SUSTAINABLE URBAN WATER SYSTEMS:
POLICY AND PROFESSIONAL PRAXIS

by

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This thesis is presented for the degree of
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Declaration

I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for degree at any other tertiary education institution.

Michael John Mouritz
ABSTRACT

The provision of water, wastewater and stormwater infrastructure is an essential ingredient of cities. However, questions are being raised about the type and form of urban infrastructure, for economic and environmental reasons. Traditionally these technologies have offered linear solutions, drawing increasing volumes of water into cities and discharging waste at ever increasing levels, causing escalating stress on the environment. In addition the costs of water infrastructure provision and replacement, both in the developing and developed world, is becoming prohibitive. In response, a new paradigm has been called for and new solutions are emerging that have been labelled as Integrated Urban Water Management (IUWM). This concept can be considered to consist of both technical and philosophical dimensions, and represents a new form of professional praxis. However, the adoption of these techniques and concepts is constrained by the inertia of the existing urban water systems. It is therefore argued that the introduction of any change must occur across a number of dimensions of the technoeconomic system of the city. These dimensions - artefacts and technical systems (i.e. the technology and knowledge systems), professional praxis and socio-political context (i.e. institutions, culture and politics) and biophysical realities and world views (i.e. the environment and underlying values) - provide a framework for analysis of the change process - both how it is occurring and how it needs to occur. This framework is used to illustrate the link between environment values and the process of technological innovation, and points to the need for the emerging values and innovations to be institutionalised into the professional praxis and socio-political context of society. Specifically, it is argued that a new form of transdisciplinary professional praxis is emerging and needs to be cultivated. A broad review of the literature, an evaluation of selected emerging technologies and three case studies are used to illustrate and argue this position. These examples show the potential economic, social and environmental benefits of IUWM and provide some insight into the potential which this approach has to influence the form and structure of the city and at the same time highlighting the institutional arrangements required to manage urban water systems.
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To these people and all the others that helped along the way I am truly grateful.
Above all, my deepest gratitude and appreciation goes to my wife, partner and friend Fiona and my children Tom, Joel and Liam (da boys!!) for putting up with a husband and father who was preoccupied with this project for longer than it should have taken. They sacrificed more than I can imagine. Fiona continually provided moral support and has inspired me with her strength of will and dedication. I could not have started, let alone finished this project without Fiona's love and support.

I hope this document provides a contribution to an evolving sustainability of the urban water systems, natural and human made. However, as Christopher Titmus suggests in his inspirational book - The Green Buddha:

So we must ask: What will awaken the heart? Rather than concentrating on gaining knowledge, we must explore different routes to realising the intimacy of human beings with each other and with the Earth. It is futile to shuffle between knowing a little and appearing to know a lot. Both are deceptions. It is not knowledge that we are short of but the inspiration to transform our life, to break out of the mould of mechanical existence, and live on the edge of simplicity with others in a communal respect for the ordinary (p 31).

To all those who have helped and provided inspiration along the way - thank you.

Mike Mouritz
May 1996
CHAPTER 1

INTRODUCTION

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

1.1 Overview of Urban Water Systems

The urban water system can best be pictured by thinking of the role of water in the household. The urban inhabitant "unconsciously connects the proverbial but misleading cycle between the sky and the earth, with a turn of the tap, push of the button, or flip of the lever"; they link the water supplied by large reservoirs, complex distribution networks and the water disposed, via the home and back to the hydrological cycle through an equally complex sewage network and treatment process mainly to ocean outfalls (Havlick 1974: 107).

This picture of an urban water system is accurate but incomplete. It provides an image of only the 'water use' part of the water cycle and has omitted the rain which falls on the city and the engineered pathways of stormwater. Omitted, also are the urban water ways: the creeks, streams, wetlands, estuaries and beaches that our cities are built around. These are not just water systems but in many ways are part of the spiritual and social hearts of cities.

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1 Herbert Dreiseitl is a German urban designer and artist who specialises in designing with water by synthesising art, architecture, technology and ecology. He visited Australia in September 1994 and presented talks on water and urban design in Brisbane, Sydney, Melbourne and Perth. Copies of the paper he presented are included in the proceedings of the 2nd Annual Conference on Soil and Water Management for Urban Development - Creative Stormwater Management, 6-7 September 1994, Sydney and in the proceedings of How do you do it? Water Sensitive Urban Design, 12 September 1994, Institution of Engineers, Perth. He has also recently published a book on integrated water management with Professor Wolfgang Geiger, titled "Neue Wege fur das Regenwasser".
But this picture of the urban water system is still incomplete. It has not yet acknowledged the interplay of the "seamless web" (Hughes 1988: 18) of events, social institutions and administrative arrangements and their interplay with the technological innovations that have shaped our cities. The result of that interplay has been an urban water system which is characterised by large scale technology and correspondingly large bureaucracies. The technologies have offered linear 'solutions', to what have been conceptualised traditionally as engineering problems. These solutions involve drawing increasing volumes of water into cities and discharging waste at ever increasing levels, causing escalating stress on source and sink environments. It is now also becoming increasingly recognised that the costs of water infrastructure provision and replacement, both in the developing and developed world are becoming prohibitive.

These tensions provide the context within which a debate about the future of the urban water sector is occurring. That debate also needs to be seen within the wider context of 'Sustainable Development' and the growing focus being placed on urban sustainability in general. This thesis explores the implications for the urban water sector in the context of these factors and the contemporary questions about urban sustainability.

1.2 Context and Hypothesis

The provision of water, wastewater and stormwater infrastructure is an essential ingredient of cities. However, it is now increasingly recognised that the water sector poses economic and environmental implications to urban communities around the world. The provision of water and wastewater represents a large and growing cost associated with urban expansion. In addition, the refurbishment and replacement of infrastructure as it ages adds to this cost. This is apparent in older systems in Europe and America and is becoming recognised in the Australian context. Less developed countries face massive infrastructure expenditure costs simply trying to establish adequate water and wastewater systems. At the same time there is increased
recognition of the environmental impact of existing water, wastewater and stormwater systems. This push has typically come from the environment movement, but even the wider establishment has added to the debate, for example, the typically conservative Australian Medical Association issued a press release over Christmas 1995 urging the Australian government to phase out sewerage ocean outfalls, for health and environmental reasons. In response to all of these pressures there has been an emergence of new environmental standards and guidelines. These potentially add to the cost implications of new and replacement systems.

Questions about the cost and price of water services are inextricably linked to the equally valid question of whether or not to maintain the social welfare function of water service provision. Traditionally, water and wastewater services have been subsidised by governments as part of a broader egalitarian and social program (Synnott 1991), which has been aimed at providing that most basic of service, adequate water and wastewater. Contemporary pricing concepts, such as full cost pricing are being proposed, which include both the full cost of the infrastructure and such things as resource rents and externalities of pollution (Warner 1993). These proposed reforms potentially provide a much needed feedback signal to consumers of the real cost of water services. But of course there are equity and political implications of such moves.

Traditionally the water sector has been thought of as a public utility, but as the costs associated with these demands have grown, Governments have increasingly wanted to distance themselves from these costs. For example in Britain and Australia economic reform processes have pushed the water sector down the commercialisation and privatised management route. The aim has been to achieve efficiency through sharpened commercial focus and the establishment of more profit driven objectives, either through partial or wholesale commercialisation of all or part of the water sector.
In the developing world, private investment in these water infrastructure services is now promoted as potentially the only way to resource these schemes.

These institutional changes have been primarily designed to make the water sector more accountable in financial terms. However, the increased commercial focus of the water sector places potentially increased risk on the environment as a more commercial water sector is likely to resist the push for raised pollution standards. Thus as the commercialisation process has progressed, increased attention has been focused towards clarifying the regulatory environment within which the water sector operates. The focus of the reform process has been primarily directed at the water utilities, but the management of the urban water cycle is highly fragmented institutionally, involving a complex matrix of agencies at state and local level. In addition provision of water, wastewater and stormwater services is linked to the land use planning and development control processes. Equally, water technologies do not operate in isolation, they are part of a system involving many elements of urban society and culture. Thus water technologies are deeply embedded in the institutional and cultural fabric of society. While less attention has been given to these complex relationships, the whole institutional setting of the urban water sector, particularly in Australia, is in a state of flux.

These institutional changes are occurring at a rapid rate, but questions are being asked about the actual ability of the existing technological solutions adopted in the water sector. In some quarters strong arguments are being presented that these institutional changes will not be sufficient to meet the challenges ahead. In particular, evidence appears to be mounting that the current water technologies and systems are in the final phase of economic and technological development (Thomas and Mcleod 1992). Thus researchers in this field have argued that a new 'greener' paradigm is required (Niemczynowicz 1992, Beder 1993a).

In fact it appears that the paradigm is emerging as a synergistic form of ecological design which combines ecological planning and ecological engineering. However, as Kemp and
Soete (1992) have noted, the transition to "greener technologies" is likely to be hindered by technical, economic and institutional barriers, since the new technologies have significant difficulty becoming embedded into the 'selection environment', because it is adapted to an old regime. Thus there is an in built inertia which is difficult to shift.

Therefore to move beyond a critique of the problems in this area and into a mode of aiding in the process of resolving the mismatch between society, its water technologies and the environment, a broader appreciation of what water technologies are and how they interface with society is required. This thesis sets out to explore the relationships between people, cities, water and the water related technologies that connect them. Within the thesis a framework for analysing 'technology' is developed and applied to the urban water sector to answer the following hypothesis:

*The sustainability of cities requires that land and water planning be better integrated at a range of scales and time horizons in urban planning and redevelopment processes.*

*However, for a more sustainable city to be achieved, the emerging sustainable urban water paradigm needs to become institutionalised and merge into a form of transdisciplinary professional praxis which links ecological design and urban management.*

### 1.3 Dimensions Of Technology - A Framework For Change

No technology operates in isolation and water technologies represent a good example of a complex array of artefacts and systems linked inextricably with both its physical and institutional setting. There are numerous ways of examining technologies and the social shaping process that form them and how technologies in fact shape society (see for example Barns 1991, Scarbourough and Corbett 1992: 3-4). One useful approach is that provided by Willoughby (1990) who has suggested a tri-level way of describing technologies and their context:
• Artefacts - i.e. objects or equipment
• Technical Systems - i.e. systems of artefacts and ways of doing or building things and management systems for artefacts
• Technology Practice - i.e. the broader socio-political dimensions of how technologies are used, regulated and shaped, because no technology can be seen without considering its social context.

While this framework is useful, it is also limited because it does not consider adequately the interactions between a technology and the biophysical environment in which technologies operate or adequately deal with the political or human dimensions of technological innovation and choice. Thus the framework presented in Figure 1.1 has been developed as a way of breaking the system into meaningful categories for discussion and analysis.

