp profiles
  - nutrients to follow
- Technical reports
  - as required
- Annual Report



PHYTOPLANKTON ECOLOGY UNIT &

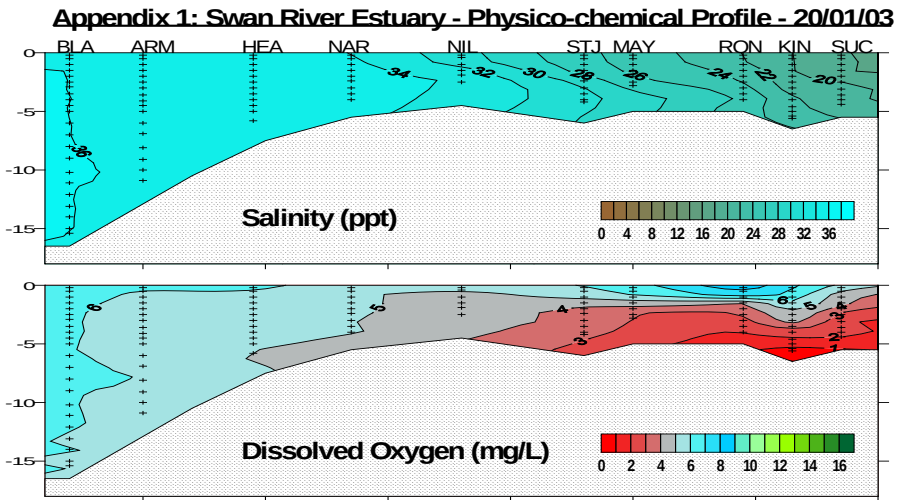
CCP ENVIRONMENTAL MONITORING AND REPORTING

PHYTOPLANKTON AND WATER QUALITY REPORT

Region	Swan-Canning Estuary and Rivers
Date	23rd January 2003
Subject	PHYTOPLANKTON and WATER QUALITY REPORT 18th November 2002– 20th January 2003

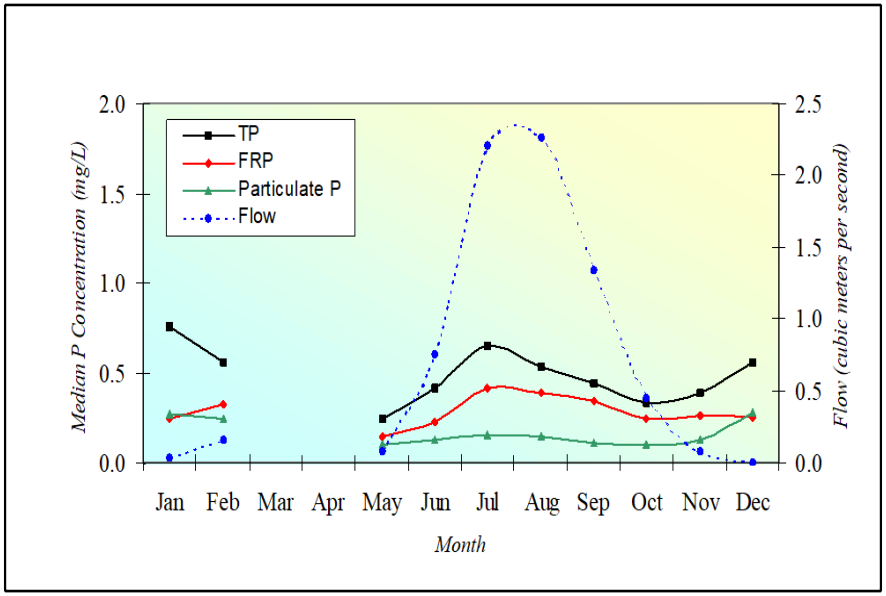
1. SUMMARY

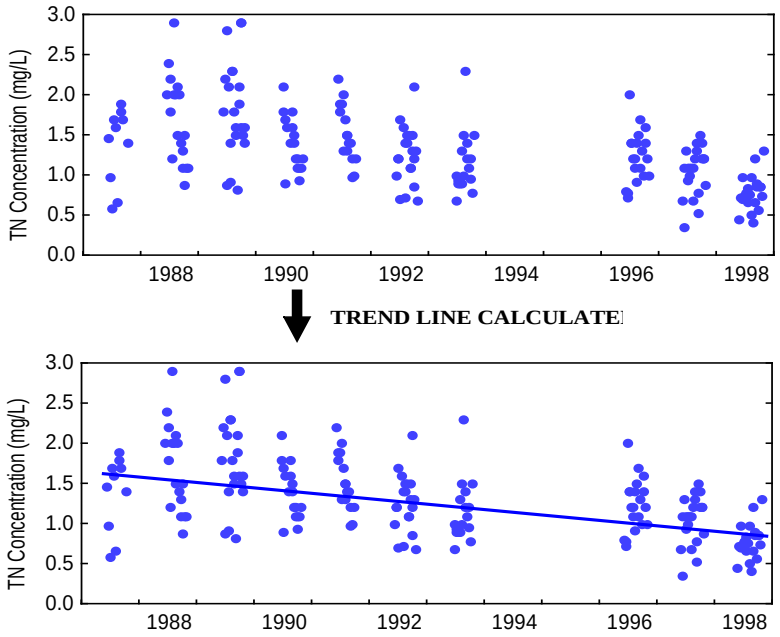
WARNINGS: A toxic cyanobacterial bloom (*Anabaena circinalis* / *Anabaena* spp) was evident in the upstream Canning River on 7th January and 14th January 2003. Preliminary bioassay results indicate the bloom is toxic (Dr. J. Allen, AgWA). Warning signs have been installed and media releases have been issued since 9th of January 2003. The lower Canning reaches have also had high levels of potentially fish-killing raphidophyte *Heterosigma*. However no fish kills have been reported. Previously blooms of this species have occurred without any reported wild-fish deaths.

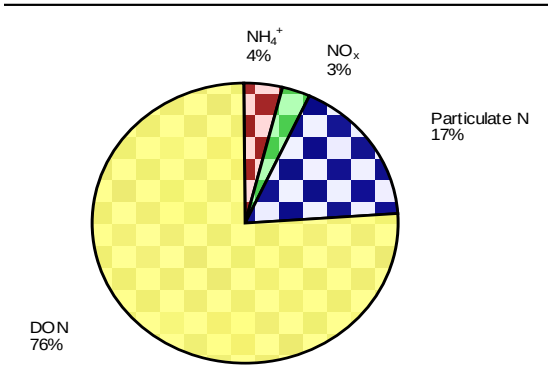


SCCP Case Study
Data Analysis and Interpretation

- Nutrient pathways
- Catchment trends
- Catchment loads
- Catchment and Estuarine Targets
- Fluxes







Department of Environment

SCCP Case Study
River Science



Sources of nutrients to the Swan and Canning rivers

The role of nutrients in our waterways

Nutrients from these sources can either be delivered directly to waterways via point sources or indirectly (and more slowly) via diffuse sources.

CONTENTS

The role of nutrients in





Kent Street Weir on the Canning River

CONTENTS

Tidal dynamics of the Canning River 2
Water quality is monitored weekly 3
Nitrogen and phospho-rus are the nutrients of most concern 3
Nutrients in the Canning come from diverse sources 3
Pathways... what happens to the nutrients once they enter the estuary? 4
The role of sediments 4
Phytoplankton and macrophytes in the Canning 5
Seasonal nutrient patterns in the Canning 5
Summary of nutrient dynamics in the Canning 9
Symbol glossary 11
Addressing nutrient problems in the Canning 11
Conclusion 11
Glossary 12
Acknowledgments 12
For more information 12

Seasonal Nutrient Dynamics in the Canning River and Estuary, 1995–98

The Canning River joins with the lower reaches of the Swan River at Melville Water to form the Swan-Canning estuary. The Canning is relatively shallow, ranging from 1 to 6 metres deep. It drains a heavily populated subcatchment that incorporates diverse residential, commercial, industrial and agricultural land uses. Upstream pumping by local water users, releases from upstream dams and the downstream Kent Street Weir regulate river flow. There is considerable seasonal variability in flow, with high flows during the winter months and almost negligible flow in summer.

The Kent Street Weir was built and rebuilt several times during the early 20th century to maintain freshwater conditions for irrigation and domestic water supply. Weir boards are put in place in September or October corresponding to reduced river flow. They are then removed with the onset of the first winter rains, usually in April or May. When the weir boards are in place, the freshwater section upstream of the weir is impounded in a pool with minimal flow and low levels of oxygen.



Water Quality Monitoring is a vital part of the SCCP Action Plan





Aerial view over Kings Park looking towards The Narrows and Perth Water with the Darling Range in the background

CONTENTS

Water quality in the Swan is monitored regularly 2
Nitrogen and phosphorus are the nutrients of primary interest 2
The Swan estuary is eutrophic 2
Water quality varies across the estuary and through time 3
Winter nutrient dynamics 4
Spring nutrient dynamics 6
Summer nutrient dynamics 8
Autumn nutrient dynamics 10
Symbol glossary 11
Conclusion 11
Glossary 12
Acknowledgments 12
For more information 12

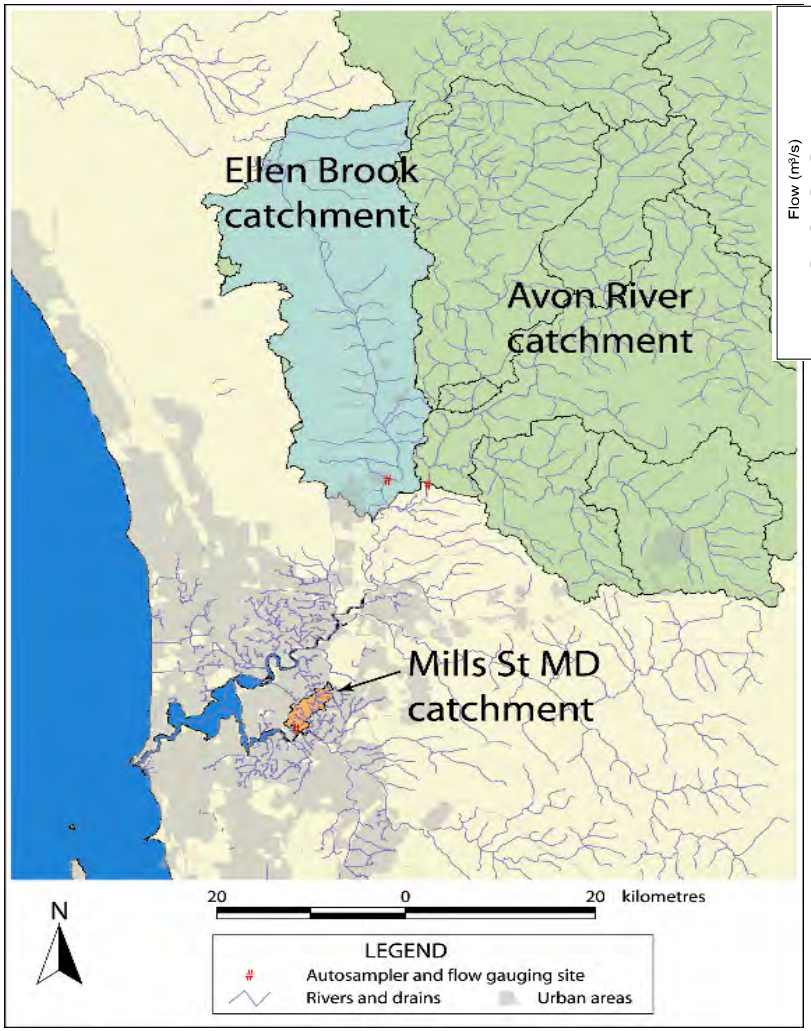
Seasonal Nutrient Dynamics in the Swan Estuary, 1995–2000

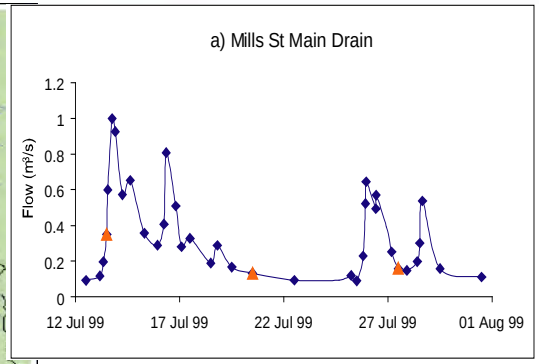
The estuary is a dynamic environment

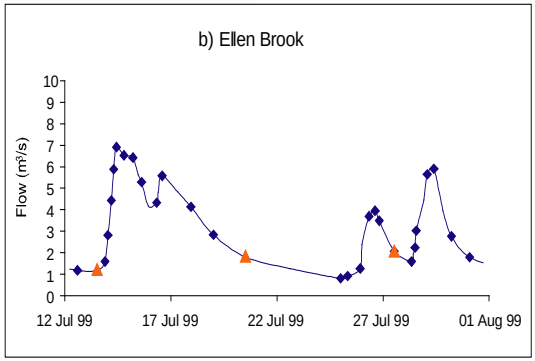
The Perth region has a Mediterranean climate. Most rain falls in winter – some 60% of the annual average falling between June and August – while summers

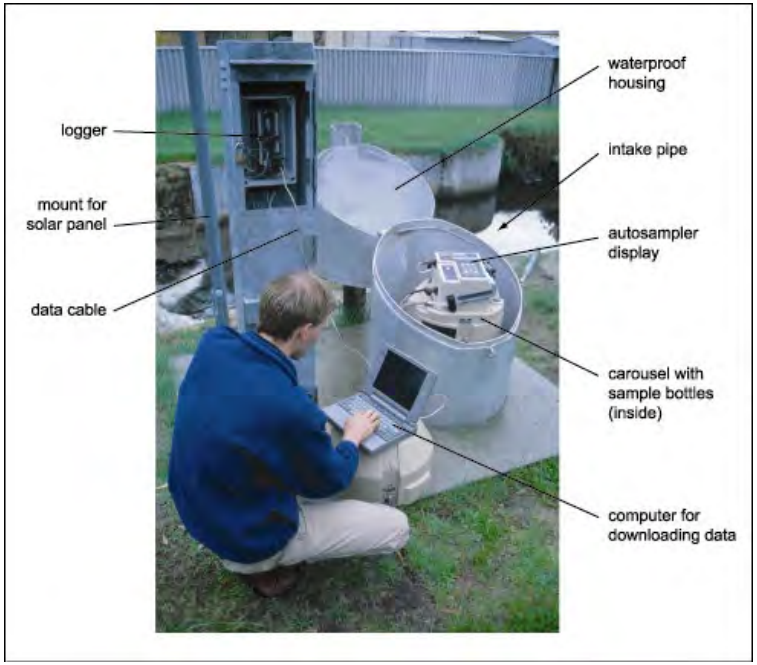
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SCCP Case Study
Nutrient Loads