The value of the framework is that it views technology as part of an interlinked matrix of cultural practice. It provides a way of differentiating between the physical and technical dimensions or knowledge elements of technology and their links to other dimensions of technology which form the social, political and institutional fabric of the technoeconomic system which is contemporary society (Barns 1991). Thus the framework provides a way to explore the wider dimensions of technology, not just as artefacts or a knowledge system, but as an interacting set of dimensions or modes. These dimensions are intimately interlinked and are therefore artificial, but they provide a language or way of isolating the key features within any technoeconomic system.
Figure 1.1 Dimensions of Technology - Framework for Change

A description of the elements of the framework follows:

- The dimension of Artefacts and Technical System represents the connected system of artefacts that make up a technology and the knowledge system which supports its design and management, as well as the people who manage that system.

- The dimension of Professional Praxis aims to distinguish the professional practice and institutional setting of a technology from the purely technical sphere or knowledge system that surrounds and supports any particular artefact. As a dimension of the technology framework it aims to encapsulate the human and political elements of those involved in designing and managing technologies, as opposed to the technical (know-how). The notion of professional praxis includes the institutions and bureaucracies created by professionals and the culture of being a professional; an expert.

- The Socio-Political dimension or context provides a distinction between those involved at a professional level and the broader social, cultural and political fabric of a society. As a dimension of the technology framework it aims to disguise the political, cultural and social shaping forces that influence technology design and
implementation as well as recognising the social shaping consequences of technology.

- The World View dimension of the framework is essentially about the abstract, even metaphysical images and values any particular culture has of nature, technology and society itself. The significance of this dimension of a technology framework is that it is crucial to appreciate the value base upon which technical innovation and choices in technology are made. Simple examples of a world view might be the distinction often made between western and eastern culture or the distinction made between ecocentric and technocentric philosophy.

- The dimension of Biophysical Realities refers primarily to the natural environment and to the growing evidence of environmental decline. The word 'realities' is used in a way that acknowledges that there is a variety of perceptions about the condition of the biophysical world, dependent upon the world view or lens that it is perceived from. However, the use of the term also aims to stress that there are biophysical or ecological processes which continue to occur no matter what world view is applied. The perception is emerging that these processes must be maintained for future generations.

All of these dimensions are intimately linked, but by creating the distinctions between the dimensions it becomes possible to examine the process of technical innovation and technology choice in a more clearly differentiated way. Thus the framework provides a practical way of illustrating the human and political dimensions of technology as opposed to viewing technology as value free artefacts.

A key feature of this framework is that it asserts that new artefacts and technical systems capable of aiding in the transition to a more sustainable future emerge as a consequence of an interaction between how people view the emerging biophysical realities (i.e. the link between world views and biophysical realities). Every technology is framed by the values of a particular world view. If there is a value shift or
divergence from the dominant values or understanding, or if there is a recognition of a significant deterioration in the biophysical world (e.g. ozone depletion) opportunities for creative invention occur or present themselves. These shifts may potentially provide the basis for innovations that are transformative. However, while invention is relatively easy, the process of translating that invention into an 'innovation' that changes the way things are done or what 'technologies are used' is far more difficult.

The research presented in this thesis supports the notion that there is a strong 'path dependency' within the contemporary technoeconomic system which makes the transition from one form (or paradigm) of technology to another very difficult. Thus for an 'invention' to become an 'innovation', a process of institutionalisation is required. Essentially innovations need to become embedded within professional praxis and socio-political settings before they become a dominant technology or policy. In fact it is asserted that for a significant 'technological' paradigm shift to occur there needs to be change in all the dimensions of the technology framework.

In the context of the argument presented in this thesis about urban water management and technology, the inventions struggling for acceptance include an array of artefacts and technical systems which can be clustered under a broad title of ecological planning and ecological engineering. The key characteristic of these artefacts and technical systems is that they:

• recognise the earth's surface as a dynamic system
• focus on mitigation of impacts and utilise an increased ecological knowledge, particularly local knowledge and tend to be more site specific than universal
• include both soft and hard technologies (or structural and non-structural solutions)
• aim to be inherently more flexible and seek to enhance opportunities for change rather than resist change
Significantly, it is asserted here that for the benefits of these new ways to be realised, a new form of transdisciplinary professional praxis is required which crosses an array of disciplines related to urban design and management\(^2\). That is not to say that individual disciplines must disappear. On the contrary they may be strengthened, but what is required is a transdisciplinary framework within which the skills and techniques of the various disciplines forge new design and management responses for building and managing the sustainable urban water systems or in fact any part of the sustainable city. This new form of professional praxis also needs to find ways to overcome the barriers created by traditional institutional boundaries. In fact it should work to influence the shape of new institutional arrangements and be respectful of the various socio-political contexts within which it operates.

**1.4 Outline of the Thesis**

This thesis has a further thirteen Chapters. Chapters 2 to 10 focus on illustrating the linkages between the dimensions of the technology framework, while Chapters 11 to 13 present cases studies of the emerging sustainable urban water management paradigm.

The purpose of Chapter 2 is to place contemporary professional praxis of urban water management in an historical context and show how it has been influenced and shaped by dominant world views. The values arising out of this world view have been expressed in technological and in institutional form. The basic arguments for, and origin of, the sustainable urban water management paradigm are introduced.

In Chapter 3 the discussion presents the case that the global quest for sustainable development represents a shift in world views on a global scale. The Sustainable Development debate illustrates the linkage between the World Views and Biophysical

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\(^2\) The term transdisciplinary is used here to distinguish it from single disciplinary, multidisciplinary, interdisciplinary. In a transdisciplinary approach the problem becomes focus and all relevant disciplinary insights are used to define the problem and develop the conceptual framework. See Chapter 5 for a more detailed discussion of transdisciplinary praxis.
Reality dimension of the framework. In particular it illustrates that the evolving ethic of Sustainable Development is seeking to reshape much of society, requiring local and global links to be made more explicit.

In parallel to the evolving Sustainable Development debate the emerging science of complexity, encompassing chaos and self-organising theory, has occurred. Like past revolutions in science this new thinking framework presents new ways of viewing the world and thus is beginning to have a significant effect on all areas of professional, technical and private life. In particular it has shown that this world view provides powerful insights into sustainability. These concepts are presented in Chapter 4.

Largely as a consequence of these wider shifts, there has been a wave of new approaches to management and administration, as society and business look for new forms of management that are inclusive and more efficient as well as sustainable. These emerging forms of professional praxis are explored in Chapter 5.

The broader influences on professional praxis that are described in the previous Chapters are illustrated in a more focused way by considering the Sustainable Cities Movement in Chapter 6. The discussion presents the challenge of managing cities for sustainable outcomes. This chapter presents the sustainable cities movement as an expression of new world views and biophysical realities and changing socio-political circumstances.

In Chapter 7 the focus shifts back to the central focus of the thesis - the professional praxis of urban water management - and presents a broad review of the contemporary milieux of urban water management. This provides both an account of the contemporary challenges and the responses being developed to meet those challenges. Importantly this chapter introduces some of the elements of the emerging sustainable
urban water management paradigm that are explored in more detail in following chapters.

To illustrate the relationship between world views, biophysical realities and emerging artefacts and technical systems, a small cross section of innovative wastewater and stormwater systems are discussed in Chapter 8. These provide an insight into the innovation process, illustrating the problems faced by individuals and organisations who attempt to offer alternative solutions. This review shows that the more radical innovations come from outside the existing knowledge systems and are often constrained by existing professional praxis.

Building on this theme of innovation, Chapter 9 presents the concept of Integrated Urban Water Management using the Australian examples of Urban Integrated Catchment Management and Water Sensitive Urban Design. This discussion illustrates that Integrated Urban Water Management represents one of the strongest elements of the emerging sustainable urban water management paradigm.

Chapter 10 provides an account of the evolution of Water Sensitive Urban Design. This illustrates that the concept is more than a new technical system. It represents an evolving form of professional praxis which is both stimulated and constrained by existing professional praxis and the socio-political dimension of the technology framework. The result of this tension is a shift towards a more transdisciplinary form of professional praxis.

The following three Chapters, 11, 12 and 13 contain case studies which present examples of that transdisciplinary praxis in action and are the product of a transdisciplinary design team (referred to as the WSUD team) coordinated by the author. In Chapter 11 a feasibility study of applying an Integrated Urban Water Management approach is provided. It uses a comparison between a conventional
urban subdivision and a hypothetical application of Water Sensitive Urban Design. This illustrates the opportunities provided by this approach and also points to the essential ingredients necessary to apply these techniques in full scale demonstrations.

In Chapter 12 the focus shifts to an analysis of an Urban Integrated Catchment Management project which adopted a participative model, involving community groups, local and state government officials. The case study also illustrates how the Water Sensitive Urban Design technique can be used to interface with the participative processes and provide the tool (or technical system) to achieve community based catchment repair objectives. The case study reveals the importance of linking community aspirations with the wider policy settings and the redevelopment processes occurring in the catchment.

In the case study presented in Chapter 13 the issue of catchment repair is again the focus. This time, however, the challenge is an urban catchment undergoing a rapid redevelopment process where the receiving water environment is under severe stress. The case study presents an example of how water resources and related environmental objectives can be introduced into the planning system, using the Water Sensitive Urban Design framework. It is argued that the outcome of such an approach is the achievement of higher quality development, provision of enhanced amenity for the community, the creation of opportunities for catchment repair and mitigation of any future adverse impacts of the redevelopment process.

The thesis is concluded in Chapter 14 with a synthesis that draws on both the material presented in the earlier chapters and the practical experience gained from the case studies. A number of important implications are drawn from this review for both urban water management and the related but wider process of urban design and management.
CHAPTER 2
HISTORY OF URBAN WATER SYSTEMS

The view from the bridge, mercifully concealed from mortals of small stature by a parapet as high as man is characteristic for the whole district. At the bottom flows, or rather stagnates, the Irk, a narrow, coal-black, foul-smelling stream, full of debris and refuse, which it deposits on the shallower right bank. In dry weather, a long string of the most disgusting, black-green, slime pools are left standing on this bank, from the depths of which bubbles of miasmic gas constantly arise and give forth a stench unendurable even on the bridge forty or fifty feet above the surface of the stream. Above the bridge are tanneries, bonemills and gasworks, from which drains and refuse find their way into the Irk, which receives further the contents of all the neighbouring sewers and privies ... Below the bridge you look upon the piles of debris, with filth, and offal from the courts on the left bank; here each house is packed close behind its neighbour and a piece of each is visible, all black, smoky, crumbling, ancient, with broken panes and window frames.

F. Engels 1845

2.1 Introduction

This chapter places the evolution of water technologies and particularly professional praxis in an historical perspective. It shows how the dominant world view of the last few centuries had its birth place in the Enlightenment, and the modernising quest. But it also shows that it was not until around the turn of the century that the socio-political context and biophysical realities brought about by the industrial revolution were combined with an emerging understanding of water science and engineering. This gave rise to today’s urban water system. Those technologies and the paradigm that surround them are largely still dominant almost a century later. The problems in the water area faced by the modern city looking towards a sustainable future are then summarised.

The chapter concludes by outlining some of the key arguments that are being presented as the foundations of an emerging paradigm of sustainable urban water management.

2.2 The Globalising of Water Technologies and Localisation of Water Management

The manipulation of the landscape as part of the development process changes the flow and characteristics of water. Engineering techniques have been developed to manage this interaction between the sky and the earth. Water technologies and engineering are

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an essential ingredient in any society: without adequate water and wastewater systems no society could survive. But it would seem that as the modernising quest has unfolded, this process of managing and harnessing the water cycle has had substantial negative effects. The economic, environmental, social and even spiritual consequences of the 'civilising' process are becoming increasingly recognised. As society moves beyond the industrial era, it is looking for ways to "constitute a more humble and unified way of conceiving the relationship between earth, water and human life" (Cosgrove 1990: 8). This may involve both searching out the old and looking for new ways to undertake the task of managing the interface between land, water and human settlements.

Western water technologies (artefacts and technical systems) and water related civil engineering (professional praxis) have provided an important contribution to development and human well-being. However, as a form of applied science, 'civil' engineering is now at the crossroads. Water management and technologies are now required to be more ecologically sound and more local at a time when the pressures of urbanisation and the globalisation of the water industry are tending to push in the opposite direction.

2.2.1 Ebb And Flow Of Human Settlements

It is important to remember that the early 'hydraulic civilisations' of Mesopotamia, the Middle East and the early Chinese dynasties all excelled in terms of hydraulic engineering. Whole civilisations grew and prospered on the basis of their engineering ability, even if their 'scientific' interpretation of hydrological and hydraulic processes was incomplete by today's standards. Ultimately these civilisations declined, at least in part because of the environmental insensitivity of their water systems.

However, this aside, it was Renaissance Europe that provided the starting point for European-inspired water technologies to become an essential element in the

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2 There were numerous reasons why these civilisations declined, however, because their water systems were fundamental to their survival the relationship and interaction of the water systems, political systems and the environmental conditions were intimately interlinked.
modernisation quest'. It was during the sixteenth and seventeenth century period that the 'mathematical practitioners' - the surveyor, cartographer and military engineer - emerged as a new professional class who serviced merchants and the emerging nation states of France, Britain and Spain in their empire building and the Westernisation of the new worlds. They were the forefathers of the scientists, hydrologists and engineers of the eighteenth and nineteenth centuries who developed the modern understanding of the hydrological cycle and the theory and practice of calculating water flow (Cosgrove 1990).

It was the forging of these skills and the application of these 'sciences' throughout this period that "elevated the status of the engineer as midwife to the Enlightenment and Republican vision of a new age of reason in which applied science would master the environment" (Cosgrove 1990: 9). With these skills and the advantage of an accumulated capital and imperialist might, 'Western water technologies' have dispersed throughout the world with both negative and positive effects.

It was often argued that engineering control of water would act as the mechanism for a great leap forward into the industrial future for developing countries. In many situations this has not been the case. An understanding is now beginning to emerge of the negative effects of some of these water engineering feats. For example, mega dam projects, "the most inspiring monuments to modern society" are being questioned in terms of economic, social and environmental consequences (Pearce 1991: 33).

On a more positive note, water science and engineering in 18th and 19th centuries played a significant part in securing the health of human settlements. The significant scientific advances of this period, emanating from the work of Pasteur and others, ushered in the 'conquest of water' and the advent of public health in the industrial age (Goudert 1989). This knowledge was combined with the late 19th century concepts of social engineering and domestic science, out of which new social norms now taken for granted, such as washing each day, became accepted social practice.
The late 19th and early 20th centuries provided the basis for much of today's water technologies. Henry Crapper invented the flush toilet during this period and this technology has imbedded itself in western society with what seems to be an amazing permeance. A large part of this permeance is the result of an eighteen-year long British Royal Commission into sewage disposal (1898-1915). Out of that process the engineering community reached a consensus that water carriage and various early treatment processes provided the basis for subsequent practice (Beder 1993a). It was also during this period of rapid urbanisation and industrialisation that approaches to stormwater became more formalised within the engineering profession. The so-called rational method of calculating rainfall run-off was developed as the basis of hydrological studies, providing a basis to design urban drainage systems (Walesh 1990).

Throughout this period where technical knowledge has increased there has also been a loss of recognition of the spiritual relationship of water to human life. In the past, water had a more celebrated place in cultural and social life. In the contemporary setting, water has been commodified to such an extent that much of its spiritual meaning has been lost, although socially and recreationally water still has a significant place in modern culture.

It is apparent that society is now at a turning point, where there is a recognition that the wider issue of environmental integrity must merge with the traditional public health focus of water management to form a new way of approaching water management and the technologies of water and wastewater services. In fact a new, ecological public health is emerging (Chu and Simpson 1994). An increased respect for water might even lead to renewed awareness of water's spiritual significance.

2.2.2 A Watershed - Ecological Thinking

While Western-inspired science and technical knowledge has enhanced our awareness of cause and effect, so too has it increased our understanding of complexity and interdependence. The concept of ecology has added more to this understanding than
any other. As Goerner (1994: 7) explains, ecology has provided a model of the world
where the whole arises out of "many interdependent parts ... where connections can be
hidden in complex systems and the components are bound together in a network of
mutual effect; if you change one thing, another is affected." Often it has not been simply
the science that has pressed these issues; it has been the philosophy that has emerged
out of this way of approaching the world and its interactions (eg. social ecology, deep
ecology, trans-personal ecology). For ecology is the study of interactions and even the
various philosophies and social movements that have sprung up around the notion of
ecology argue for an understanding of those interactions. Goerner (1994:8) argues that
the emerging ecological perspective provided by both the humanities and emerging
science of complexity (see Chapter 4) has helped to reframe and renew science so that
gaps between the sciences and the life-focused discourses such as biology and
human/social sciences are dissolving. Goerner (1994:10) asserts a revolution is
occurring which has:

"a transformed vision of the world, resulting in a transformed vision of ourselves
with implications for how we live and act in the world, and very different
interpretations of our times. Basic ecologism (since the 1960s) creates a root
metaphor for an evolving ecological universe. The deep ecological vision (derived
from complexity theory) creates a literal one, i.e., a physically based understanding
of an evolving, order-producing universe that consists of and is governed by
ecological dynamics."

These perceptual changes are having a fundamental effect on the way water is managed.
In physical terms water tends to integrate all other natural resource and environmental
issues by the simple fact that everything lives in a river catchment or on a groundwater
catchment (or watershed). While many people have a reasonable understanding of the
basic concepts of the hydrological cycle, there is a less well developed awareness of the
dynamics and complexity of catchment processes. Increasingly an awareness is growing
that the energy and material fluxes which occur within catchments are the essential
control mechanisms of life. It follows that if human systems are to be more in tune with
natural processes, then social systems and structures need to be compatible with these processes (Curry 1977, cited in Crombie 1991: 104).

Management strategies which reflect the importance of the sensitive interaction between human and natural systems is gradually being recognised. The Earth Summit's Agenda 21 recognised this point and stresses water management must occur on a catchment basis, even when catchment boundaries transgress country boundaries. It stresses that decisions should be made at the lowest appropriate level, involving all water-user groups, especially women and indigenous people. Importantly Agenda 21 also points to the need for new technologies in the areas of water saving, pollution control, waste treatment, recycling and including flexible and adaptable infrastructure, particularly for developing nations (Sitarz 1994).

In the Australian context, the same recognition is beginning to emerge. Since the late 1980s there has been a growth in the policies and programs aimed at establishing what is referred to as Integrated Catchment Management (ICM). The principles that underpin ICM and its application have been suggested to be as follows (Collett et al 1993):

• The management of land, water, and flora and fauna should be undertaken on a catchment basis because the water catchment is the fundamental environmental unit
• Catchment-wide co-ordination and integration of programs must increase effectiveness in achieving overall environmental and development objectives
• The operational responsibility for action should be allocated to specific individuals and agencies
• Local issues should be identified and as far as possible dealt with by people living in the catchment.

These principles imply a considerable change to the way natural resource and development issues have been tackled. They reflect an attempt to shift away from sectoral approaches and constraints created because natural resource management agencies have not been designed to deal with 'inter-linkages and inter-relationships' of
broad scale ecological and catchment issues (Mitchell 1991). Thus there has been a 
gradual institutionalisation of ecological thinking designed to provide mechanisms for 
improved management at the regional scale.

2.2.3 Some Triggers for Change

The demand for these ecologically oriented approaches is widespread. To illustrate the 
importance of these shifts it is worth reflecting on just three Australian examples which 
indicate a growing awareness of the need for a new relationship between water and 
development.

The first is the controversy and final rejection of the Franklin Dam in Tasmania during 
the early 1980s. It marks a 'watershed' in the nation's political ideology by illustrating 
the rejection of a future dominated by the excess of the modernising quest and a future 
dominated by the engineering control of water. The second is the events of Good Friday 
1989, when a quarter of a million people gathered at Bondi Beach to protest against the 
sewerage pollution of Sydney's beaches. The third is the extensive blue green algae 
which spread throughout Australia's largest river system, the Murray-Darling, in late 
1991. The media images of the Australian aquatic heartland turning green sent shock 
waves through the wider community as the very vulnerability of Australia's waterways 
was made evident, especially as reports of other outbreaks began emerging up and 
down the eastern seaboard and in South West Australia.

The significance of these three events is that they have provided triggers for seeking new 
ways of approaching the problem of how best to manage the interface between water 
and human settlements. But we have a real problem. The present shape of our water 
and wastewater technologies has become so entrenched socially and institutionally into 
the fabric of human settlements and social life, that we find it almost impossible to 
think of alternative solutions. But such alternatives are becoming increasingly necessary 
for environmental and economic reasons.
2.3 But What of Cities?

The water system - both constructed and natural - provides that interface between human settlements and local and regional ecosystems. Water is drawn into cities and towns, often from far afield and discharged after use (and abuse). Thus its use and abuse can provide a good measure of the stress being placed on both source and sink environments. It is becoming increasingly apparent that there is also a need to face the challenge of finding a way to integrate the 'city landscape' into the broad regional landscape or ecosystem, rather than perpetuating urban systems that continually stress the biophysical system and the economic resources of a city's inhabitants.