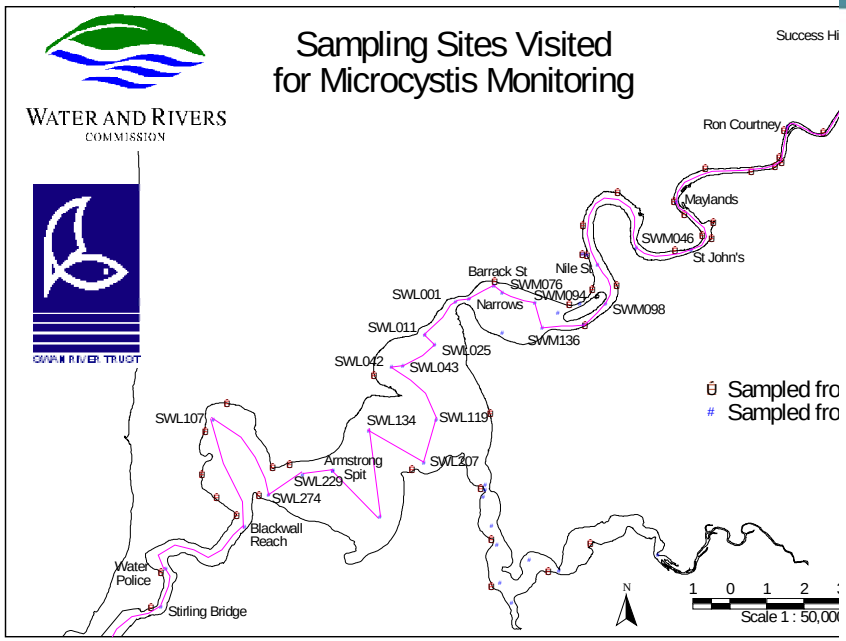




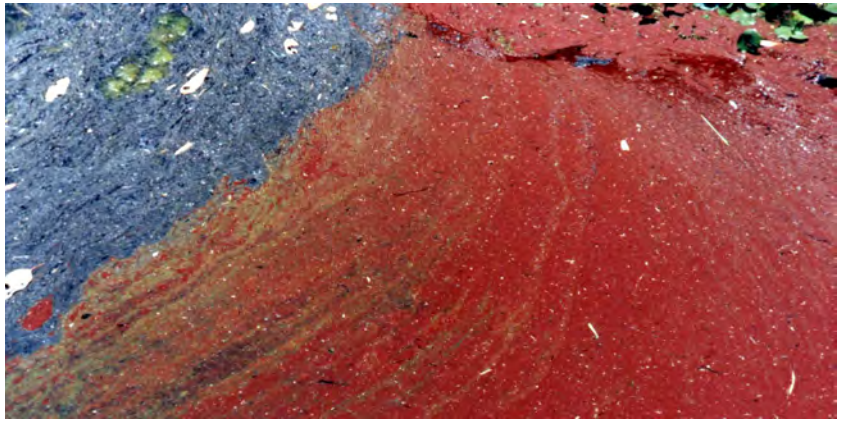


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SCCP Case Study
Bloom Response



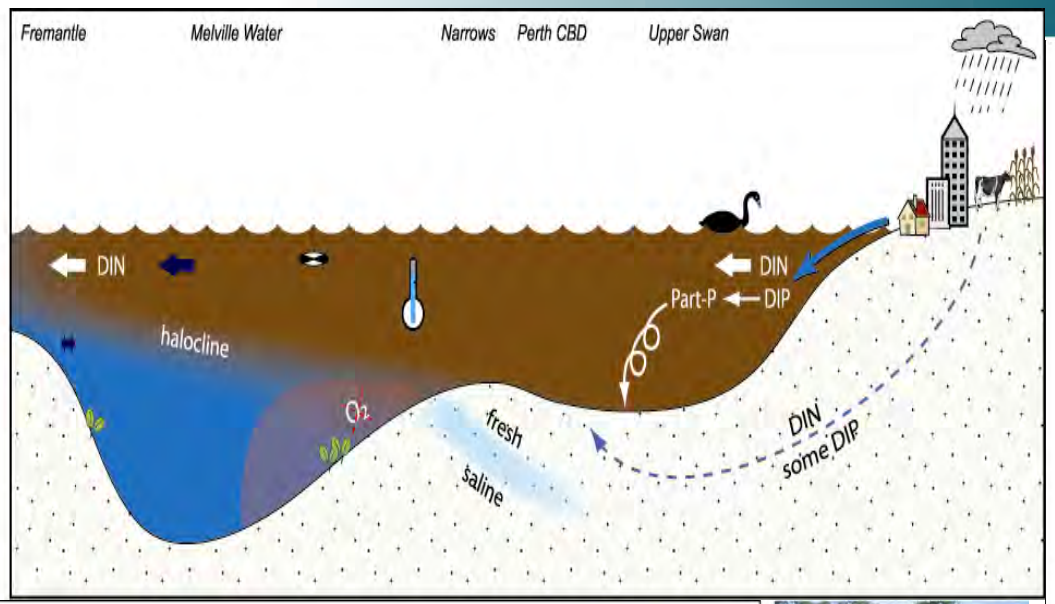


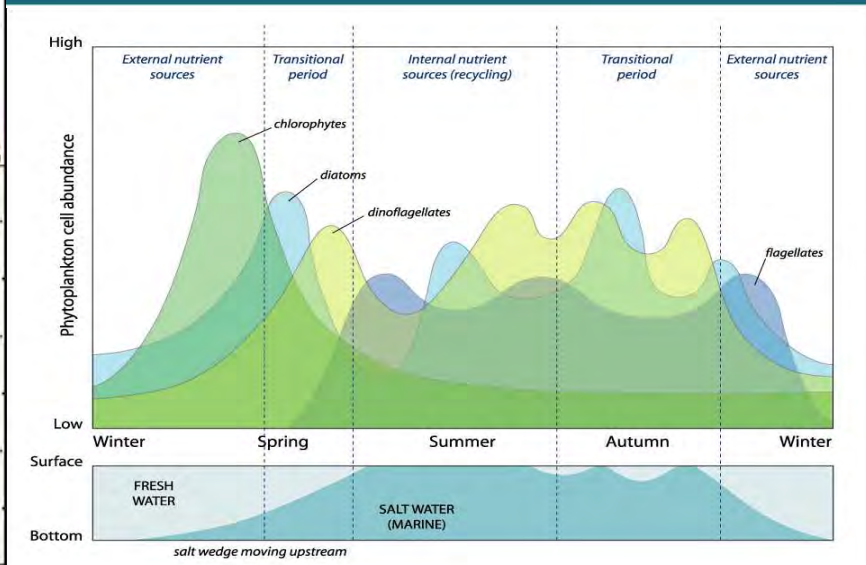


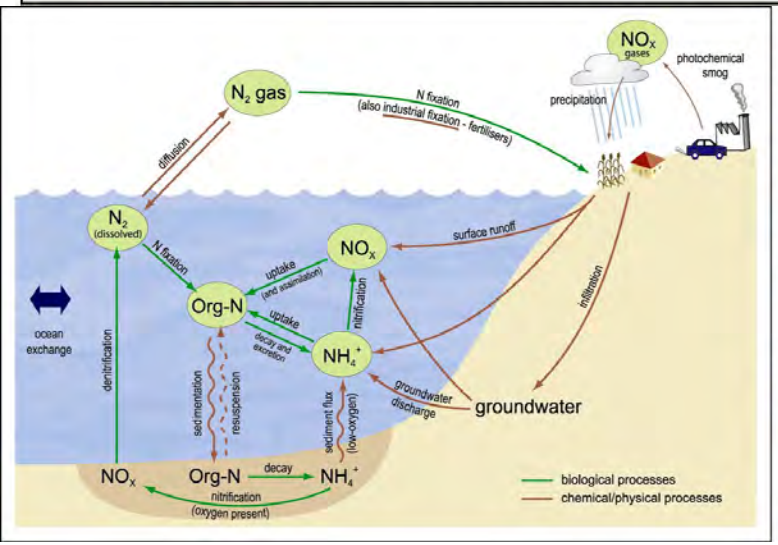


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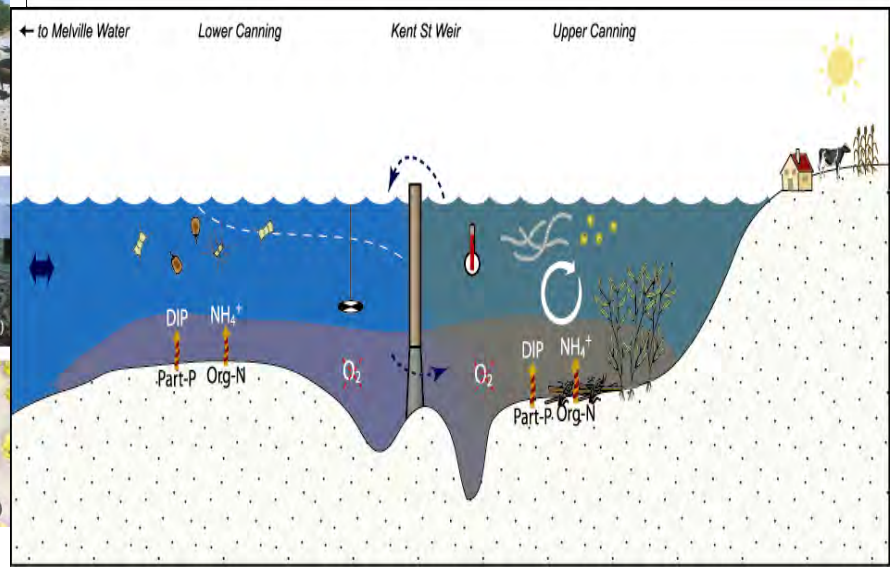
SCCP Case Study
Process Understanding











Department of Environment

Case Study
Cockburn Sound Management Council

- CSMC coordinates Environmental Quality Monitoring Program in Cockburn Sound based on EPP requirements
- Monitoring Program comprises industry groups, local, state and federal government
- Combination of physical, chemical and biological indicators, range of temporal and spatial intensities
- Standard Operating Procedures to ensure consistent consistent sampling and analysis
- Results Stored in a single, publicly accessible database managed by Department of Environment

Cockburn Sound monitoring groups

DEFENCE

FREMANTLE PORTS

Department of Health

AUSTRALIAN MARINE COMPLEX COCKBURN SOUND

Department of Environment

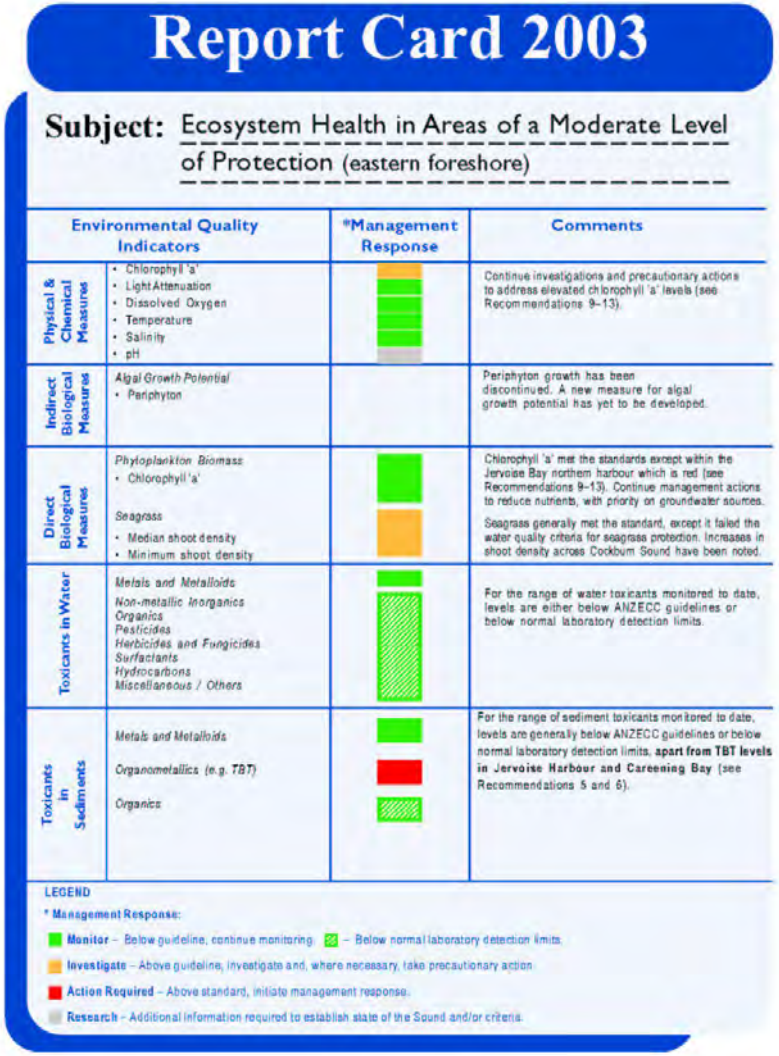
KWINANA INDUSTRIES COUNCIL

Fish for the future

Department of Environment

Cockburn Sound Monitoring Program

- Monitoring Program results used by CSMC to provide information on the health of Cockburn Sound marine environment to stakeholders and the community
- An annual Report Card for each environmental value is presented at a community forum
- Report Cards are derived through assessing compliance of monitoring data with criteria
- Criteria are benchmarks for measuring success of management actions in achieving environmental objectives



Report Card 2003

Subject: Ecosystem Health in Areas of a Moderate Level of Protection (eastern foreshore)

	Environmental Quality Indicators	*Management Response	Comments
Physical & Chemical Measures	• Chlorophyll 'a' • Light Attenuation • Dissolved Oxygen • Temperature • Salinity • pH		Continue investigations and precautionary actions to address elevated chlorophyll 'a' levels (see Recommendations 9–13).
Indirect Biological Measures	*Algal Growth Potential* • Periphyton		Periphyton growth has been discontinued. A new measure for algal growth potential has yet to be developed.
Direct Biological Measures	*Phytoplankton Biomass* • Chlorophyll 'a' *Seagrass* • Median shoot density • Minimum shoot density		Chlorophyll 'a' met the standards except within the Jervoise Bay northern harbour which is red (see Recommendations 9–13). Continue management actions to reduce nutrients, with priority on groundwater sources. Seagrass generally met the standard, except it failed the water quality criteria for seagrass protection. Increases in shoot density across Cockburn Sound have been noted.
Toxicants in Water	*Metals and Metalloids* *Non-metallic Inorganics* *Organics* *Pesticides* *Herbicides and Fungicides* *Surfactants* *Hydrocarbons* *Miscellaneous / Others*		For the range of water toxicants monitored to date, levels are either below ANZECC guidelines or below normal laboratory detection limits.
Toxicants in Sediments	*Metals and Metalloids* *Organometallics (e.g. TBT)* *Organics*		For the range of sediment toxicants monitored to date, levels are generally below ANZECC guidelines or below normal laboratory detection limits, **apart from TBT levels in Jervoise Harbour and Careening Bay** (see Recommendations 5 and 6).

LEGEND

* Management Response:

Monitor – Below guideline, continue monitoring. ▨ – Below normal laboratory detection limits.