Historically, the development of reliable water and sewerage systems has been a determinant of the growth of large cities. This is still the case and none can deny that the provision of basic water and sanitation services is recognised as a basic human need. But by the year 2000 most of the world's population will be living in cities and this proportion is likely to continue to grow. In response to this massive growth of urbanisation around the globe, which is largely occurring in less developed countries, Western water technologies are even more pervasive than they have been in the past. But questions are being posed about the appropriateness of forms of technology which some have suggested are at the end of their technical and economic life (Thomas and McLeod 1992).

These technologies and systems were originally inspired by the notion that applied science would master the environment. They derived from a period when water was considered an unlimited resource and when 'dilution' was considered the solution to pollution. But this does not stand up to critical examination of the longer term risk to receiving environments. Urban wastewater and stormwater pollution is now increasingly recognised for what it is - an accumulative contaminant and, in some cases, even toxic. Negative environmental messages are continually being observed, with eutrophication of waterways being the most notable example.
2.3.1 Water Technologies and City Form

But to shift from one form of water technology to another it is essential to understand the historical relationship between water technologies and urban form. Cities are shaped primarily by the dominant transport technology but water technologies are also critically involved. It has been shown by Newman and Mouritz (1992) that there is a convergence in the implications for urban form when consideration is given to sustainability from the perspective of urban water as well as transport and energy. To understand how transport technologies have shaped cities it helps to see the history of cities as set out in Figures 2.1, 2.2 and 2.3 which show the transition from walking to transit to auto technology. Such city types still exist in different parts of the world, with Australian cities clearly in the latter form though there are remnants of the walking and transit cities within many cities.

The transport energy associated with these three city types has been analysed (Newman & Kenworthy 1989). This has shown an exponential relationship between the use of gasoline and the density of the city. Whilst Australian cities continue to build new suburbs of uniformly low density with an assumption of car dependence, they will face increasing questions about their sustainability whether it be due to their oil vulnerability, smog, greenhouse gases, traffic problems or the social and economic problems they raise (Newman, Kenworthy & Vintila 1992).

Water can be analysed in similar fashion to transport energy in cities. Typically Australian cities show that the consumption of household water increases as the density of the suburbs decreases due to the greater need for garden watering lower density developments (Sumner 1990). However the issues of urban water sustainability - ocean sewerage outfalls, stormwater pollution, loss of wetlands and creeks and the sheer costs of providing water and sewerage infrastructure - these issues can also be better understood by looking at an historical perspective on cities.
As pointed out above much of today's urban water management and technology was developed in the 19th century. In the walking-based pre-19th century cities (Figure 2.1) water was managed with a localised supply and treatment; such small cities were able to manage quite adequately without the need for more extensive supply, collection or treatment. However when the industrial revolution came and cities grew rapidly it was no longer feasible to manage cities in this way. The much greater quantities of water needed and the associated increase in sewage, as well as the increased stormwater from the larger urban area, generated the need for new technology, new management processes and new urban form.

The transit-city (Figure 2.2) not only provided a new way to solve the problem of where people lived and worked and moved around, but it provided a way to manage water as set out in Box 2.1. The result was the 'big pipes' engineering approach - both for bringing water in and for removing wastewater. This technology was associated with a particular highly centralised management approach and worked well in the linear or corridor based transit cities.

However with the twentieth century and the automobile, cities have increased considerably in population size and have sprawled extensively in area and in every direction with low density development. Along with problems of automobile dependence outlined above, there are now problems with water management in such cities. This is because the large sprawling city is approaching new limits in the capacity of surrounding water supplies and receiving waters; there is new awareness of the ecological value of natural water systems; and there are new constraints on the economics of providing the infrastructure for the 19th century 'big pipes' - oriented solutions (CEPA 1993) - see Box 2.2.
TRADITIONAL WALKING CITY

Up To 1850 In Europe

- High Density
- Mixed Use
- Organic Structure
Figure 2.2

TRANSIT CITY
1850 - 1940 dominant city form in industrial world

- Medium Density
- Mixed Use
- Grid Based
- Centralised

Tram Suburbs

Rail Based Suburbs
Figure 2.3

AUTOMOBILE CITY

1940 - Present, US + Australian Cities Mostly

- Low Density
- Separated uses
- Arterial Grid and cul de sac Based
- Decentralised
**Box 2.1**

**19th CENTURY SOLUTIONS TO URBAN WATER MANAGEMENT**

- **WATER SUPPLY**
  - Large scale water supply system from a few large water sources.

- **STORMWATER**
  - Collect it all and discharge to receiving waters.
  - Engineer water courses and drains.

- **SEWAGE**
  - Collect it all and discharge after some treatment to receiving waters i.e. based on dilution.

i.e. "BIG PIPES IN - BIG PIPES OUT"

(Source: Newman and Mouritz 1994a)

---

**Box 2.2**

**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.

- Costs of "big pipes" infrastructure is becoming too high.

- Water supply augmentation solutions are becoming economically and environmentally questionable.

(Source: Newman and Mouritz 1994a)

---

Note: In relation to the magnitude of the problems identified above most of Australian stormwater systems are referred to as separated systems where as much of Europe and parts of North America have traditionally had combined sewer and stormwater systems. Therefore there is considerable variation in the degree of problems depending upon the type of systems installed.
2.3.2 Towards a Sustainable City

A more Sustainable City (The Future City, see Figure 2.4) needs to address the problems summarised above (Box 2.2). Some possible goals as far as water management is concerned are set out in Box 2.3 as important features of achieving a more sustainable city.

The idea of doing more with less is nothing new, but in the water sector the emergence of water conservation represents the last realistic oasis (Postel 1992) as continued supply augmentation is becoming increasingly expensive and environmentally unfriendly. Although water conservation has been an element of water management for some time, it is fair to say that it is only just beginning to receive the attention and resources it deserves. A "new water agenda" is beginning to emerge, and Australia has the opportunity to learn from others' experience (American Water Works Association 1993).

<table>
<thead>
<tr>
<th>Box 2.3</th>
<th>WATER-ORIENTED GOALS FOR A SUSTAINABLE CITY</th>
</tr>
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<tbody>
<tr>
<td>• Reduced import of water into cities.</td>
<td></td>
</tr>
<tr>
<td>• Ocean and river outfalls made redundant.</td>
<td></td>
</tr>
<tr>
<td>• Recycling of water for various urban and peri-urban uses.</td>
<td></td>
</tr>
<tr>
<td>• Recycling of nutrients and organics.</td>
<td></td>
</tr>
<tr>
<td>• Creeks and wetlands an integral part of city but managed for their ecological integrity.</td>
<td></td>
</tr>
<tr>
<td>• Increased soft surfaces (and reduced urban sprawl) for stormwater retention.</td>
<td></td>
</tr>
<tr>
<td>• Reduced requirement for large pipes. (Source: Newman and Mouritz 1994a)</td>
<td></td>
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</tbody>
</table>

While reduction of use is essential, other innovations may provide a more radical change in the structure of the urban water cycle. It would appear that it is now technically feasible to manage cities with far less water and in much more environmentally compatible ways. Instead of big pipes of water coming in and big pipes of wastewater
going out, it is possible to opt for localised water harvesting, recycling and ecological engineering to treat wastewater locally and use it again.

A key element in this argument is that the current mix of investment in urban water infrastructure is approximately 85 per cent for the distribution network and 15 per cent for treatment. Increasingly the question is being asked whether this is the most appropriate or the most efficient and effective means of meeting demands (Thomas and McLeod 1992). If the investment ratio could be balanced as the process of urbanisation and asset replacement goes on, there could be increased investment in the treatment of water instead of its transport. Potential whole new water systems, more decentralised in nature, might develop. Such shifts will require new technology, new urban management processes and new urban form. The kind of urban technologies and water management processes that are being developed, with potential to solve these problems within the new ecological and economic constraints, are set out in Box 2.4. All of these technologies and management approaches are actively being examined by urban water authorities around the world and in Australia, all of whom are facing increasing pressure to be more economically efficient and environmentally effective (AIUS 1991 and DITAC 1992).

---

**Box 2.4**

**WATER AND SUSTAINABLE CITIES**

**NEW URBAN TECHNOLOGIES**

- Small scale high quality sewage treatment.
- Localised stormwater treatment and recycling.
- Water harvesting for localised supply purposes.
- Water efficient appliances, fittings and technologies.

**NEW URBAN MANAGEMENT PROCESS**

- Integrated water management.
- Least Cost Planning
- Urban integrated catchment management.
- Localised community processes in water management.

(Source: Newman and Mouritz 1994a)
The implications, however, for urban form and urban land management are only beginning to be considered. The kind of city form which would enable such solutions to be worked out, is set out in Figure 2.4 as Future City, showing the establishment of more localised urban management areas based around transit-oriented urban villages. The inherent reductions in transport energy used in such a city are already being realised in cities that are adopting such a strategy (e.g. Toronto, Stockholm, Portland, Zurich - see Newman, Kenworthy & Robinson 1992). These localised areas can also become the basis for water management using small scale wastewater treatment systems, recycling locally and using various water harvesting possibilities. With the reduced automobile dependence produced from enhanced transit and greater localised (walking-based) destinations, the city also has the possibility of stopping urban sprawl and increasing the proportion of soft surface in order to improve local stormwater management. Such a city may have linked systems with strong co-ordination but considerably greater local orientation and community involvement.

The process of change in water management from the localised Walking City through the Transit City and Auto City to the localised Future City are summarised in Box 2.5.

<table>
<thead>
<tr>
<th>Box 2.5</th>
<th>CHANGES IN WATER MANAGEMENT APPROACHES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CITY FORM</strong></td>
<td><strong>WATER MANAGEMENT</strong></td>
</tr>
<tr>
<td>pre 19th century WALKING CITY</td>
<td>Localised supply and treatment</td>
</tr>
<tr>
<td>19th century TRANSIT CITY</td>
<td>&quot;Big pipes in - Big pipes out&quot;, with quantities of water supply and sewage generally not exceeding surrounding capacities.</td>
</tr>
<tr>
<td>20th century AUTO CITY</td>
<td>Same as transit city but with capacities exceeded.</td>
</tr>
<tr>
<td>21st century FUTURE CITY</td>
<td>Localised systems, linked to the broader city, but with less centralised big pipes approaches and more sensitivity to local environment.</td>
</tr>
</tbody>
</table>

(Source: Newman and Mouritz 1994a)
Figure 2.4  FUTURE CITY

- Extended Transit (heavy and light rail).
- Urban Villages (walking distance to transit stops)
- Mixed Use.
- Low Density areas within short bus or cycle distance of transit/Urban Village.
2.4 The Basis of a Sustainable Urban Water Management Paradigm

The contemporary perceptions presented above of the need to look for more integrated and sustainable approaches to management of the urban water cycle have been developing for some time. Figure 2.5 illustrates how societal goals are changing and forcing the need for some basic rethinking about the objectives and outcomes of water management and technologies. This section provides a review of the main arguments which underlay the apparent shift that is underway.