Investigate – Above guideline, investigate and, where necessary, take precautionary action.

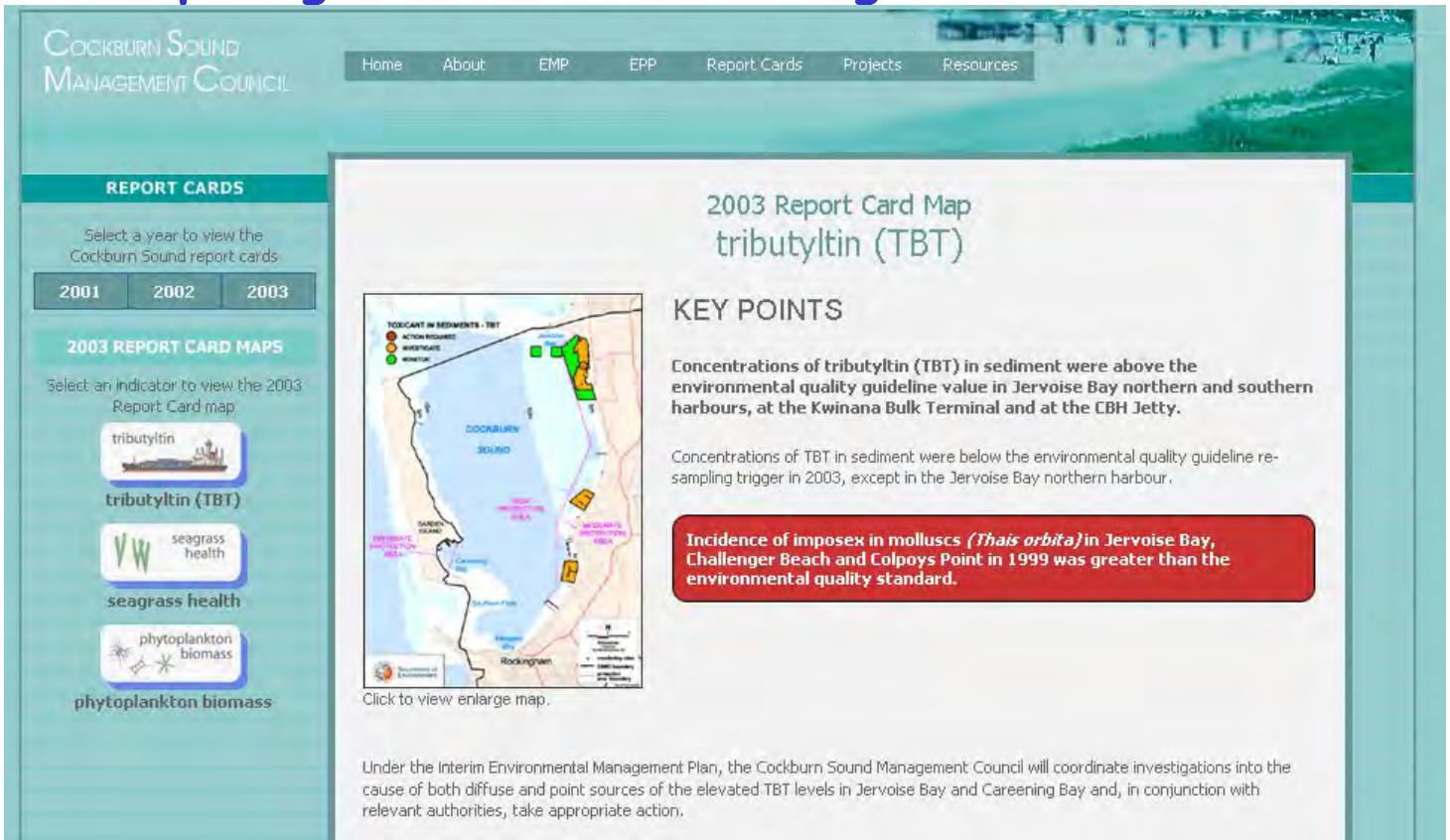
Action Required – Above standard, initiate management response.

Research – Additional information required to establish state of the Sound and/or criteria.

Department of Environment

Cockburn Sound Web Reporting System

- Web Reporting System comprising Report Card Maps has recently been developed to build on existing report cards
- Report Card Maps identify specific locations of concern and areas requiring additional monitoring effort



Case Study - Moreton Bay Healthy Waterways Campaign

- Strategy developed that comprises a comprehensive and integrated program for protection and restoration of ecological health of South East Queensland's waterways
- Federal, state and local government, community and industry commitment to implementation of the Strategy and 'Healthy Waterways' vision

STRATEGY



MONITORING

RESEARCH

Healthy Waterways Framework

Department of

Social Harmony

Cultural Heritage

Public Involvement

Process Studies

Nutrient Cycling:Role of Benthic Microalgae in Estuaries

Nutrient & Sediment Processes: Rivers

Riverine Turbidity

Sediment & Nutrient Sourcing

Bremer River Processes

Stormwater Studies

On-the-ground works

Evaluation

Riparian Rehabilitation

Planning

On-the-ground works

Evaluation of DownstreamEffects

Bay/Estuaries

Freshwater/Catchments

Management Support Tools & Integration

AEAM Process (Decision Support)

Catchment Modelling

Bay & Estuaries Modelling

Data Management

WATER QUALITY STRATEGY

Evaluation of State of Waterways

Ballast Water

Ship Source Pollution

Lyngbya

Vessel Wash

Loads& Impacts: Maroochy/ Mooloolah

Logan-Nerang Studies

Ecosystem Health Monitoring Program: Bay & Estuaries

Design & Implementation of Evaluation Program: Freshwater & Catchments

Environmental Planning

EHMP: 8 councils, industry, EPA, UQ, CSIRO, QH

NHT/Councils

SPIRT ARC

CCS, DNR

PoBC, EPA

QDoT

EPA
NB: gaps

Coastal CRC

Department of Environment

Ecosystem health MONITORING PROGRAM

- Coordinated, integrated and cost-effective aquatic ecosystem health monitoring program developed as part of Moreton Bay Strategy
- Monitoring program conducted by a team of multi-disciplinary scientists from state government, universities and CSIRO
- Monitoring program independently audits the effectiveness of community, council, state government and industry investments in improved waterways management to restore and protect South East Queensland waterways

Queensland Government Environmental Protection Agency

Marine Botany The University Of Queensland

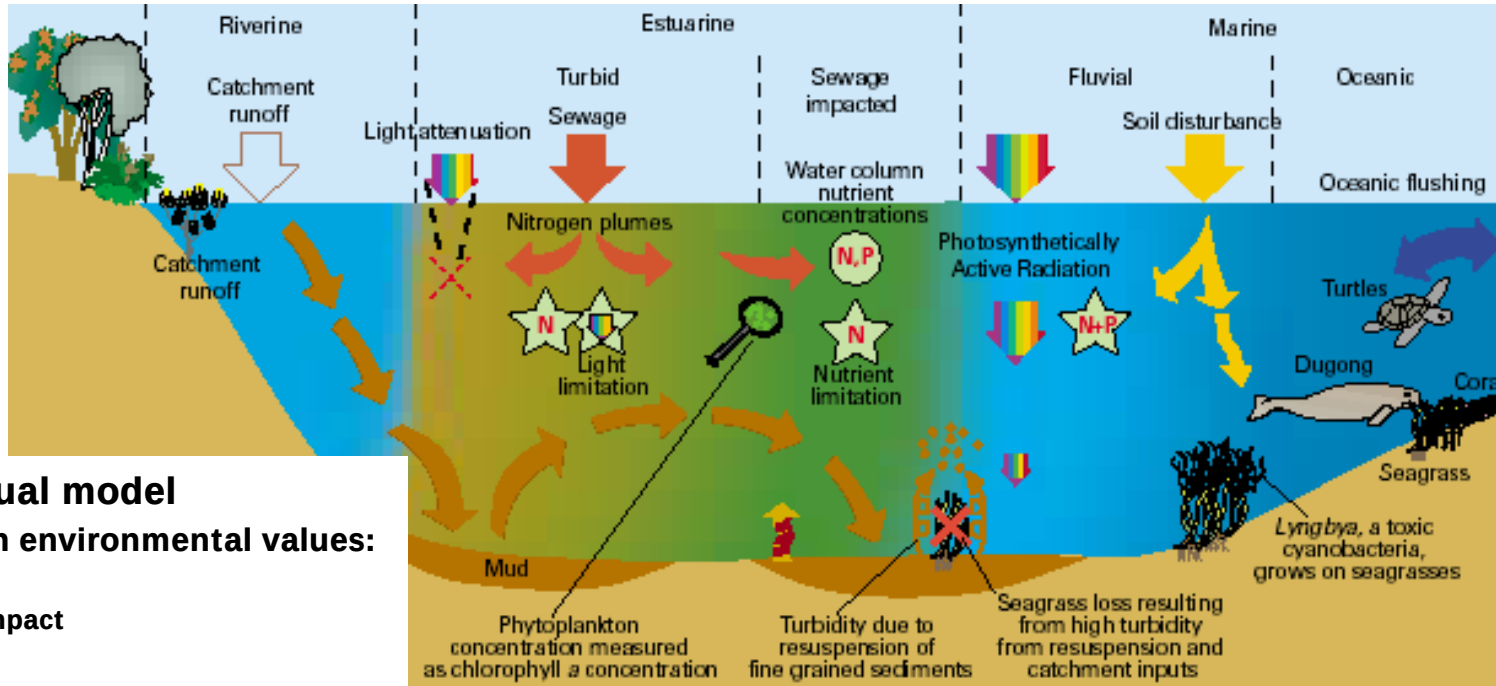
CSIRO

Queensland Government Queensland Health

CRC for Coastal Zone Estuary & Waterway Management

Ecosystem Health Monitoring Program

- Based on a conceptual model that integrates current scientific understanding of the waterways with community derived values
- Funding based on local government population and industry nitrogen loads
- Strong focus on communication of clear and informative accounts of monitoring activities, results and community benefits



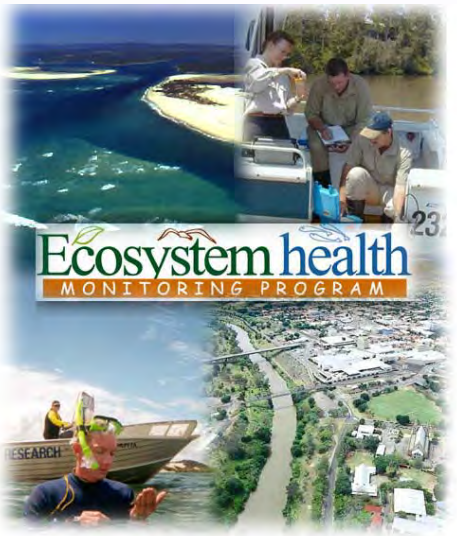
Moreton Bay conceptual model

Indicators based on environmental values:

- **Key processes**
- **Zones of human impact**
- **Critical habitats**

Ecosystem Health Monitoring Program

- **Communication strategy includes:**
  - regular newsletters
  - technical reports
  - a comprehensive website, and
  - annual report cards





River Estuary Report Card 2001

Moreton Bay Report Card 2001

Ecosystem health
MONITORING PROGRAM

Noosa River A-
- extensive seagrass and mangroves
- ecological processes intact
- overall low nutrients

Maroochy River C
- remnant seagrass beds
- elevated nutrients and phytoplankton
- sewage nitrogen in food web

Mooloolah River B-
- evidence of metal pollution
- riparian habitat loss/stream modification
- generally good water quality

Pumicestone Passage B?
- no ecosystem health monitoring
- extensive seagrass and mangroves
- black water runoff



Caboolture River C
- low sediment and nutrient impact on Deception Bay
- high level of nutrient processing by abundant phytoplankton
- persistent algal blooms in upper reaches
- seagrass loss from river mouth



Pine Rivers D+
- reduced sewage inputs
- large turbidity, nutrient and phytoplankton flood plume
- some biological processing of nutrients
- high phytoplankton biomass
- stormwater inputs from increased urbanisation



Brisbane River D-
- massive increase in turbidity during flood
- highest sediment and nutrient loads in region
- low phytoplankton biomass
- highly impacted riparian vegetation
- limited biological processing of nutrients
- large sewage and stormwater inputs
- highly urbanised catchment
- impacted by unhealthy tributaries



Bremer River F
- extremely high nutrients and turbidity
- unknown source of nitrogen
- high phytoplankton biomass
- heterotrophic
- highly degraded riparian vegetation



Logan River D-
- flood flow caused large plume of nutrients, sediments and phyoplankton into southern bay
- high nutrient inputs from aquaculture and sewage treatment plants
- limited biological processing of nutrients
- sewage plume into bay
- no seagrass recovery at river mouth

Albert River D?

Nerang River B?

Coomera River B?

Tweed River B-
- some seagrass
- no mangroves
- impacted riparian habitat
- strong seasonal impacts
- localised sewage impacts
- consistently elevated phytoplankton
- well flushed river mouth



Nth Deception Bay D-
- summer Lyngbya blooms cover important seagrass meadows and impact mangroves
- nuisance macroalgae (Caulerpa taxifolia) present
- minimal impact from flood



Sth Deception Bay D
- elevated turbidity, nutrients and phytoplankton
- impacted by flood runoff
- no seagrass recovery
- seagrass loss from Caboolture River mouth



Bramble Bay F
- flood causes nutrient plume
- flood causes phytoplankton bloom
- high nutrients from Cabbage Tree Creek
- no seagrass recovery
- major sewage treatment plant upgrades not yet evident



Eastern Banks C
- *Lyngbya* blooms covering important seagrasses
- high dugong mortality
- turtles have tumours and not fertile
- nuisance algae (*Caulerpa taxifolia*) present
- minimal impact from flood
- excellent water quality



Eastern Bay A
- excellent water quality
- extensive seagrass supporting dugongs
- corals at Peel Island and Myora
- nuisance algae (*Caulerpa taxifolia*) present
- tumours on turtles
- slightly elevated phytoplankton from flood



Central Bay B
- elevated phytoplankton, turbidity and nutrients from flood
- generally good water quality
- seagrass and corals present



Waterloo Bay B-
- some *Lyngbya* present
- minimal impact from flood
- stable seagrass beds
- some sewage inputs from Tingalpa Creek
- dugongs/turtles/corals present
- relatively clear water



Southern Bay C-
- west to east gradient in water quality
- generally poor water quality
- large sewage plume from Logan River
- large ammonium plume from flood
- highly variable water quality
- some seagrass loss

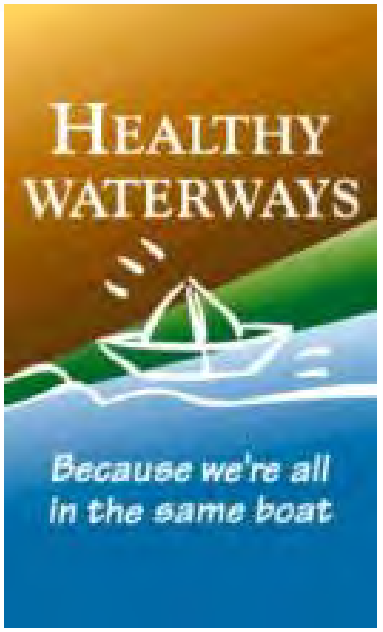


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Ecosystem Health Monitoring Program

Key aspects of Moreton Bay approach:

- Multi-agency monitoring program
- Monitoring tools directly related to environmental objectives and management activities
- Built in flexibility to respond to new environmental issues
- Extensive interactions between scientists, councils, industry and community
- Highly accessible information in simple but scientifically accurate format
- Funded through a public environmental levy
- Industry levy based on N load contribution



Monitoring and Reporting Swan Proposed approach

Department of Environment



Reporting

IHT2/NAP (Swan Region NRM Strategy

State of Environment

River Plan (Swan-Canning EPP)

Information needs

- Compliance
- Management effectiveness
- Trends
- Status
- Health
- Hotspots
- Public safety
- Land use impacts
- Community education

Operating procedures

- Standard field sampling protocols
- Consistent sample analysis methods
- Coordinated data management
- Relevant data analysis
- Rapid and appropriate communication of results

Indicative monitoring programs

- Estuarine and catchment ecosystem health
- Estuarine water quality (SCCP)
- Priority catchment nutrient output (SCCP)
- Catchment 'hotspots' nutrients & contaminants
- Main drain catchment nutrients & contaminants
- Road run-off nutrients & contaminants
- Management action implementation
- Education & awareness
- Lakes & wetlands nutrients, contaminants & health

Swan River Trust | Water Corporation | Main Roads | Local governments | Swan Catchment Centre

Department of Environment

Monitoring and Reporting

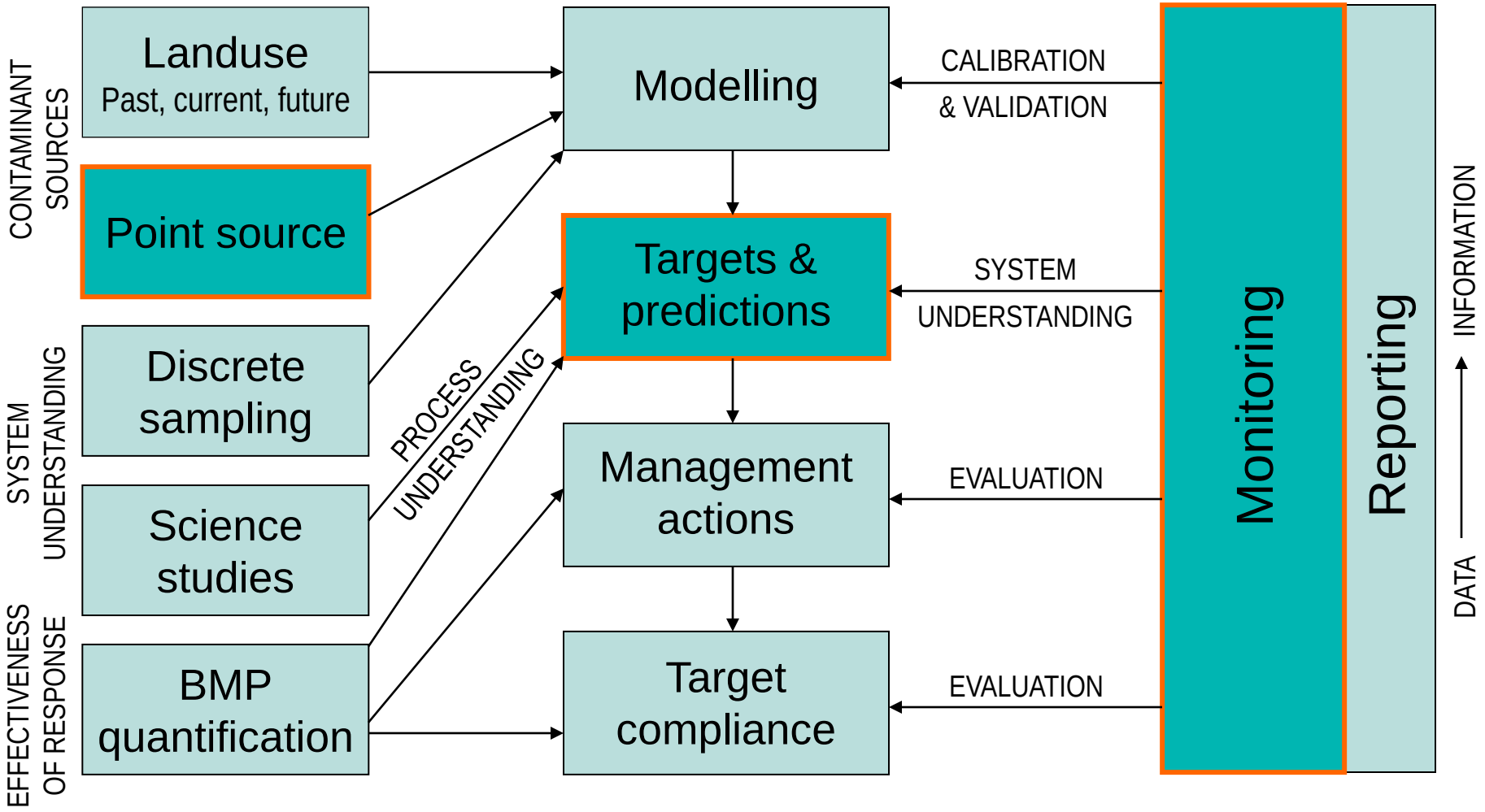
Existing Tools and systems



- Water Information Database (WIN)
  - generalised data model
  - established business rules, protocols, QA
  - publicly available
  - skilled staff
  - links to Waterwatch
- Guideline to community groups (NHT/WRC)
  - tested in Swan
  - requires update and roll out
- SCCP Program
  - already shares infrastructure
  - partnership with community programs
- Swan Catchment Centre
  - catchment coordinators etc

Department of Environment

Land Use Targets Monitoring



Department of Environment

Thank You
Questions?



Institutional Arrangements for Management of Water Quality in the Swan-Canning Catchment

George Bouma and David Annandale
Murdoch Environment

Purposes of the Study

- Identify existing processes and responsibilities for the planning, design, construction and management of drainage systems.
- Develop a management model, or models, to achieve improved water quality.
- Identify steps required to implement the new model(s).

Approach to the Study

- Stakeholder consultation
  - determined the criteria used to compare alternative governance models
- Review of existing work
- Multi-criteria analysis to compare alternative management models:
  - development of alternatives
  - development of criteria
  - “scoring” the alternatives
  - ranking the alternative models

What Does Existing Work Say About Alternative Governance Models?

- 10 studies over the last 4 years
- Single-agency, dual-agency, or multi-agency models
- 15 different models identified

The Alternative Governance Models

- See handout

The Comparison Criteria

- See handout

The Evaluation

- All 15 alternatives were scored on a 5-point ordinal scale
- Ranking of alternatives when equal criteria weights are applied

Option	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Rank	8	5	3	4	6	1	2	8	11	11	11	11	10	11	6

The Evaluation (cont.)

Change weights to the following:

- COAG requirement (10)
- Ability to reduce complexity (10)
- Community ownership (8)
- Synchronize land and water resources planning (8)
- Whole of catchment jurisdiction, and at local level (8)

Option	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Rank	8	5	3	4	5	1	2	10	11	11	11	11	9	11	5

The Best Options

F: Policy and Approval Authority and Catchment Manager

G: DoE as the planner/policy-maker, plus Catchment Manager

C: New catchment-wide body

Implementation Steps

- Option C fails because of the COAG criterion
- Other two options can be compared according to their ability to be implemented in the current political environment, and against three governance hierarchy levels
  - policy-making and approval at the state level
  - catchment management
  - service provision

Policy-making and Approval at the State Level

Option F:

- PAA is EPA, Board of WRC, Envt. And Natural Resources Management Committee of WAPC, or new Authority.

Option C would not allow for regional, industry, and community representation that is implicit in the Policy and Approval Authority concept

Catchment Management

- Most appropriate arrangement would be a combination of Swan River Trust and Swan Catchment Council.
- Board to be widened and possibly elected.
- Water Corporation would not work as Catchment Manager, as remit is statewide and it has a responsibility as a drainage service provider.

Service Provision

Service provision to be controlled by the Catchment Manager, and to be undertaken on a competitive outsourcing basis.

Recommendation

- See handout

Resourcing Drainage Improvements

Presenter: Phil Pickering

Solutions

- On property
  - Costless non-structural

    (eg timing of fertiliser application)
  - Behaviour modification

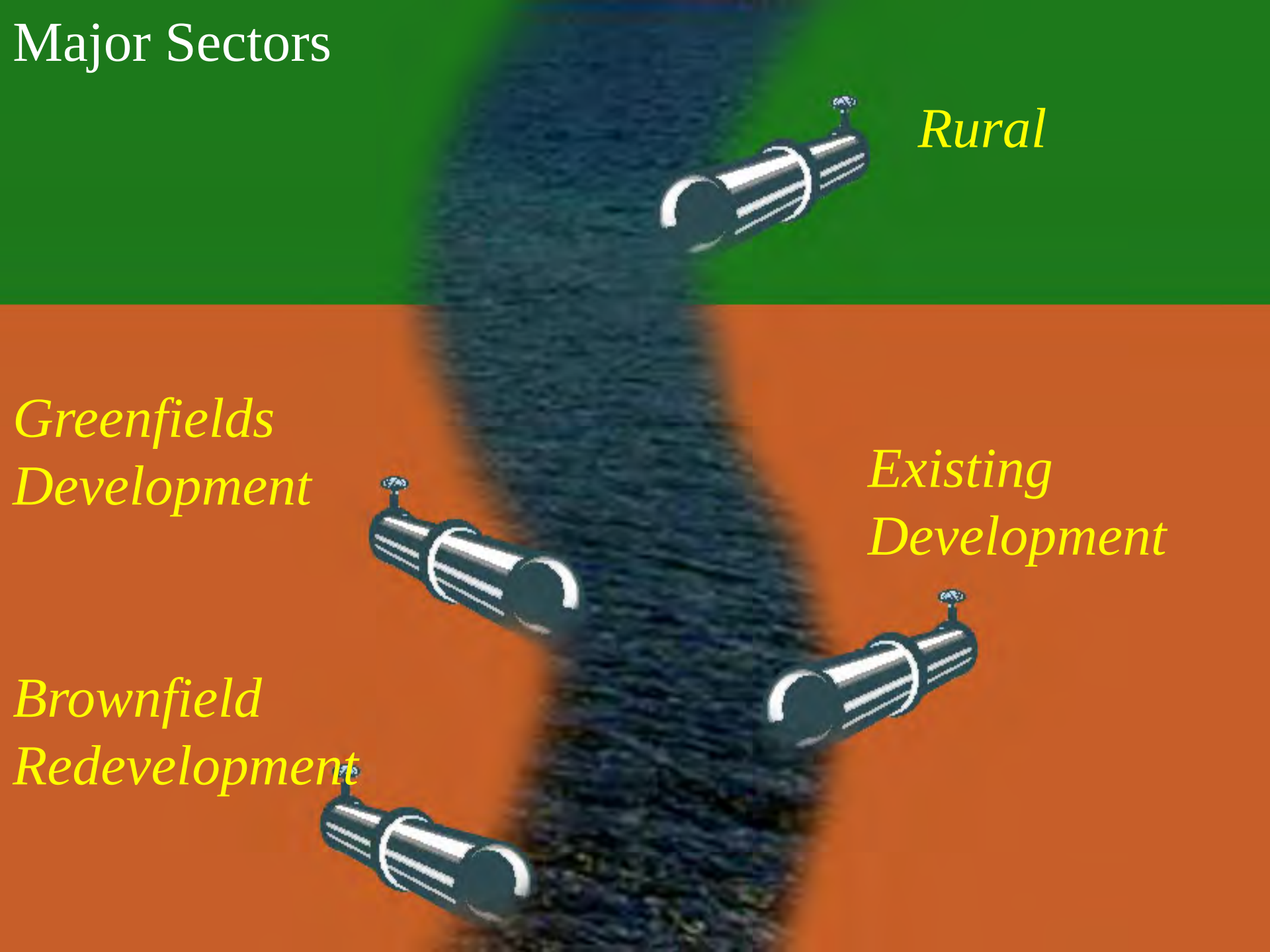
    (eg change in fertiliser product)
  - Property modification *(eg soil type amendment)*

- Off property
  - Community Infrastructure *(eg constructed wetlands)*

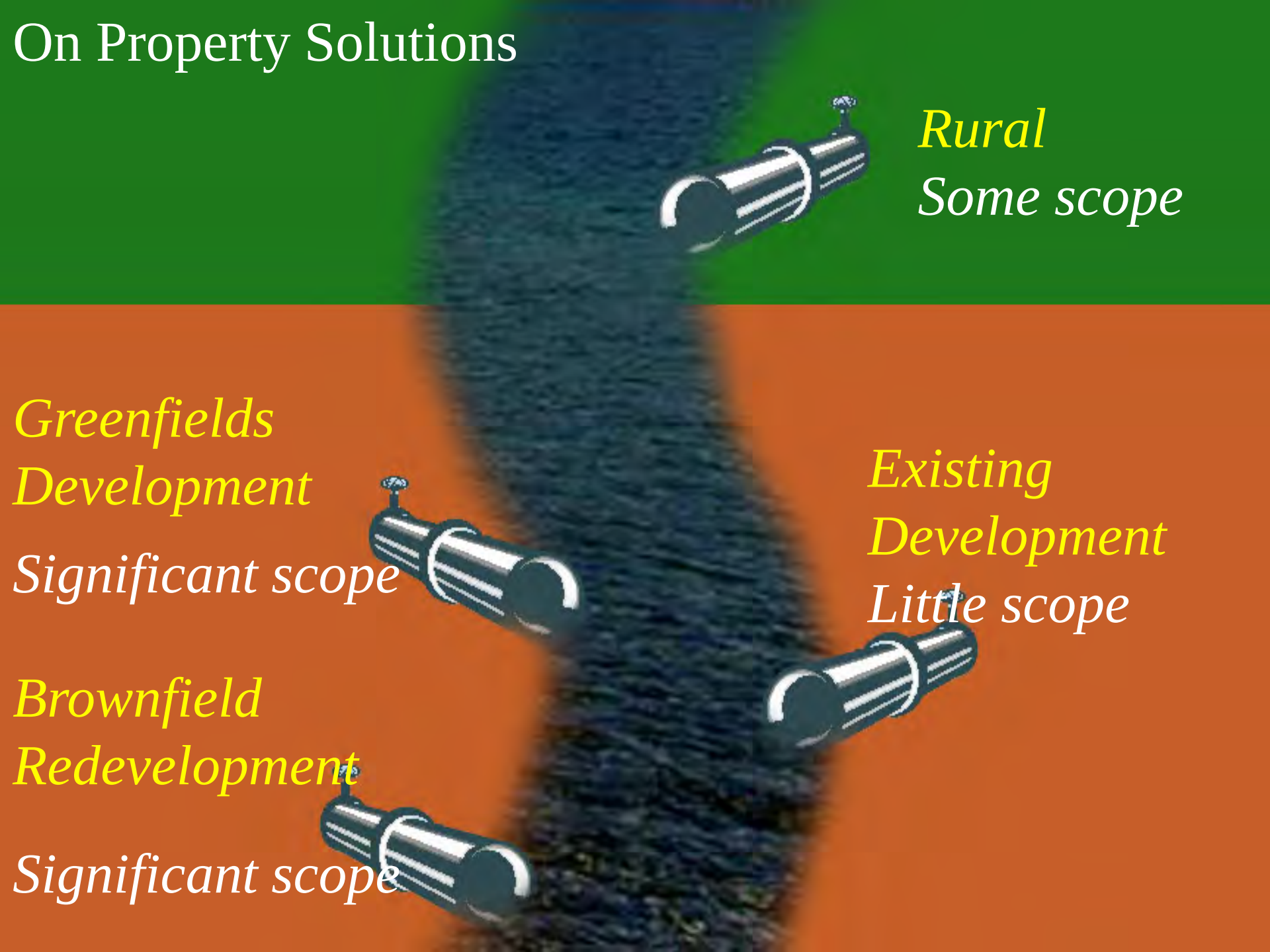
On-property Solutions

- Property owner funded, due to:
  - Regulation
  - Community education (moral 'call to arms')
  - Emission trading programs
  - Avoidance of pollution charges
  - Avoidance of higher developer charges
- Community funded
  - Financial incentives
  - Community funded retrofit