In fact the call for a new paradigm of sustainable urban water management has emerged from broad range commentators. For example Winneberger (1974: 3), an established and well respected American engineer provided a very pointed attack on the 'monumentalism' of the big systems in a review of on-site grey water technologies, suggesting that:

"For over one hundred years since its initial widespread use in London, the water flushing toilet always has used substantial amounts of pure drinkable water to transport relatively minuscule quantities of body waste through a network of sewer pipes to rivers, lakes or oceans (with and without intervening treatment) or to an individual, on-site treatment and or disposal system. Mixed with the body waste is wastewater from baths, sinks and other water - using household appliances and fixtures as well as industrial waste in the case of centralised sewerage systems. Recent advances in sanitation engineering technology have raised serious questions about such methods".
**TIMES OF TRANSITION**
Societal goals are changing

**Shift of focus to sustainability**

<table>
<thead>
<tr>
<th>Old Technical Paradigm</th>
<th>New Technical Paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. MANAGEMENT OF URBAN WATER</strong></td>
<td><strong>2. SOURCE CONTROL</strong></td>
</tr>
<tr>
<td>• provide water, drainage and sanitation</td>
<td>• to protect the environment and recycle resources</td>
</tr>
<tr>
<td>• sectorized approach</td>
<td>• multi sectoral approach</td>
</tr>
<tr>
<td>• target local scale</td>
<td>• Act local: Think global</td>
</tr>
<tr>
<td><strong>3. TECHNOLOGY</strong></td>
<td><strong>RESULTS (possible)</strong></td>
</tr>
<tr>
<td>• to reduce flooding</td>
<td>• to reduce pollution formation</td>
</tr>
<tr>
<td>• &quot;traditional&quot; hard solutions</td>
<td>• &quot;novel&quot; softer solutions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RESULTS</th>
<th>RESULTS (possible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• mixture of water qualities</td>
<td>• circular flows of water and resources</td>
</tr>
<tr>
<td>• linear flows of material</td>
<td>• public participation &amp; acceptance</td>
</tr>
<tr>
<td>• increasing environmental degradation</td>
<td>• changes in lifestyle</td>
</tr>
<tr>
<td>• loss of resources</td>
<td>• restoration</td>
</tr>
</tbody>
</table>

*Figure 2.5 Times of Transition in the Water Sector*  
(adapted from Niemczynowicz 1993).

Similarly, Stoner (1977) and van der Ryn (1978) provide outlines of the contemporary wastewater problem set in historical contexts. These documents provide an indication of the relationship between welfare policies of the industrial city and the dominant influence of the engineering paradigm of that period, illustrating the social shaping of technology (MacKenzie and Wajcman 1985). But they do more than this by illustrating new artefacts
and technical systems emerging from a green perspective (world view) of the 1970s and call for wholesale changes to the system.

Evidence of an emerging paradigm can also be seen in the focus of international conferences, symposia and workshops. This has been particularly evident during the 1990s. For example the 1992 Stockholm Water Symposium focused on the:

"Rethinking needed in the water quality management sector... (based on) ... the concept that 'getting rid' of pollutants is fundamentally misguided ... (and pointed out) ...

pollution problems can therefore be coped with only if land and water are managed in an integrated way. In the long run, the cycles of crucial nutrient and non-degradable elements involved have to be closed, for the sake of nutrient conservation and to prevent toxic substances from entering food chains" (Skogsfors and Falkenmark 1992).

The Hydropolis International Workshop in 1993 provides another example of the shift in professional practise, with its focus towards integration of science and engineering, with urban planning and design and decision making processes (van Engen et al 1995). Similarly in November 1993 the Sydney Water Board held a conference entitled "Ecologically Sustainable Water Management - a Threat or an Opportunity" (Sydney Water Board 1993). At that conference the focus was articulation of new approaches and on the potential commercial opportunities that they might provide. Another good example is that of the Urban Water Lifecycle Partnership, which is a partnership of research users and suppliers in the Australian water sector. At their National Scenario Workshop on urban water science and technology needs, the participants called for a new paradigm and articulated a number of potential scenarios which may shape the Australian and in fact the world's water industry (Australian Science and Technology Council 1995). A summary of these scenarios is provided in Box 2.6. All the scenarios describe a future where there is a radically different shape to the water industry and to the technologies used. Therefore it is apparent that significant questions are being asked about the future shape, form and characteristics of water technologies.
All of these conferences are supported by mainstream professional bodies or institutions in the water arena and thus tend to exhibit the changing landscape of values and concerns that underlay emerging artefacts, technical systems and professional praxis.

While the preceding discussion has highlighted the shifts that are occurring in professional attitude, at a deeper level the call for a new paradigm needs to be seen as consistent with the wider shift from modernism to a post modern and/or post industrial age. As pointed out earlier, society is moving into a post-industrial phase, it is looking for ways to "constitute a more humble and unified way of conceiving the relationship between earth, water and human life" (Cosgrove 1990: 8). However, finding a way to establish a new relationship is not necessarily straightforward. As one of the world's most eminent hydrologists, Malin Falkenmark has pointed out, there is an absence of a useful conceptual framework for understanding and thus managing the manipulation of human intervention in the hydrological cycle and landscape change. Falkenmark (1992: 10) points out that:

Development = Landscape Change = Hydrological Change, stressing that:

"intervention of the landscape is necessary to make biomass, water, energy available for supporting livelihood, socio-economic improvement and life quality. The interventions, however, produce unavoidable environmental consequences".
ASTEC Urban Water Lifecycles Partnership

National Scenario Workshop 4-5th July - Outline Report

The national scenario workshop of 4-5 July developed four scenarios for the future of urban water systems. Each of these scenarios describes a possible future urban and social context, together with a characteristically different water system that might be expected to develop in that context. These scenarios allow exploration and assessment of the future scenarios of water supply, storm water management, and sewerage. A draft summary of each scenario is presented here. The titles are provisional.

The final versions of each scenario will be presented for discussion at the regional workshops.

Market World
In this scenario, the Australian public sector has been fully privatised. Water is provided by a large number of retail suppliers who draw from a common 'spine' supply that in turn is fed by a variety of water sources and water producers. Catchments are sold off to raise money. Regulation is light, which permits many innovatory services and 'water products' to be marketed. The population is expanding, and greenfield sites are developed using innovative technology. Competitive integrated systems with export potential are developed. Environmental concerns are addressed through the market with the introduction of tradable waste permits. Overall water use is controlled by demand management programs. Electronic metering allows variable pricing, for example off-peak and in droughts.

Eco-Event World
In this scenario, the steady build-up of ecological problems and crises worldwide has driven dramatic change. Australia has passed legislation that requires the design of all new infrastructure projects to follow ecologically sustainable development (ESD) principles. The structure of industry is shifting towards closed-loop production systems, with a high level of recycling. Environmental costs are now fully internalised. The price of water has risen, but this is offset by successful demand management, and innovative technology for water reuse. Water management is focused at catchment and sub-catchment level, and is supplied at several different quality levels, tailored to end use requirements. Water supply, storm water handling and sewerage are now integrated into a single focus on the water lifecycle.

Slow Change
This scenario tells the story of the current system in decay. This is a future in which there are no overriding events to force change, and little public money is available for maintenance and repairs to the existing system. There are increasingly frequent sewer collapses and burst mains, and increasing water loss across the system as a whole. Dam capacity is being reduced by siltation, waterways are polluted, and there is growing pollution of groundwater. In this scenario, if expenditure on maintenance is withheld long enough, there is eventually a crisis in which the whole system breaks down and there is simply not enough capital available to rebuild it. At this stage the only response is radical innovation.

Public Health Crisis
In this scenario there are overriding concerns about threats to public health. The threats include the emergence of new pathogens, the drug resistance of existing pathogens, and the exposure through air travel to increasingly frequent international epidemics. Central control of the water system is increased, and strong leadership is exerted at the local level. Catchments are protected, and recreation on waterbodies is restricted. Environmental concerns are sacrificed where there is a conflict. Water and waste water treatment is stepped up, with increased disinfection, and strict hygiene requirements are introduced for staff. No water recycling is permitted, as it increases the risk to health. Personal diagnostic kits for testing water quality are popular. In some areas, drinking water is delivered to households by tanker, and water factories for bottled water are beginning to emerge.

Box 2.6 Urban Water Lifecycle Partnership - Scenario Summaries

(source ASTEC 1995)

36
Thus Falkenmark calls for a new conceptual framework which relates land use change to water responses and higher order environmental risks and human health. Others such as Hollick (1991) have pushed the debate a step further and have developed the argument that in order to better understand how to manage water resources for sustainability, there is a need to shift from a Newtonian world view to a self-organising systems world view (see Chapter 4). He points out that while much of the human developed water system is not self-organising, i.e., pipes and reservoirs, it is essential to recognise that "management" is about enhancing a system's capacity for self-organisation, rather than applying 'command and control' strategies. Thus, Hollick argues for a shift to management structures and processes which are adaptive and embrace change through the use of interdisciplinary processes and heterarchical structures (rather than sectoral approaches and hierarchical structures). He also asserts that technologies need to be more decentralised and thus more inherently adaptable to change and the uncertainty of a post modern world.

In a similar vein, Browne (1993: 26) concurs with this general thesis, pointing out that water and particularly wastewater systems have been planned according to deterministic/mechanistic principles, usually with a single objective and "conceptualised as being substantially separate from their operating environment, i.e., as servant mechanisms." Browne (1993) calls for more ecologically and holistically based water cycle planning, that is iterative and multi-objective and incorporated into an action-oriented decision making system based on risk assessment. Browne suggests to facilitate this shift, reform of management and regulatory frameworks is required, and issues a warning that economically inspired commercialisation needs to be balanced with integrating processes.

In a paper that addresses the whole essence of sustainability and the urban water sector, Clark (1990) pointed out that the water system provides one of the most significant interfaces between human settlements and ecological processes. Clark suggested that reforms associated with commercialisation might provide an opportunity to clearly differentiate between the regulatory and service delivery areas.
However, Clark's real contribution to this debate was to point out that simply transferring from a public monopoly to a private monopoly provides little in terms of dealing with the real challenges faced by urban water systems (see section 7.2). He suggested that in the context of sustainability there is an 'inappropriateness' of the water technologies developed during an era when the notion of the so-called 'economies of scale' has dominated thinking. Clark (1990: 23) affirms that the "growth of large, interlinked and complex water systems has been both a cause and a result of the paralleled growth in large monolithic organisations to operate them." He pointed out that as water infrastructure of our cities began to deteriorate, an opportunity would arise for a new form of water management and technology to be devised in a more sustainable manner.