Major Sectors



On Property Solutions



Rural
Some scope

Greenfields Development

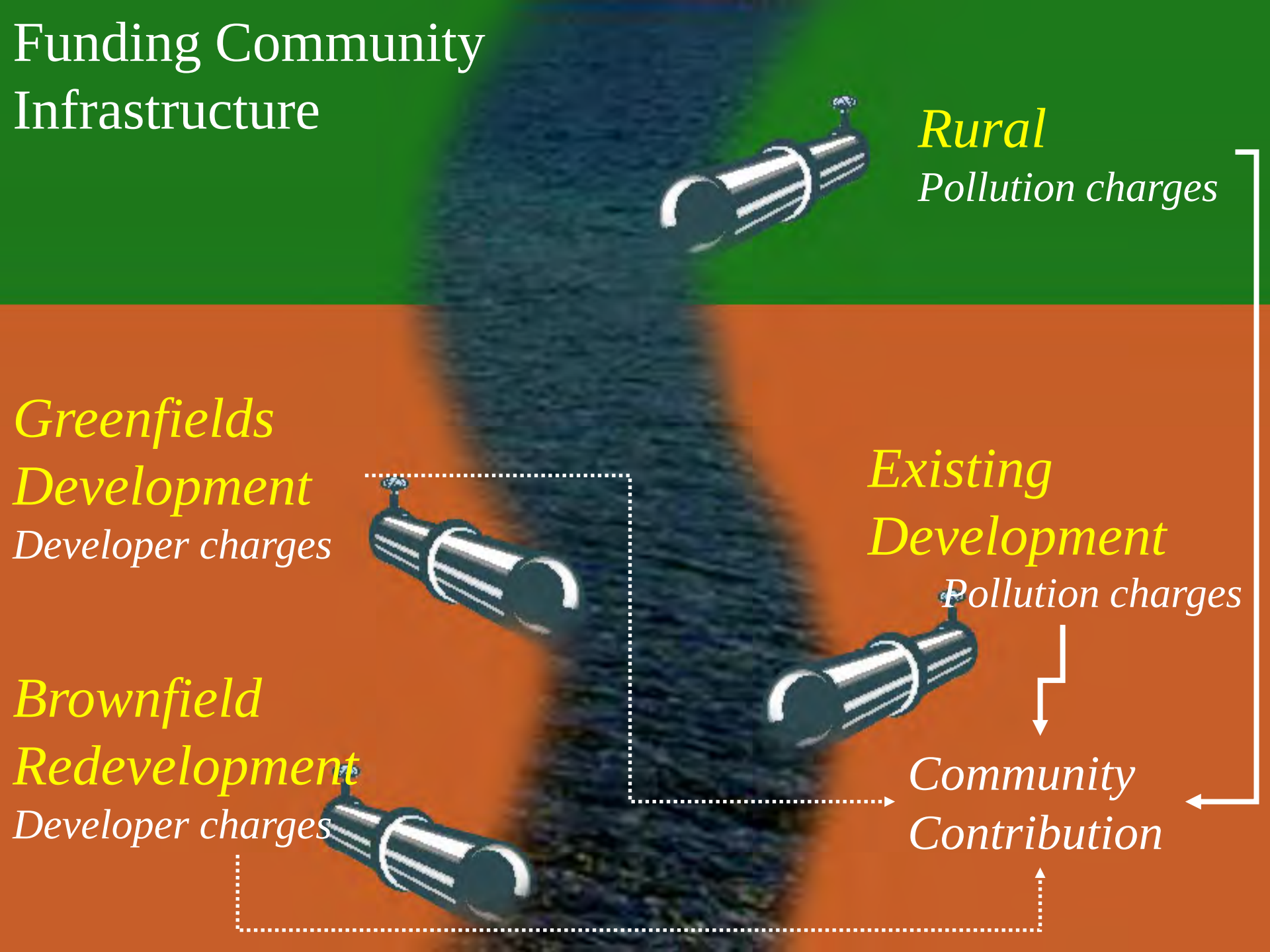
Significant scope

Existing Development
Little scope

Brownfield Redevelopment

Significant scope

Funding Community Infrastructure



Rural

Pollution charges

Greenfields Development

Developer charges

Existing Development

Pollution charges

Brownfield Redevelopment

Developer charges

Community Contribution

Pollution charges

- Polluter pays
- Difficult due to non-point source nature
- Forms
  - Ambient pollution schemes
  - Input based schemes
- Potential to alter behaviour?
- Unlikely to raise sufficient funds to pay for community infrastructure

Developer charges

- Powerful economic signal
  - Significant potential to alter behaviour
  - Significant potential to alter outcomes
- Can allow for on-property offsets
  - Require clearly defined alternatives
- Equity issues

Community Funding

- Offset by pollution charges and developer charges
- Alternatives
  - Funding from general government revenue
  - Expansion of current drainage rates
  - Special levy (recommended by ACIL Tasman)

Implementation Issues

- Many versions of equity
  - eg historic vs future contribution to the problem
- Power of special interest groups
- "Another tax slug" reaction
- Creating a balance

Outcomes of Days 1 and 2

Key Themes

- Examination of two possible institutional models for drainage management – a single responsible agency or two agencies with separate regulator and operator functions;
- Provision of greater transparency and accountability in decision making;
- Engagement of greater transparency and accountability in decision making;
- Engagement with the community and improved integration of stakeholder input;

Key Themes *(continued)*

- Achievement of behavioural change in the community through education and regulation;
- Raising revenue through expanding the current drainage rating base and using a mix of funding sources;
- Managing the whole ecosystem not solely the drainage system;
- Putting in place adequate monitoring, performance and reporting systems; and
- Providing adequate support for volunteer catchment management groups.

Principles

- Nutrient management as part of total water cycle management;
- Community ownership of the problem and the solution;
- Standards set for receiving environment(s);
- User pays/beneficiary pays; and
- Accountability for outcome(s) including monitoring and reporting.

Activities Since November

- Steering Committee
- Eight Consultancies

Outline of Today

- Agenda

- Objective
  - Consensus view on conclusions regarding issue of drainage management for water quality and quantity.

  - Consensus view on recommendations to achieve an appropriate framework for managing water quality and quantity.

Breakout Groups

Three Questions

1. What is the most appropriate corporate governance framework for managing drainage (water quality) in the Swan-Canning catchment?

2. How should drainage services be resourced?

3. How do we integrate WSUD into decision-making?

Review of Best Management Practices for Improvement of Urban Water Quality on the Swan Coastal Plain

ECOLOGICAL ENGINEERING

PB PARSONS BRINCKERHOFF

Scope of Investigation

- Assessment of the relative values of best management practices for the improvement of urban drainage quality on the Swan Coastal Plain
  - Non-structural measures
  - Structural measures
- Case study – Mill Street Catchment (as a typical built-up urban environment)
  - Assessment of water quality
  - Modelling of likely performance BMPs and preliminary life-cycle cost analysis

Context – Causes of WQ Problems

- General agreement that the high-level management goal should be to minimise the frequency and severity of harmful algal bloom is related to the management of nutrient discharge from the catchment
- No agreement as to the principal source of nutrient discharge and its cause-effect linkage
  - Urban Area vs Non-urban Area
  - Stormflow vs Baseflow
  - Phosphorus or Nitrogen
  - Significance of seasonal flow (eg. summer vs annual)

Context – Water Quality

- High fraction of dissolved inorganic phosphorus (25% to 60%)
  - Baseflow has the higher proportion of dissolved inorganic phosphorus (50% to 60% of TP)
  - Stormflow ~ 25% dissolved inorganic phosphorus in TP
  - Typical urban areas (eastern states and USA data) ~ 10% dissolved inorganic phosphorus.
- Nitrogen – highly varies
  - A reflection of landuse practices, ie. illegal industrial discharge, septic systems etc.

BMPs considered

- 16 assessment criteria based on (i) financial/economic; (ii) environmental/ecological; and (iii) social considerations
- Assessment made separately for baseflow and stormflow management objectives

Non-structural

Soil Amendment

Xeriscaping and water/nutrient management plans

Site-based water management officer

“Master Gardener” style education & participation programme

Town planning controls

Point Source regulation, education and enforcement

Maintenance regime for the urban drainage network

Erosion and sediment control programs

Illegal discharges elimination programs

Water management strategies

Financial incentives to lower the water table

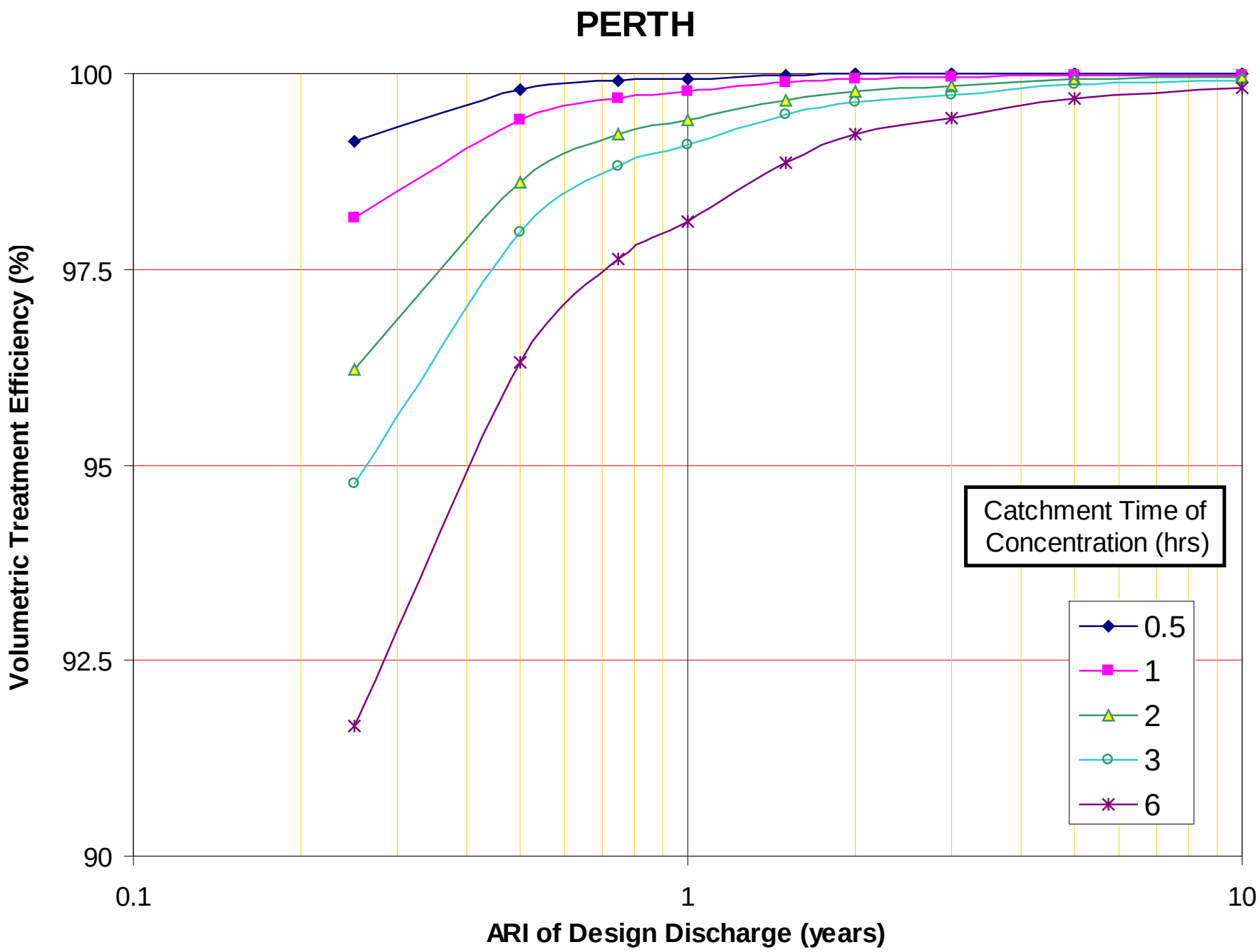
Financial incentives to retrofit the use of xeriscaping and/or soil amendments