Clark (1990) suggested that there is a whole range of small or medium scale water technologies which have the potential to provide community scale water services. However, he points out that these types of approaches are resisted because they threaten the industry's traditions and established modes of operation. Thus before any substantive change could emerge it would appear there is a need for both a change in institutional arrangements and approaches to technology choice and provision. These insights imply that before the concepts such as "appropriate technology" and "technological choice" can be successfully applied in the water sector, acknowledgment needs to be given to the social, institutional and political context of how technological solutions are sought. As Willoughby (1990: 7) points out:

"The appropriate technology notion points to the need for knowledge of a diversity of technical options for a given purpose, careful analysis of alternative options, and the exercise of political and technological choice. Conscious human effort is required to ensure that technology is appropriate. The factors which are implicated in technological choice extend beyond those normally taken into account by engineers and business managers under the rubrics of efficiency or profit."
In the water sector, processes of 'conscious choice' are starting to emerge with wider involvement of the public in water and wastewater planning (see Section 7.3.5). But economic reform issues are also ingredients of this change: as Clark (1993) suggests in a more recent paper, there is likely to be a defection to 'integrated' solutions as they become seen as more viable than existing systems. This defection poses significant risks to major water utilities who stand to lose a significant share of their customer base unless they begin to focus on delivery of integrated water service solutions. Thus a transition is likely to emerge due to converging perspectives on the need for integration and commercial realities.

While the commentators reviewed above have presented arguments about broader need for paradigm change, Beder (1993a) has focused her research and analysis on the paradigms within sewerage engineering. She points out that the engineering community reached a consensus earlier this century that a narrow range of treatment options would be the basis of their subsequent practice. Beder asserts that this consensus appears to have prevented serious consideration of alternative technologies and constrains innovation at a time when the old paradigm is no longer adequate to the demands of emerging environmental and economic constraints.

These insights point to the need to guard against establishing a consensus on treatment options or standards; the debate needs to focus on outcomes and then seek out solutions which meet those outcomes. If this approach is adopted then solutions presented are likely to come from outside of the domain of the current skill base within the water sector, both managerially and technically. In a review of research priorities within the Australian Urban Water Sector, Thomas and McLeod (1992: 1) reflect an awareness of this type of concern, suggesting:

"The urban water industry in Australia faces both radical institutional change and some daunting technical challenges ... anticipated institutional and managerial changes will not in themselves be sufficient to overcome the challenges ahead. Nor, even, will continued incremental technical change be sufficient to achieve the
efficiency gains, infrastructure cost savings and environmental quality targets to which Australians aspire. We argue that some of our problems require a rethink of the basic system-wide design for water provision and wastewater disposal.

And that this in turn demands an unprecedented integration of knowledge about community preferences, system options, economic analysis and technical research: in particular, research into urban stormwater hydrology, near-urban storage sites (including aquifers), water and wastewater treatment technologies, water re-use, system-wide management and urban planning."

These insights are also supported in the international literature in a paper by Niemczynowicz (1992: 133-147) who suggests:

"The traditional approach to water related problems must change drastically; wastewater treatment technologies applied at present need to be complemented, and eventually replaced by novel, economically efficient and environmentally sound technologies".

And later Niemczynowicz (1992) suggests the basis for a new approach will need to include all of the following key elements:

- **Integrated systems approach**, with both structural and non-structural elements in contrast to narrow-minded technological approaches.
- **Multi disciplinary cooperation**, in order to solve complex problems.
- **Small scale**, in contrast to technological monumentalism.
- **Source control**, instead of 'end of pipe' approaches.
- **Local disposal and reuse**, instead of exploitation and wastefulness.
- **Pollution prevention**, instead of reacting to damage.
- **Use of biological systems and ecological engineering**, in wastewater and solid waste management.
This review of contemporary challenges to the water sector has illustrated the degree of changes being called for. The so-called "big pipes in - big pipes out" approach to urban water management is facing a real challenge. But it would appear that a realisation of any change will only emerge if there is wide-spread adoption of new frameworks of thinking and practice (world views and professional praxis).

For the shift to occur it will require an unprecedented integration of land and water planning in the urban context. Thus there is an urgent need for tools with which to integrate land and water planning in the urban context. Two emerging themes from the literature which have the potential to aid in this transformation are ecoplanning and ecotechnology. They represent a fairly substantial shift away from the traditional flat earth planning and mechanistic approaches to engineering design, towards recognition and incorporation of ecological processes. The notion of ecological planning has a longer history than ecological engineering and most notably has its origins in McHarg's famous design book - "Design with Nature" in 1969 (see also Hough 1984, Lyle 1984, Dorney 1989). On the other hand ecological engineering is a more recent arrival and can be linked to the publication by Mitsch and Jorgensen (1989) "Ecological Engineering: an introduction to ecotechnology".

It can be argued that ecological thinking is increasingly becoming a basis for design with potentially far reaching effects. For example Todd (1987: 132) suggests:

"... applied ecology has an intrinsic potential to dissolve old divisions between north and south, industrial and agrarian, and rich and poor. This is because ecological knowledge can be applied universally and, equally importantly, it can often be directly substituted for capital and for non-renewable resources."

These ideas are reinforced by Mitsch and Jorgensen (1989: 4-5) who go to some length to distinguish between the concepts of ecological engineering or ecotechnologies and
traditional environmental engineering. They affirm Todd's ideas, by suggesting that ecological engineering and ecotechnologies:

"...has as its raison d'être the design of human systems with its natural environment (for the benefit of both), instead of trying to conquer it. And unlike conventional engineering, ecological engineering has in its toolbox all of the ecosystems, communities, organisms, that the world has to offer."

While the principles and practice of ecoplanning and ecological engineering are yet to be fully part of professional praxis there are at least some steps along the way. One of the most notable examples has been the emergence of the notion of Integrated Urban Water Management (IUWM). At its core it challenges the designers to shift their thinking and management focus to a more local orientation. At the design scale this means site responsiveness and use of natural processes rather than use of hard engineering solutions which have often been applied universally with little respect for the local environment (see Chapters 7 & 9).

Thus the notion of 'ecological engineering' and 'ecotechnologies' are set to supplement and potentially replace the discipline of environmental engineering, which has all but replaced the practice of sanitary engineering that emerged about a century ago. Similarly ecological planning is supplementing the traditions of town planning. These are more than mere name changes, as they represent shifts in the focus and scope of professional praxis and have a real potential to influence institutions. The challenge for the next century, in terms of provision of urban water services, will therefore be to introduce innovative water technologies, management systems and institutional arrangements which are able to meet, simultaneously, the multiple objectives of equity, environmental integrity and economic efficiency, while maintaining a high level of water services for urban dwellers (Newman and Mouritz 1992). This shift in focus also presents a challenge to the increasingly global nature of the water "business".
2.5 Summary

The link between human settlement and water management and technology is inseparable. It appears that there has been a globalisation of Western water technologies since the Renaissance, however, there has been a rapid spread of these European inspired water technologies since about the turn of the century. These technologies are now beginning to be questioned in terms of their environmental and economic performance. In particular, an increasingly ecological world view is building an awareness that engineering design needs to be more locally responsive and incorporated into urban design in an era when the water industry is becoming increasingly more transnational and therefore more likely to apply similar solutions in vastly different environmental and cultural contexts.

Increasingly it is being argued that opportunities exist for developing a new more sustainable form of urban water management - even a new paradigm has been called for - one that is less dependent upon a 'big pipes-in-big pipes out' approach. This presents a major challenge to those involved in the water sector, the urban planning profession and to the recipients of the technologies.

The question that needs to be at the forefront in any water technology or institutional choice, is whether the system being designed has the capacity to both provide the desired service to humans being asked of it and the ability to provide enhanced environmental outcomes rather than contributing to environmental decline. More humble and unified relationships between land, water and life are being sought. But this will only be achieved if there is an increased willingness to integrate concepts and ideas in a transdisciplinary way.
CHAPTER 3

CHANGING WORLD VIEWS - SUSTAINABLE DEVELOPMENT

The standard policy of hard-nosed leaders is: maintain course and speed and if it ain’t broke, don’t fix it. This was the policy of the captain of the Titanic. The Titanic sank, but the policy didn’t. Major changes in political and/or economic institutions are only possible after existing institutions have been conclusively discredited by some major disaster. We must learn to look further ahead, and to change course before disaster is unavoidable. For this we need the social equivalent of the radar and the rudder.

Udo Simonis 1993

3.1 Introduction

The previous chapter provided an historical perspective of the need for developing new approaches to urban water management. The objective of this chapter is to illustrate how the changing world views associated with the introduction and promotion of sustainable development are beginning to influence the various dimensions of the technology framework, particularly professional praxis. In particular it will focus on providing an outline of the concept of sustainable development and the societal shift it is attempting to create. This review covers a brief account of the origins of the concept and the need for a shift to sustainable development which integrate environmental and economic concerns.

The problems of defining sustainable development is outlined in a way that illustrates the divergent values that underlie various interpretations. While the problem of definitions cannot easily be overcome the chapter provides a review of the core meaning and key features of the concept. An outline is also provided of what Agenda 21 contains. Finally the chapter is concluded with an outline of some of the political implications of implementing sustainable development.

3.2 Origins of Sustainable Development

The notion of Sustainable Development (SD) can be traced to the emergence of the conservation movement over the last 20 to 30 years. The notion began being articulated around the time of the UN Conference on the Human Environment (Stockholm 1972) where the first World Conservation Strategy was endorsed.

At that conference 113 nations pledged their support to begin tackling environmental issues on a global basis. The problems of chemical contamination and global consumption of natural resources were high on the agenda of concern. Contaminants had crossed all borders so it was no longer possible to allow DDT or PCB's or radioactivity to be released anywhere without it affecting everyone. Natural resource consumption patterns were seen to be too high. The inequity of resource consumption between the developed and developing world also had begun to be realised. Thus the idea of slowing development to help the environment came hard against the reality of poverty and the need for development. The one billion people living in abject poverty with not enough food to eat, did seem to have some legitimate claim on the world's resources.

Around that time the term eco-development emerged as an alternative to traditional development thinking (see for example Riddell 1981). The original concept of eco-development was little different to today's use of the term SD. This is that economic development processes need to more fully recognise and integrate environmental and social issues, particularly intergenerational issues i.e. solving poverty and environmental problems can be done simultaneously. However, it was not until the UN established the World Commission on Environment and Development in 1983 that the term Sustainable Development became popularised and gave more substance to the idea. In 1987 they published "Our Common Future" or the Brundtland Report (1990), which clearly showed the interdependence between development and the environment
and vice versa, presenting for the first time a coherent argument about the need to synthesise or integrate development and ecological thinking in a global context.

Nations then had to show how they would do this when they met in Rio de Janerio in 1992 for the Earth Summit Conference on the Environment and Development. This conference cemented the concept into the dialogue of international diplomacy and policy. The resulting documentation was signed by 179 nations representing 98% of the world. This was no ordinary conference as it established global commitments by the nations who signed the agreements. To achieve these agreements there had been three years of preparatory talks between scientists, activists and administrators. The documents developed through this process and agreed to at the Earth Summit were:

- A statement on sustainability called the Rio Declaration.
- A 700 page action plan for sustainability called Agenda 21.
- A convention on Climate Change.
- A convention on Biological Diversity.
- A statement on Forests

(Keating 1993).

As a lead-up to that event the Australian Government undertook the Ecologically Sustainable Development process (ESD) which provided a major review of the issues and policy options to achieve sustainability. ESD was choses as the term in Australia as it was thought that SD did not give enough ecological content. A number of ESD working groups were established, representing industry, government and conservation interests. The resulting nine volumes and 480 recommendations have remained a major source of policy advice for governments at all levels. The Federal Government condensed the ESD reports into two documents which were seen by most contributors to the ESD process (conservationists and industry) to be a shadow of the original nine documents. However, the ESD process did provide a forum for dialogue and has cemented the term into the vocabularies of the conservation movement, industry and
government. Various sectors of Australian society are now struggling with how it will implement the concept of ESD.

Thus the period of the late 1980's and early 1990's can be seen as a period when the earlier notion of eco-development became institutionalised and legitimised to a point where sustainable development is now an over-arching political objective for many. However, there is still a long way to go from rhetoric to reality, particularly to be part of professional praxis. The following discussion helps to explore this issue in more detail.

3.3 Why sustainability?

As pointed out above, the call for SD as an overarching concept has come about through increasing recognition that environmental, social and economic problems are linked. At the policy formulation level the dominant paradigm of economic development has often been at the expense of the social and environmental spheres. Figure 3.1 illustrates the lack of adequate integration of environmental indicators, and to a lesser extent social indicators, with the commonly used national account and development indicators.

The lack of an integrated approach to policy formulation in response to environmental disasters and environmental management issues in general, is set out in Figure 3.2. This shows how responses are typically dominated by highly reactive and political solutions.
Figure 3.1 Poorly Integrated Policy Processes Lead to Unsustainable Development
(adapted from Ten Brink 1991)

A typical example of this reactive approach was the outbreak of blue green algae in Australia's largest river basin, the Murray-Darling system in 1991, and the gradual emergence of similar problems in many other inland rivers. Although the threat of such an occurrence was well understood by scientists and regulatory agencies, little was being done to combat the problem. The political response brought about by the media attention given to the situation saw the immediate development of an Algal Task Force of 'experts' to assess the issue. Subsequently a policy and management program was formulated and money became available. However, the problem was not new, just more widespread and politically captivating at the time.
The same is true for many other waterways, for example the eutrophication problems of the Swan and Canning Estuary in Perth. Ten or more years of investigations depicting the declining health of the river are little incentive to act, by comparison to the media attention given to algal blooms during the summers in recent years.

Traditionally, decision makers respond most often to the 'squeaky wheel.' The question is whether or not such reactionary approaches provide meaningful solutions. In contrast one of the underlying tenets of sustainability is the adoption of the Precautionary Principle, which shifts the burden of proof to the polluter and requires preventative action to be taken, even when the risks are not able to be proven scientifically, but simply on the grounds that it is preferable that there should be risk minimisation via a choice of a least risk strategy (Stebbing, 1992). The adoption of a precautionary approach would suggest it is time for change before the environmental damage is clear (see Figure 3.3). Increasingly the precautionary approach is being integrated with notions of ecological integrity or health as a more appropriate means of devising pollution abatement and restoration strategies than reacting to problems.
3.4 Definitions and Values

One of the problems with the concept of SD is that as the discussions, research and practice have advanced, so too have interpretations of its meaning or definition. There are reported to be at least 100 or more definitions. Many are similar and are often an interpretation of the World Commission on Environment and Development's perspective.

A small cross section is included in Box 3.1. The key point that can be made from this small sample of definitions is that they represent various value positions. An indication of these positions is provided along with the definitions. Typically, definitions of SD provided by ecologists point to the need for preservation of the status and functioning of ecological systems, while economists are likely to focus on the maintenance and improvement of human living standards (Toman 1992).

For example, Rees (1990:18-23) takes an entropic view, using the second law of thermodynamics to argue that "all modern economies are dependent on fixed stocks of
non-renewable material and energy sources" and thus "they (economies) necessarily consume and degrade the very resource base which sustains them". Developing this argument further in terms of global carrying capacity, Rees points out that the World Commission's route to SD through an implied five-to-ten fold increase in economic activity, does little more than extend the "entire material growth ethic, the central pillar of industrial society" (Rees 1990:21). Rees therefore points to the ecological limits of development. He is aligned with an array of non-government organisations and critics who see the notion of SD as providing the basis for a more radical overhaul of the industrial growth paradigm and assert the need for a "remaking of society along very different lines"(Albrecht 1994: 97).

By contrast authors such as Pearce et al (1989), have more conservative views of sustainability, suggesting that sustainability requires the maintenance of existing productive or natural capital (i.e. ecological processes that have value to humans). They suggest that natural capital and human capital are not interchangeable and that it is essential for the global economy to begin living off the "interest" rather than the "principal" if sustainability is to be achieved. While this concept is commendable in terms of appreciating the value of the natural world, that value base is very much utilitarian in nature.
Sustainable development = a development strategy that manages all assets, natural resources, and human resources as well as financial and physical assets, for increasing long term wealth and well-being. Sustainable development, as a goal rejects policies and practices that support current living standards by depleting the productive base, including natural resources, and that leaves future generations with poorer prospects and greater risks than our own (Repetto 1986: 15). - Economic and anthropocentric in orientation.

Sustainable development = development that meets the needs of the present without compromising the ability of future generations to meet their own (World Commission on Environment and Development 1990: 87). - Anthropocentric in orientation

Ecologically Sustainable Development means using, conserving and enhancing the community’s resources so that ecological processes, on which life depends, are maintained and the total quality of life, now and in the future, can be increased (Commonwealth Government 1990: preface). - Greater ecological orientation.

Sustainable Development is a pattern of activities which meets the needs of this generation without prejudicing the ability of future generations to meet theirs. This criterion imposes at least four conditions:
1) there must not be unreasonable depletion of any resource;
2) there must not be significant damage to ecosystems;
3) there must be no significant decline in social stability;
4) the sustainability of other societies must not be harmed (Lowe 1991). - Some elements ecocentric with social justice and anthropocentric orientation.

Sustainability is the persistence over an apparently indefinite future of certain necessary and desired characteristics of the socio-political system and its natural environment (Robinson et al 1990). - Anthropocentric orientation.

Sustainability implies avoiding catastrophic change at a systemic and subsystemic level while retaining the capacity for creative self-organising evolution without affecting the capacity of other similar, external, systems for the same persistence and evolution (Slocombe 1990). - Not ecocentric or anthropocentric.

Box 3.1 Sample Definitions of Sustainable Development

However, as Beder (1993b: 6) has pointed out, many definitions of SD do not "guarantee the needs or quality of life of animals or other living organisms... (and) ... for some environmentalists this concept does not go far enough. They argue that all living creatures have a right to exist that is separate from their usefulness or value to humans." Thus the various interpretations of SD are very much value based and depend upon the world view held by the author.
These two examples and the definitions presented in Box 3.1 illustrate a range of divergent views at an ethical level, however, they all present a case for a more environmentally sensitive view of development.

While there will be a continual struggle to define SD, there are some points of apparent agreement between environmental groups, business groups and government: that economic activity and environmental quality are closely related and that there is an increased need to recognise the interests of future generations (i.e., intergenerational equity) (Beder 1993b: 6). These are major attitudinal shifts that have resulted from the debates about SD in contrast to earlier conflicts between the development and conservation sectors. Conflict, however, still persists, but there is at least an increased level of recognition of the interdependence of economic and ecological issues. Conflict resolution, institutional change and technological change, particularly in terms of developing integrated solutions are recognised as being of paramount importance (Carley and Christie 1992: 38).

As shown above differences are mostly due to differences of world views or value systems. Zenthoven (1990) referred to these interpretations using the terms: shallow, intermediate and deep, to contrast the varying views of sustainability. Others such as Turner (1988 cited in Dorcey 1991: 536) present a four level way of organising and describing alternative world views. These are summarised as:

- **Cornucopian technocentrism**: an exploitative position supportive of a growth ethic expressed in material terms (e.g., Gross National Product); it is taken as axiomatic that the market mechanism in conjunction with technological innovation will ensure infinite substitution possibilities to mitigate long-run resource scarcity;
- **Accommodating technocentrism**: a conservationist position, which rejects the axiom of infinite substitution and instead supports a 'sustainable growth' policy guided by resource management rules;
• *Communalist ecocentrism*: a preservationist position, which emphasises the need for prior macro environmental constraints on economic growth and favours a decentralised socio-economic system;

• *Deep ecology ecocentrism*: an extreme preservationist position, dominated by the intuitive acceptance of the notion of intrinsic (as opposed to instrumental) value in nature and rights of non-human species.

While it is recognised that there is a continuum between these views what is clear is that the underlying values are quite divergent and debate about the value positions should be encouraged. To date there has often been a lack of adequate consideration of these value or world view issues. For example, in their critique of the Australian Ecologically Sustainable Development process, Barns *et al.* (1992: 5) point out:

"Sustainable development means much more than a moderate adaptation of existing development strategies. It involves a confrontation between opposing philosophical traditions - one predicated on continuing growth, expansion and progress, the other on conservation and limit. The sustainable development debate has the potential to foster productive dialogue between these opposing traditions, stimulate critical reflection on assumed moral frameworks and produce some measure of 'frame-integration'. The danger is that when dominant groups adopt the term 'sustainable development' these deeper questions become repressed and the elaboration of sustainable development is turned into a basically technical task."

Barns *et al.* (1992) go on to point out that the architects of Australia's Ecologically Sustainable Development process were obviously aware of the value issues, at least to the extent of needing to bring together representatives of the major interest groups with an active stake in environment and development issues. The creation of a forum in which developers, bureaucrats, scientists and conservationists could sit down together was generally constructive and productive. However, Barns *et al.* (1992: 6) suggest that the "process did little to stimulate sustained reflection on the political and philosophical
frameworks underlying 'development' and 'sustainability' approaches." While there may have been weaknesses in the Ecologically Sustainable Development process, these underlying value issues have begun to occur more openly since then in the continuing global processes of SD, such as the Earth Summit and their reflection in such things as the State of the Environment reporting occurring at national, state and local government levels, along with Local Agenda 21 strategies (see for example Brown 1993 & 1994). Thus it has been a more 'sustained' process than Barns et al (1992) predicted, although there is still a long way to go.