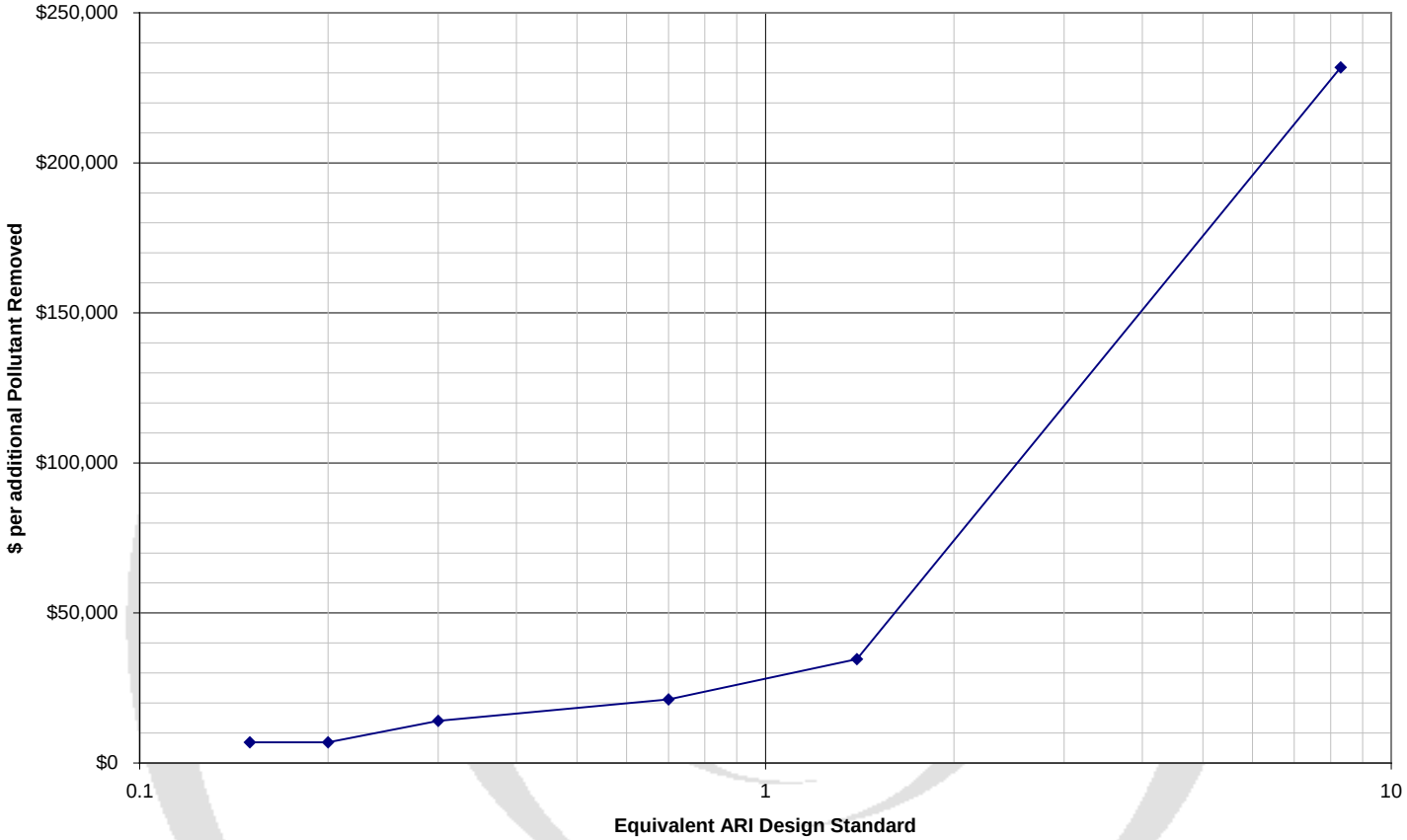
Non-structural	Structural
Soil Amendment	Gross pollutant traps
Xeriscaping and water/nutrient management plans	Sedimentation basins
Site-based water management officer	Buffer strips
“Master Gardener” style education & participation programme	Roofwater Tanks
Town planning controls	Vegetated swales
Point Source regulation, education and enforcement	Infiltration systems
Maintenance regime for the urban drainage network	Bioretention systems
Erosion and sediment control programs	Waterway rehabilitation
Illegal discharges elimination programs	Groundwater reuse
Water management strategies	Constructed wetlands
Financial incentives to lower the water table	Ponds
Financial incentives to retrofit the use of xeriscaping and/or soil amendments	Urban forestry

Hydrologic Design Standards & Cost Analysis

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PERTH
100
97.5
95
92.5
90
0.1
1
10
Volumetric Treatment Efficiency (%)
ARI of Design Discharge (years)
Catchment Time of Concentration (hrs)
0.5
1
2
3
6



Cost per kg of Additional Pollutant Removed	ARI	Hydrological Effectiveness	% Cost Difference
$10,000	3 Month	95%	
$18,000	6 Month	98%	80%
$22,000	9 Month	99%	120%
$28,000	1 Year	99.5%	180%
$250,000	10 Year	99.9%	2,400%

Mill Street Catchment Case Study

ECOLOGICAL ENGINEERING

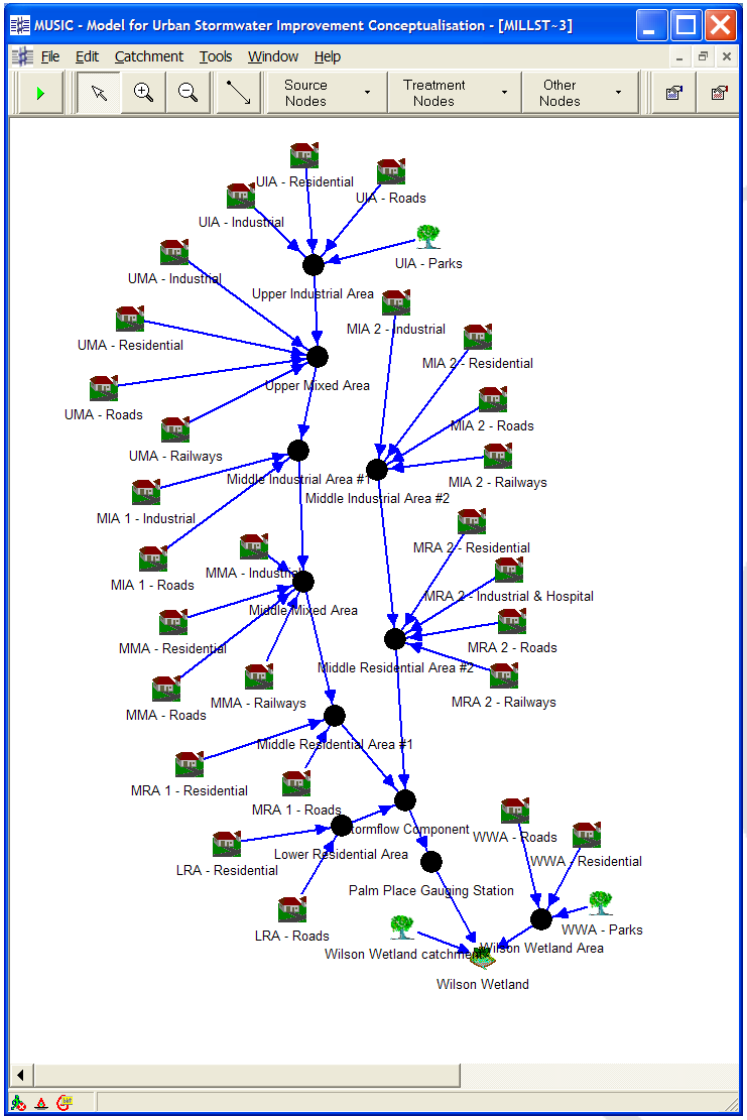
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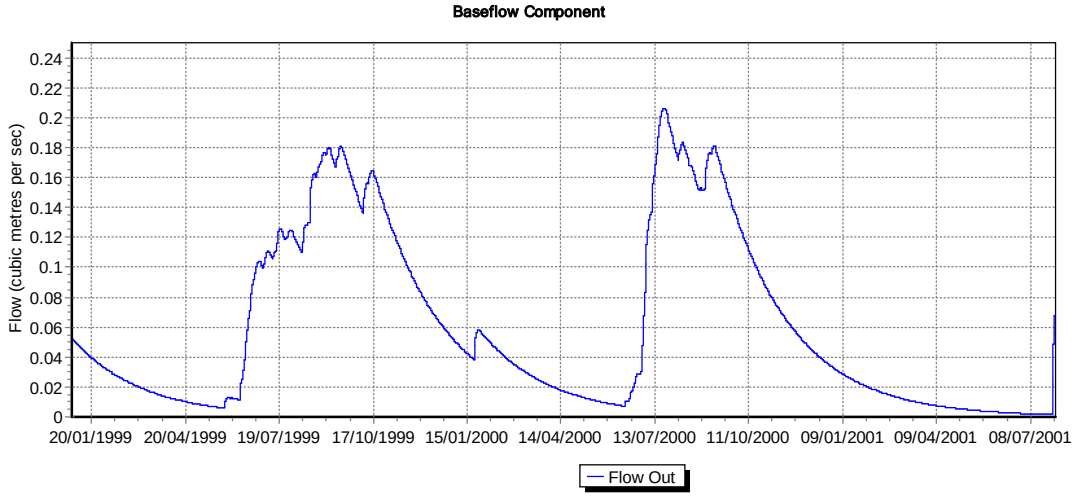
Mill Street Catchment

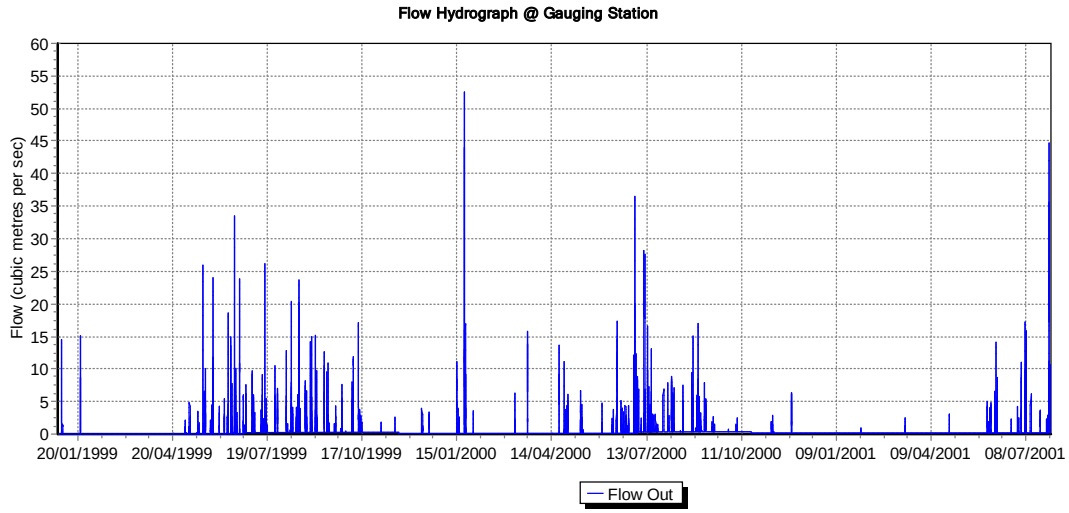
- 84% and 100% of WQ samples failed to meet relevant WQ guidelines for TN and TP respectively

Landuse	**Area**	**%**
Industrial and Hospital	572 Ha	47%
Residential	520 Ha	42%
Major Roads	101 Ha	8%
Parks & Railways	38 Ha	3%
Total	1231 Ha	

Parameters	**Groundwater Flows**	**Storm Flows**	**Total**	**DoE Estimates (1999-2001)**
Annual Flow Volume	1.88 GL	3.01 GL	4.89 GL	4.90 GL
Annual TP	500 kg	1,260 kg	1,760 kg	1,730 kg
Annual TN	3,700 kg	8,000 kg	11,700 kg	10,027 kg







Parameters	Groundwater Flows	Storm Flows	Total	DoE Estimates (1999-2001)
Annual Flow Volume	1.88 GL	3.01 GL	4.89 GL	4.90 GL
Annual TP	500 kg	1,260 kg	1,760 kg	1,730 kg
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Mill Street Catchment

- Capital expenditures of the order of $4million on non-structural and structural BMPs can have the effect of removing approximately 1000 kg of phosphorus and 4000 kg nitrogen from stormwater annually.
  - These figures represent approximately 50% and 30% of the phosphorus and nitrogen loads annually discharged into the Swan-Canning System from the catchment.
  - Approximately 40% of the nutrient reductions (ie. 20% phosphorus; 12% nitrogen) are attributed to non-structural measures

- Life-cycle cost analysis found that an equivalent annual payment of approximately $250,000 will be necessary to implement the strategy for the Mill Street catchment

Conclusions and Recommendations

Conclusions & Recommendations

- While, there was broad agreement that the high-level management goal for the Swan-Canning System should be to minimise the frequency and severity of harmful algal blooms, there was not agreement amongst the primary water managers in the region as to how water quality management of urban drainage should be undertaken to meet this goal.

- *Consensus on the specific objectives for the management of water quality in urban areas be developed*
- *Specific and quantitative water quality objectives and targets be established to aid the planning and sizing of BMPs*

Conclusions & Recommendations

- Best Management Practices with potential for application on the Swan Coastal Plain were short-listed for assessment against sixteen criteria developed to address financial/economic, environmental/ecological, and social values.
- The study identified some best management practices that are capable of reducing nutrient discharges from developing and built-up urban areas into the Swan-Canning system.
  - Non structural measures are fundamental to the provision of the necessary administrative and community-engagement framework for successful implementation of structural measures

➢ *The assessment of structural and non-structural BMPs be used in the short term to assist decisions on which BMPs to trial on the Swan Coastal Plain, be evaluated and refined using the principle of 'adaptive environmental management'*

Conclusions & Recommendations

- Analysis of Perth rainfall records has shown that in excess of 90% of the mean annual runoff and nutrient loads of an urban catchment in Perth is generated from storm events of average recurrence frequency more frequent than once every three months.

➢ *Stormwater management structures do not need to be designed for large storm events to achieve high nutrient capture effectiveness.*

Conclusions & Recommendations

- Using the 1200 Ha Mill Street catchment as a focus catchment, it was determined that capital expenditures of the order of $4million on non-structural and structural BMPs can have the effect of removing approximately 1000 kg of phosphorus and 4000 kg nitrogen from stormwater annually.

➢ *The costing information be used as an indicator of 'order of magnitude' costs for applying water quality-related BMPs to built-up catchments containing large areas of medium density urban residential land use and unsewered industrial land use*

Bioretention Systems

ECOLOGICAL ENGINEERING

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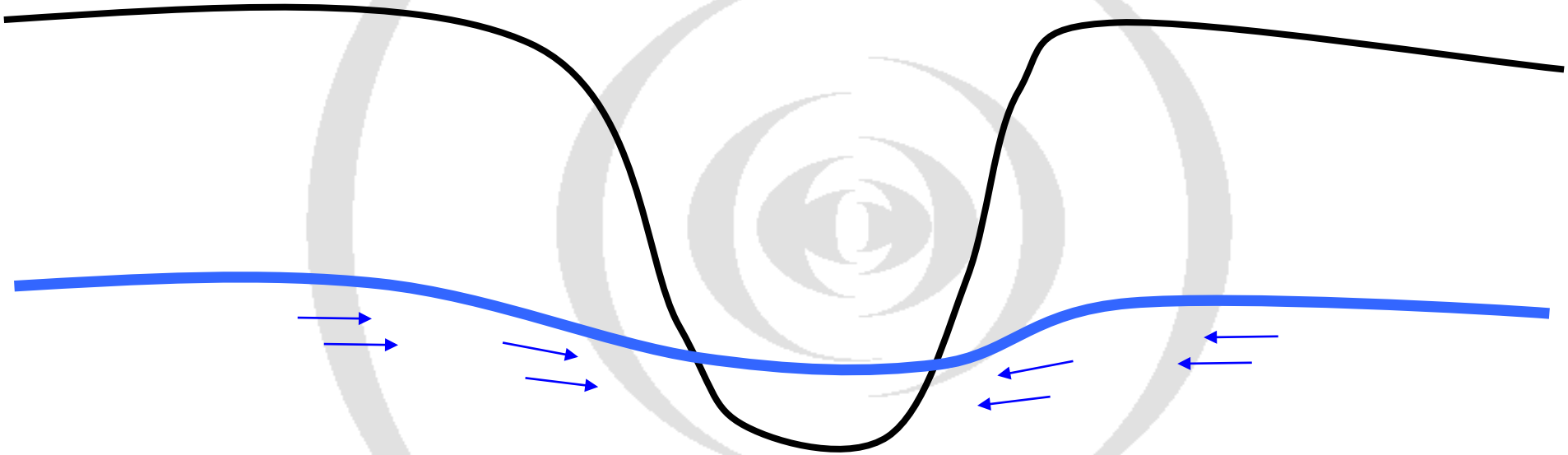


Streetscape – Lynbrook Boulevard



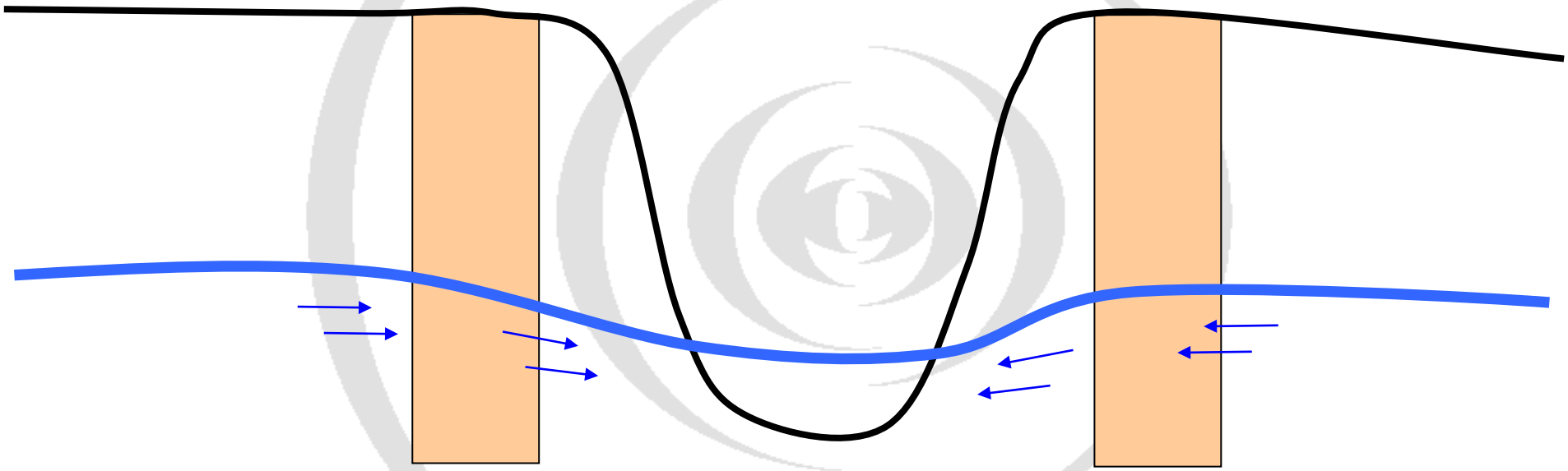


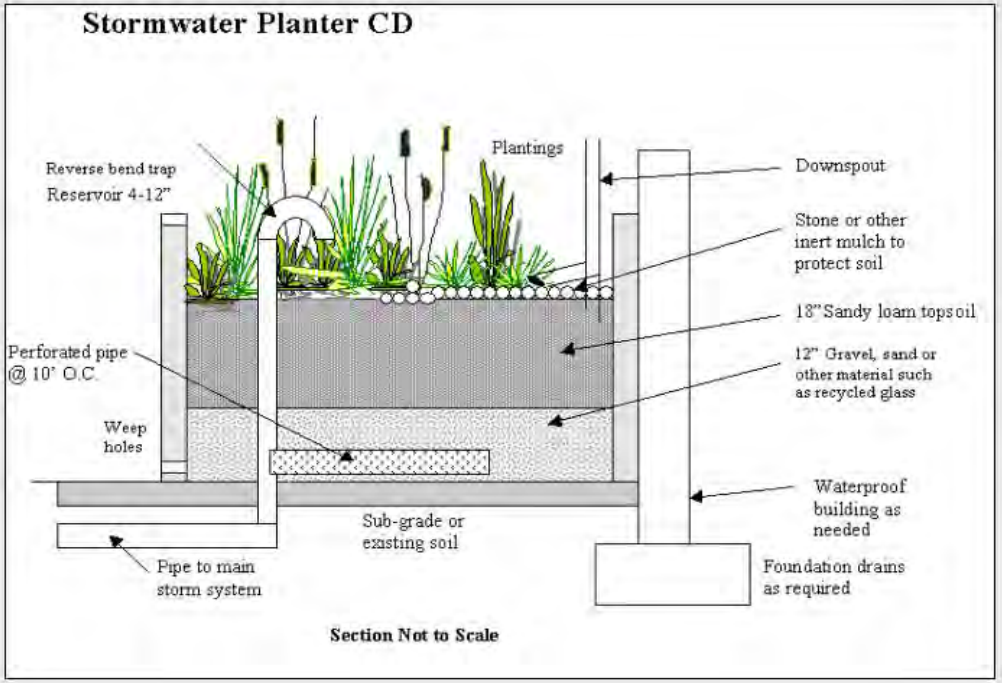




Bioretention Trenches

- High phosphorus adsorption filtration media
- Plantings to provide biological uptake of adsorbed nutrients




Stormwater Planter CD
Reverse bend trap
Reservoir 4-12"
Plantings
Downspout
Stone or other inert mulch to protect soil
18" Sandy loam topsoil
12" Gravel, sand or other material such as recycled glass
Perforated pipe @ 10' O.C.
Weep holes
Waterproof building as needed
Sub-grade or existing soil
Pipe to main storm system
Foundation drains as required
Section Not to Scale


MAY 25 2001






Sidcraft
PICTURE FRAMING
EX


CLEANAWAY
13 13 39


TRACTORS
BEYOND THIS POINT
ON THIS TOLLWAY
EXCEPT WITH AUTHORITY
TOLLWAY
ENTRANCE
STOP
ONLY
AVIS
Return

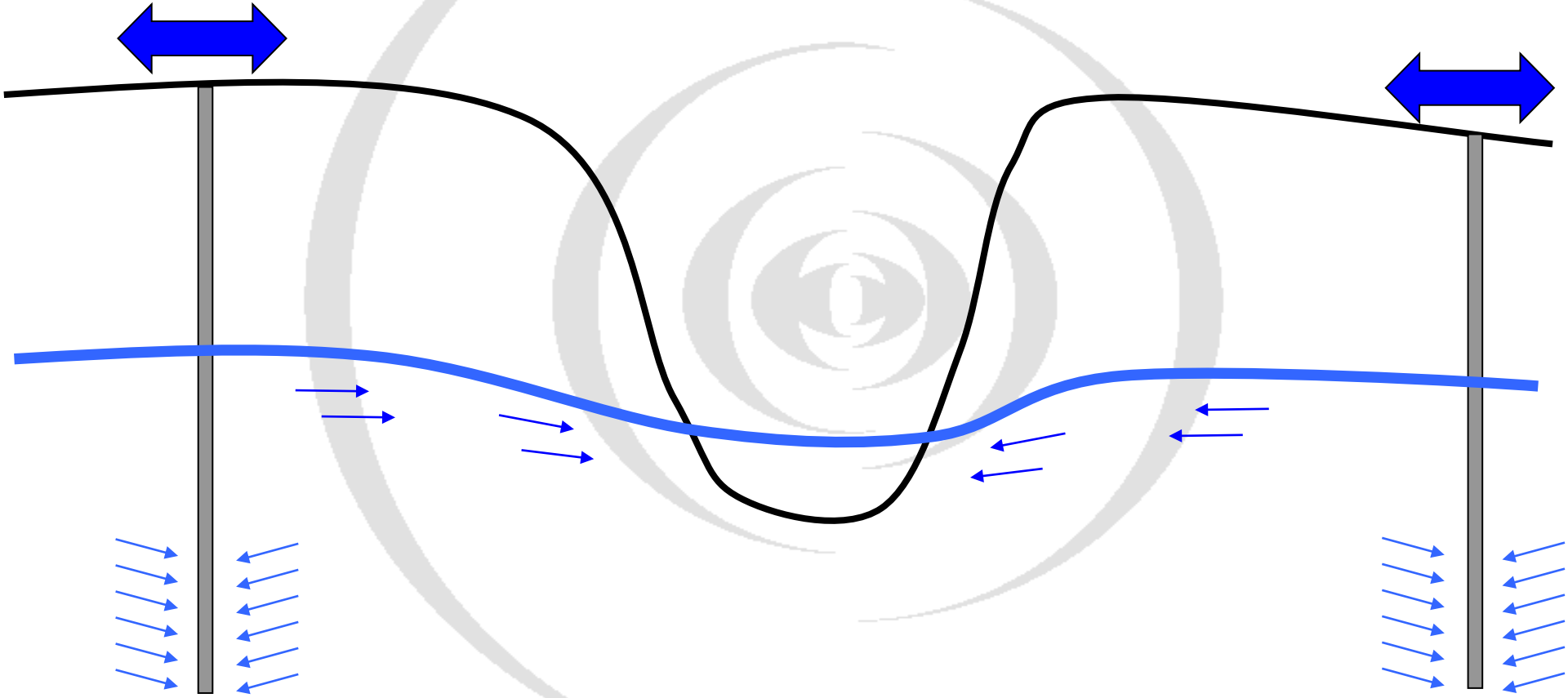
Reuse of Groundwater

ECOLOGICAL ENGINEERING

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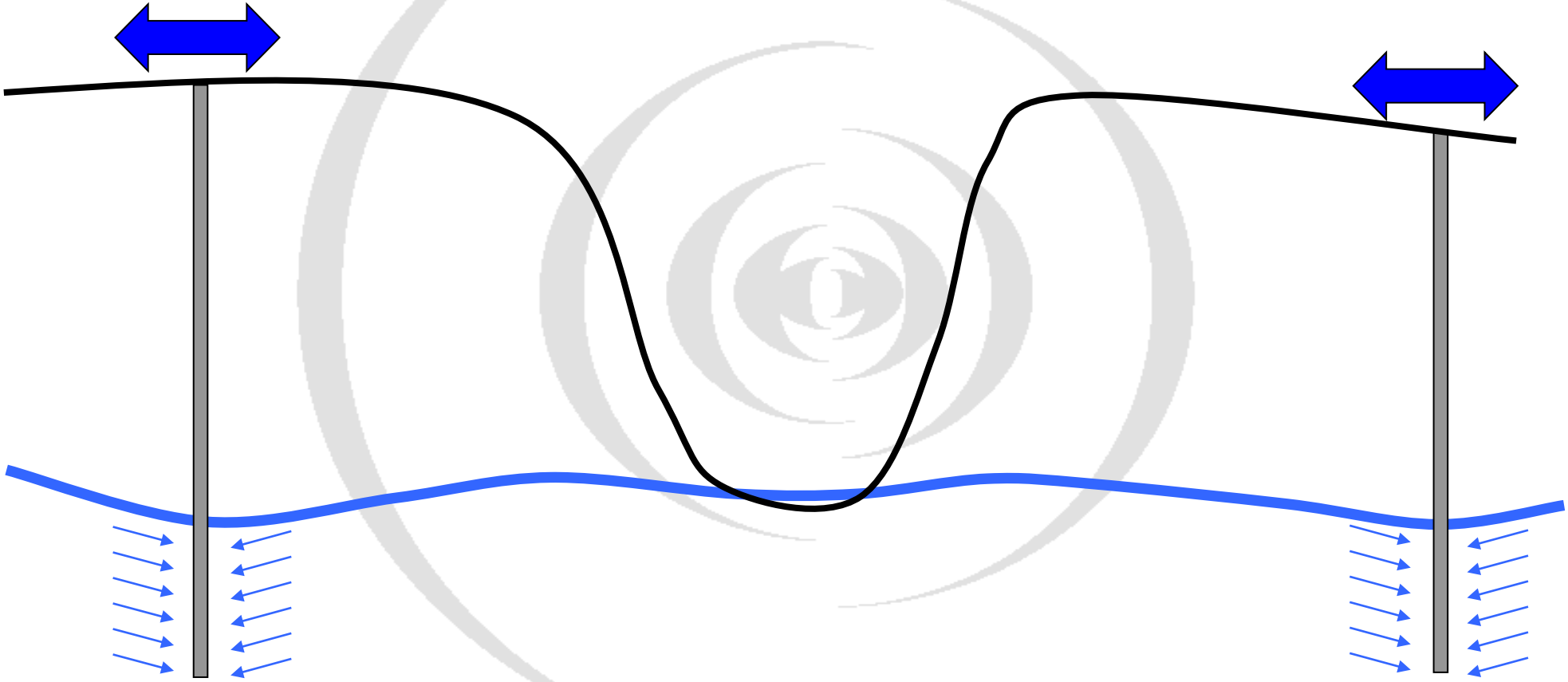
Groundwater Reuse

- Use particularly for landscape, POS watering during the summer months – locate bores close to drains
- Need to consider impact on natural wetlands



Groundwater Reuse

- Use particularly for landscape, POS watering during the summer months – locate bores close to drains
- Need to consider impact on natural wetlands



Return

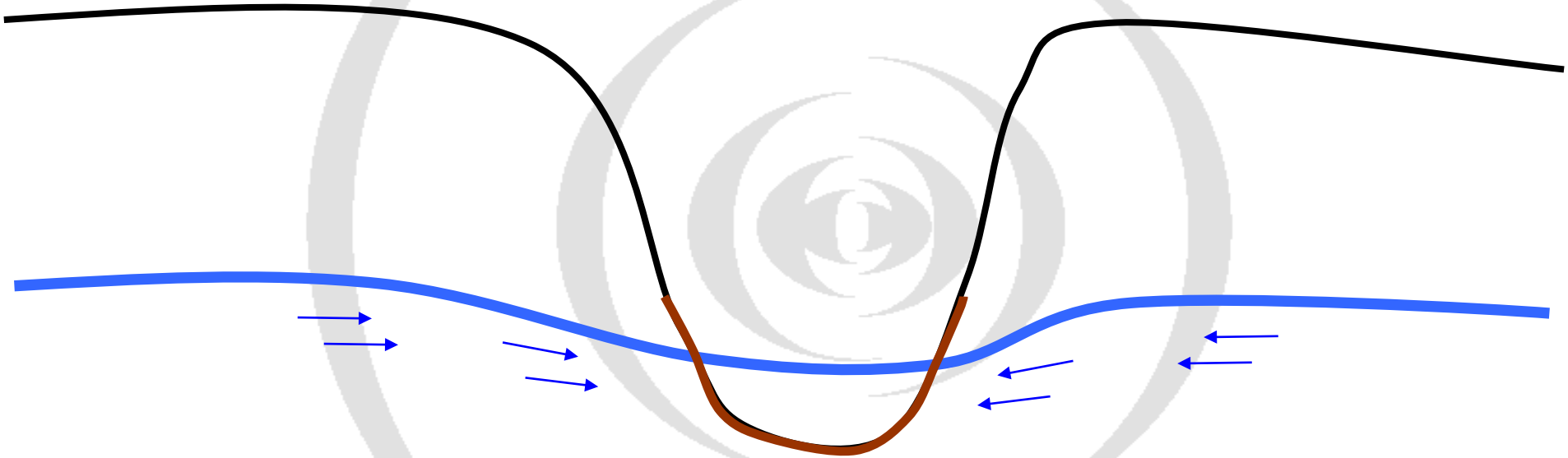
Waterway Rehabilitation





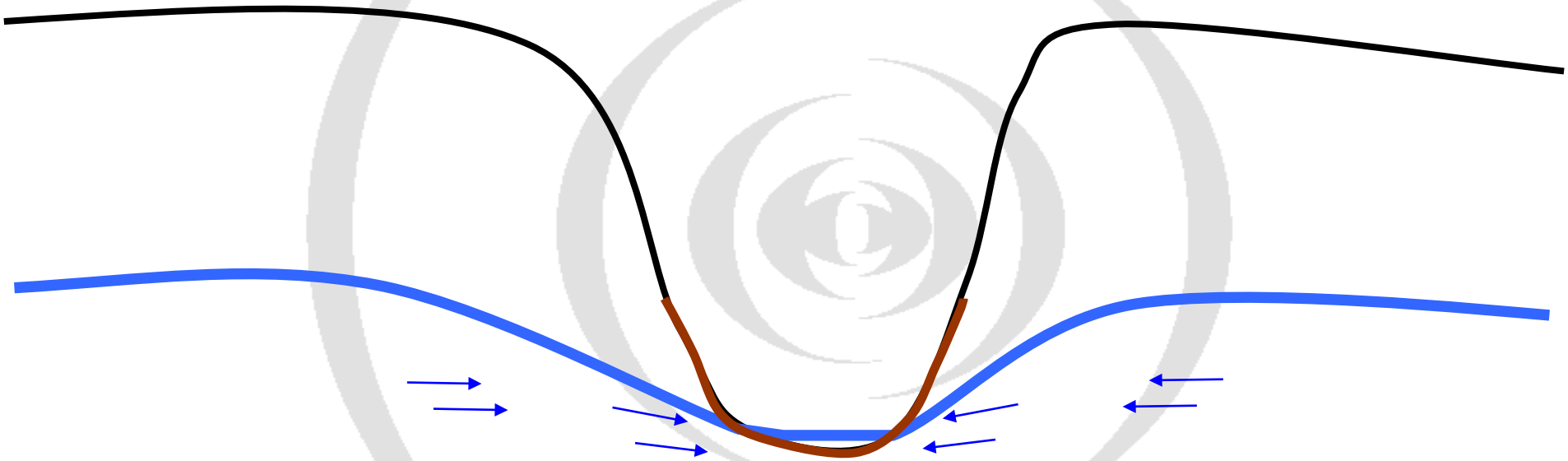
Channel Lining

- Reduce lateral hydraulic conductivity at the channel bank interface



Channel Lining

- Reduce lateral hydraulic conductivity at the channel bank interface




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Constructed Wetland Systems



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Urban Forestry



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Urban Forest


Urban
Forest






Return

Department for Planning and Infrastructure
Government of Western Australia

WATER SENSITIVE URBAN DESIGN AND THE DEVELOPMENT APPROVALS PROCESS

Identification of Issues & Potential Solutions for Better Implementation

Project facilitated by Shelley Shepherd,
Essential Environmental Services

Dr Mike Mouritz

Department for Planning and Infrastructure

Introduction

- Project initiated as a result of discussions held at the Swan Canning Catchment Drainage Management Forum in November 2003
- WSUD is one tool in a suite of mechanisms to reduce nutrients and sediment entering the rivers
- Management of urban stormwater has a significant role to play in improving water quality
- The benefits of WSUD are acknowledged but implementation is limited for a range of reasons

WSUD Study

Aims:

- **Identify the land use and development control mechanisms available to implement WSUD**
- **Assess their adequacy**
- **Identify barriers to implementation**
- **Propose solutions to issues identified**

Study Process

Stage 1: Desk-top Analysis

- Assessment of the WAPC/DPI policy framework and the local government planning system
- Discussions with key players in Local and State Government and the private sector

Stage 2: Workshop

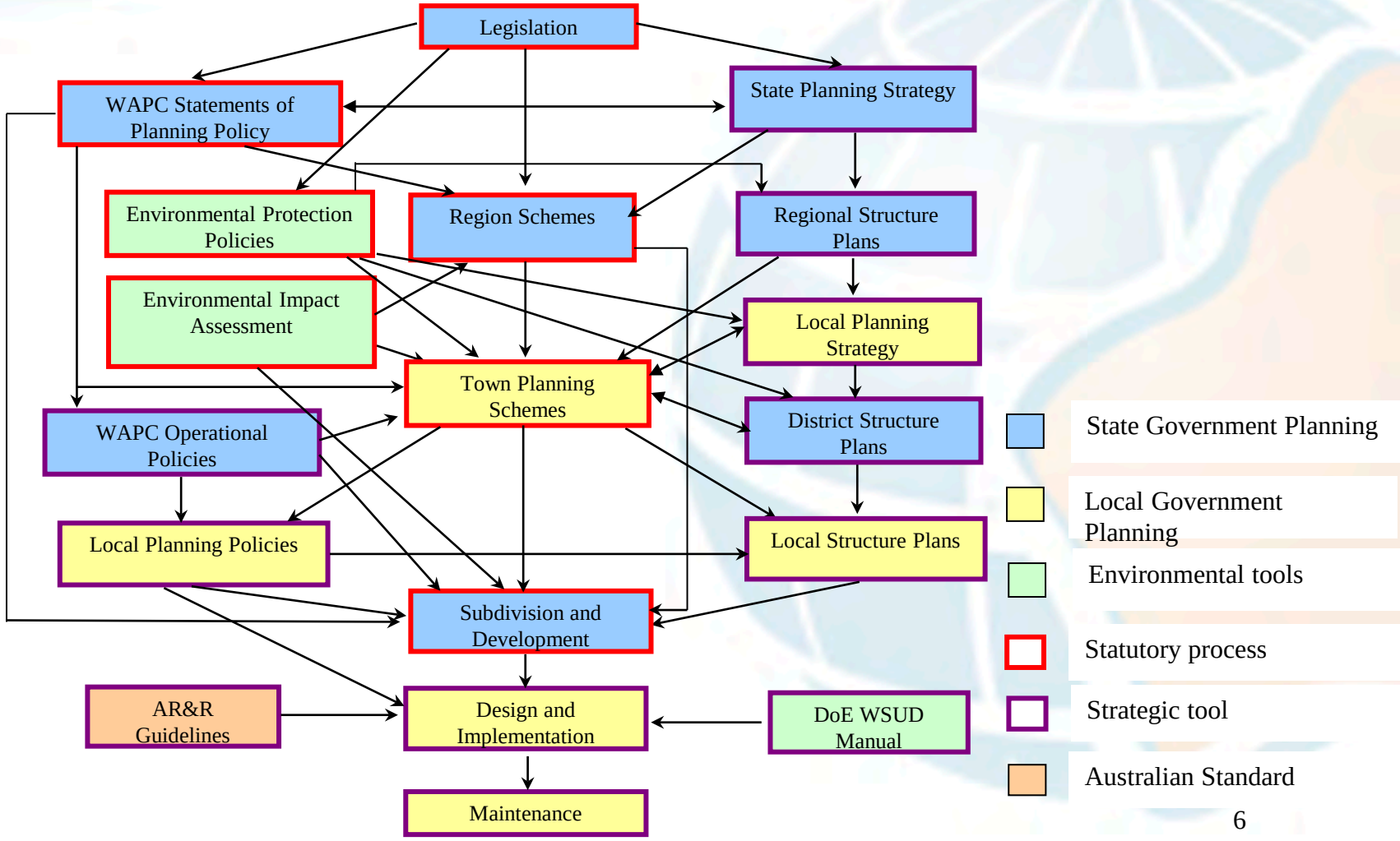
- Information gathered from Stage 1 used to scope issues for further discussion and resolution
- Attendees at the workshop from varied agencies including DPI, DoE, Local Government, the water engineering fraternity and the development industry

Stage 3: Report Preparation

Findings

- State and local government planning approval system has the largest statutory role to play in the implementation of WSUD
- The planning tools, both statutory and strategic, exist to incorporate WSUD into new developments, BUT have no impact on existing areas

Map of Statutory Approvals Process



Findings

- The existing policy framework provides support for urban water management and WSUD at all levels of the process, however, improvements can be made (and are being made) to strengthen the statutory basis
- The benefits of WSUD are acknowledged but implementation is limited….why?

Key Overarching Issues

- Institutional arrangements complicate the implementation of WSUD as no one agency is responsible for urban water management
- Limited technical assessment of on-ground performance of WSUD Best Management Practices (BMPs) in Western Australia
- Technical information specific to WA is limited as most BMPs are derived from experiences in the eastern states. Therefore there seems to be no agreed approach to best practice that works well in WA.
- Can and will WSUD actually achieve a good outcome for the Swan Canning Catchment? How much impact will changing the water management of new urban areas actually affect the river system?

Development Approvals Process

- **The top 5 tools regarded by the Workshop attendees as having importance for implementation of WSUD through the development approvals process are:**
  1. **Design and implementation (construction)**
  2. **Maintenance**
  3. **Subdivision Approval and Conditions**
  4. **Statements of Planning Policy**
  5. **Regional Structure Plans**

Detailed Design and Implementation (Construction)

Barriers

- Lack of performance standards for design and implementation
- Lack of criteria for design eg nutrient stripping, infiltration
- Cost/economic implications of complicated treatment trains

Solutions

- Develop agreed management practices to achieve required performance
- LG & State capacity building to ensure WSUD standards are enforced/complied with
- Set responsibility for monitoring and reporting of performance against conditions

Maintenance

Barriers

- Lack of funding (LG)
- Implementation cannot be enforced
- Lack of performance standards with regards to design
- High cost of maintenance to LG

Solutions

- Use demonstration projects to inform both LG and designers
- Full cost/benefit analysis of WSUD treatments compared with conventional treatments is required. If this information exists, it needs to be collated and presented in a more effective manner.
- Review funding arrangements and transfer mechanism to ensure adequate resources for management over the long term

Subdivision Approval and Conditions

Barriers

- The existing standard conditions are inadequate
- Conditions lack specificity/currency
- Clearing of conditions without adequate technical expertise supported by approved guidelines, criteria and data
- Lack of quantifiable, binding WSUD conditions that can be imposed (threat of overturing by TPAT)
- On-going conditions (post development) don't exist

Solutions

- Update conditions
- Set management targets based on receiving environment requirements (i.e. a range of targets may be developed for the different biophysical zones or receiving water requirements – it will be harder in some locations than others).
- Assess what is achievable from installation of individual BMPs. This can be used to back-up targets in conditions.
- Incorporate clear, quantifiable water quality and quantity WSUD targets in conditions
- LG (& State) capacity building to ensure WSUD standards (ARQ) are enforced/complied with

Statements of Planning Policy

Barriers

- Generic or generalised policy measures - not specific enough to achieve outcomes on the ground at subdivision level
- ENR SPP contains words like “encourage” and “where possible”. This makes it easy to discount
- SPPs are not holeproof as they are only required to “have due regard for” – may be considered and dismissed

Solutions

- Need to be more specific (include water quality objectives)
- Need to ensure incorporation into TPS
- Involve stakeholders in development
- More technical rigor

Regional Structure Plans

Barriers

- Current planning practice and existing RSPs don't adequately consider the 'water' issues
- Lack of knowledge, information and data to provide the context for an urban water management strategy
- Lack of targets for performance assessment and monitoring of effectiveness of outcomes

Solutions

- Need to "optimise" WSUD and water quality outcomes in planning policy – make targets/objectives clearer and specific
- EPA/Water agencies to set targets
- Monitor water quality
- Need investment for monitoring and implementation identified at regional levels
- A prioritised program of developing regional and sub-regional structure plans to ensure incorporation of water management plans
- Setting appropriate and clear guidelines to achieve required outcomes (LG, WAPC/DPI, EPA, SRT) with each party contributing funding based on its benefit

Summary of Findings

Barriers outside the system

- **lack of water quality targets, standards and criteria**
- **lack of regional perspective with respect to drainage = Need for Regional land/water structure plans**
- **confusion with regards to "who does what" within Government (ie no clear decision to developers**
- **lack of commitment to implementation exhibited through a lack of effective funding**

Summary of Findings

Key tools for implementation available

- **Planning policy framework**
- **Structure plans**
- **Subdivision conditions**

Barriers "inside" the system

- **Perceived cost of installation and maintenance**
- **Lack of data on existing and ongoing performance of treatments**
- **Lack of effective and agreed detailed (engineering and planning) design guidelines**

Recommendations

- Clarification of the roles and (most importantly) responsibilities for implementation of WSUD across Government, focusing on the “lower end” of the process, particularly as it relates to the roles and responsibilities of referral agencies (ie who makes what decision)
- Develop appropriate water quality (and quantity) targets on a “catchment” or biophysical unit basis for key threatened environments such as the Swan and Canning Rivers
- Improve the WAPC/DPI policy framework through the finalisation of the Water Resources SPP and the incorporation of water issues more firmly into Liveable Neighbourhoods review

Recommendations

- Develop new standard conditions (both specific and general) to enable statutory planners to impose WSUD conditions more easily
- Develop or modify the water quality monitoring framework to incorporate appropriate feedback systems to ensure that there is a process of continuous improvement with regards to implementation.
- Review and consolidate information on cost/benefit analysis of WSUD treatments in comparison with conventional drainage structures and release the information to key stakeholders

Recommendations

- Implement demonstration projects and ensure that their performance is reviewed over the medium to long-term The projects must involve monitoring, assessment, evaluation and extension of results to ensure ongoing learning within the profession.
- Develop an “easy-to-read” brief summary of what WSUD means to a statutory planner to aid in the imposition of appropriate and effective conditions.
- Undertake work and/or consolidate information on infiltration and nutrient export rates of WA soils and nutrient uptake of soils and grasses

Recommendations

- Review the appropriateness of the Australian Rainfall Quality (ARQ) Guideline for their applicability to the Western Australian context.
- Development of a Communication Strategy for the new ARQ and training for LG engineers to ensure effective capacity building
- Further develop specific, technical guidance for local government engineers consistent with the draft ARQ Guidelines and the up-dated Stormwater Management Manual

Recommendations

- **Increase focus on planning and design of WSUD treatments particularly the demonstration and review of Best Planning Practices design solutions.**
- **Develop a Communication Strategy to raise the awareness in the general community of the importance of WSUD in urban areas**

"Until stormwater is looked at as a resource rather than a waste, we will be unable to achieve significant progress."