The ethical dimensions of SD need to be continuously aired and given opportunity for debate if any form of cultural and institutional change is likely to be achieved. Engel (1990: 20) asserts that if sustainable development is to be elevated to an effective global ethic, it will depend upon "the emergence of a new kind of holistic moral understanding and action by associations of concerned citizens, from all facets of life and in every society of the world."

3.5 Understanding Sustainable Development

Although the concept of sustainability (or SD) is clouded with both theory and rhetoric at the academic level, what is clear is that it represents an evolving ethic which is articulated in many forms. As Roseland (1992: 7) puts it:

"like other political objectives (e.g., democracy), we all agree with the need for sustainable development and disagree over what it entails."

Notwithstanding these vagaries, "it appears that sustainability is becoming the clarion of a new age ... the idea of sustainability is replacing the idea of progress (and thus) the potential for change is enormous" (Norgaard 1988: 613-614). Thus because of the significance of the concept, it is useful to come to grips with what SD is not. One important distinction that has been made, is that of the comparison between SD and Environmental Protection. Roseland (1992: 7) uses the following analogy to make this distinction very clear:
"Environmental protection is like a sheet of foam - it offers some protection from a fall. We congratulate ourselves if we double our spending to double the thickness of the foam, because we assume thicker foam means more protection. However, we only get more protection if we fall the same distance. Meanwhile, unsustainable development is constantly increasing the distance we fall. Sustainable development must therefore be more than merely protecting the environment: it requires economic and social change to reduce the need for environmental protection."

The notion of SD therefore emphasises the qualitative aspects of development as opposed to the more traditional emphasis on quantitative growth. As Daly (1990), points out:

"To grow means to increase naturally in size through the addition of material through assimilation or accretion, to develop means to expand or realise the potentialities of; bring gradually to fuller, greater or better state. In short, growth is quantitative increase in physical scale while development is qualitative improvement or unfolding of potentiality. An economy can grow without developing, or develop without growing or do both or neither."

As part of a Canadian project aimed at establishing the characteristics of a sustainable society, Robinson et al (1990) suggest that the following are key characteristics of sustainable society:

- Sustainability is a normative ethical principle. It has both necessary and desirable characteristics. Therefore there exists no single version of a sustainable system.

- Both environmental/ecological and social/political sustainability are required for a sustainable society.

- There should be no guarantee of persistence for any particular social or ecological system in perpetuity. The aim should be to preserve the capacity for these systems to change.
Thus sustainability is never achieved once and for all, but only approached. It is a process, not a stable state. Robinson *et al* (1990) suggest it will often be easier to identify unsustainability than sustainability.

Numerous commentators have asserted that clear principles need to underpin any policy of SD. For example, at the initiation of the Australian ESD process, the then Prime Minister Bob Hawke, asked the ESD-Working Groups to consider the following principles as part of their deliberation of sectoral issues:

- The improvement of individual and community well-being and welfare that does not impair the welfare of future generations;
- The provision of equity within and between generations;
- Protection of biological diversity and the maintenance of ecological processes and systems; and,
- Recognition of the global dimension.

In a similar fashion the Australian conservation movement (Hare 1990) articulated the following policy principles in its submission to the ESD process:

- Maintenance of natural capital and sustainable incomes
- Recognition of biophysical limits
- Pricing environmental values and natural resources
- Precautionary policy approaches
- Qualitative development
- Social equity

Although there is a differing emphasis, these types of principles set a direction aimed at highlighting and integrating the issues of:

- Maintenance and protection of natural capital and biophysical resources, and,
• The development and improvement of the socio-economic condition of human activities (Beder 1993a).

Increasingly business leaders recognise the significance of the concept and have added their weight to the call for change. For example Hawken (1993), in his stimulating book "The Ecology of Commerce", points out that despite the good work that many companies are making, environmentally and socially, there is a need to recognise that if every company adopted the best practice of the leading companies, world society would still be moving towards sure degradation and collapse. Hawken (1993: pxiii) suggests that "recycling aluminium cans in the company cafeteria and ceremonial tree planting are about as effective as bailing out the Titanic with teaspoons."

Thus, from many perspectives the status quo is not acceptable and it appears clear that social, economic and institutional change are as important to the quest for sustainability as technological change. In summary although there is and will continue to be much debate it appears that there is at least some agreement that the concept of SD implies:

• An evolving ethic which recognises the interdependence of economic, environmental and social systems.

• Entrenching environmental considerations into economic policy and decision making at all levels.

• An inescapable commitment to social equity, within and between generations and between developed and less developed countries.

• Development does not simply mean 'growth', it implies qualitative growth as well as quantitative improvement.

• The ecological integrity of ecosystem processes must be preserved or rebuilt to ensure that the opportunity for creative self-organisation is maintained.
Sustainability is a process not an end point. Maintaining the capacity of the system to change and respond to threats and challenges is a key ingredient of the process.

3.6 What Does Agenda 21 Say?

As a major instrument in furthering the SD debate and aiding in the process of implementation, Agenda 21 represents an important milestone in the global shift towards SD. Agenda 21 is presented as a continuously-evolving framework for development of national strategies, plans, policies and processes aimed at achieving sustainability. The 500 page document reinforces the arguments developed by the World Commission on Environment and Development (1990) that population, consumption and technology are the primary driving forces of environmental change.

A high priority is given in Agenda 21 to eradication of poverty by giving poor people more access to the resources they need to live sustainably. As such, signatories to the documents are expected to accept that industrialised countries have a greater responsibility to clean up the environment than do poorer countries who utilise substantially less resources and thus create relatively less pollution. Agenda 21 also places responsibility on the developed nations to aid in the development process of the poorer nations, to build their capacity to carry out sustainable development practices.

The document stresses the need for national governments to adopt national strategies for sustainable development. However, it recognises that governments need to work creatively to foster change by working in partnership with international organisations, business, regional, provincial and local government and non-government and citizen groups. Essentially it is about a "global partnership of change" which provides for a safer and more prosperous future (Keating 1993: ix). Keating (1993:6) describes Agenda 21 in the following way:
"Agenda 21 is not a static document. It is a plan of action. It is meant to be a hands-on instrument to guide the development of the Earth in a sustainable manner. Recognising the global nature of the environmental problems that face humanity, it is based on the premise that sustainable development of the Earth is not simply an option: it is a requirement - a requirement increasingly imposed by the limits of nature to absorb the punishment which humanity has inflicted upon it. Agenda 21 is also based on the premise that sustainable development of the Earth is entirely feasible. The transition to a global civilisation in balance with nature will be an exceedingly difficult task, but Agenda 21 is the collective global alert that there is no alternative. We must align human civilisation with natural equilibrium of our planet and we must do so rapidly if we are to prevent an irreversible decline in quality of life on Earth ... Agenda 21 proposes an array of actions which are intended to be implemented by every person on Earth ...."

Agenda 21 sets out a whole range of strategies and actions in the area of social and economic development, conservation and resource management, emphasising the role of major groups and providing guidance on implementation. Two of the key recommendations are:

- Local Agenda 21 Strategies. Each local authority or regional government needs to set out a strategy by 1996, outlining how Agenda 21 is being achieved in their locality.
- State of the Environment Reporting. This is a reporting process at all levels of government on various environmental indicators.

Local Agenda 21 processes provide the opportunity to focus action at a level which people can comprehend and be involved in. State of the Environment Reporting provides a means with which to enhance the potential for better decision making about development, by simply having indices of environmental factors to complement economic indicators.
Further, Agenda 21 suggests that the concept of sustainable development is based on two central questions:

"First, is it possible to increase the basic standard of living of the world's expanding population without unnecessarily depleting our natural resources and further degrading the environment upon which we all depend? And second: can humanity collectively step back from the brink of environmental collapse and at the same time lift its poorest members up to the level of basic human health and dignity?" (Sitarz 1994: 4-5).

The Earth Summit and all that preceded it and what has transpired since has tended to suggest that there is real hope that the answer to these questions is "yes" (Sitarz 1994: 5). While Agenda 21 has established a clear idea of what needs to be done and why, the academic debate about what sustainability is still rages on. What Agenda 21 has done is to take the concept out of the hands of academics and placed it in a political context of establishing agreements and charters of action. These charters will only be achieved through awareness and political processes at the local level.

3.7 The Politics of SD

Gaining an understanding of what SD is and what Agenda 21 contains is important as a basis for rational policy development. It helps to provide a focus or goal and gradually SD is being adopted and institutionalised within society in general. At a professional level numerous institutes and associations have interpreted SD and incorporated their interpretation of what it means into their professional guidelines. Increasingly, in the Australian context the term Ecologically Sustainable Development is used in policy documents and presented as a guiding principle for how professions view their role.
While these moves are positive, representing an enculturation of the concept, there is still a political dimension which needs to be recognised. As Yanarella and Levine (1992: 760) suggest, all the positives associated with Agenda 21 need to be tempered by some caution. For example they suggest:

"Dialectical fealty to the lofty goal of global sustainable development requires us, however, to question whether this unfolding vision and strategy may not in fact have congealed into a kind of orthodoxy that inhibits as much as fosters the transition to a condition of ecological and social sustainability".

Real change and innovation more often than not comes from outside, from those "who behave randomly, ignoring conventional rationality, who enable the system to adapt creatively to new challenges" (Hollick 1991: 4). It needs to be remembered that this is where the SD concept came from - it was not invented by public servants or academics, but politicians acting to resolve two fundamental desires articulated at a global and local level - the desire to preserve the earth and the desire to overcome poverty and create a better quality of life. It is now moving to centre stage where every aspect of society needs to be viewed through its lenses. However, creativity and innovation, technical, social and political, must necessarily continue to grow to achieve SD objectives.

Change processes inevitably means politics. Without politics very little is likely to be achieved. Achieving adequate political support is dependent upon public recognition of the issues and an understanding of what mechanisms need to be implemented to achieve the changes required. Thus the process of developing sustainable outcomes is a socio-political process which will often involve confrontation between value systems. As Benveniste (1989: 134) suggests:

"In any major change situation, unless trust or authority is sufficient, action will only take place when the subjective probabilities associated with the credibility of the event are such as to allow this action to occur. If you are convinced it is going
to take place, if it appears to be inevitable, if the description of the future is so credible that you believe events are about to happen, you will respond, you will adjust to this image, you will act and respond to the fact that it is credible. This is the concept of the multiplier effect. Once there exists a general conviction that something is going to happen, individuals adjust their behaviour and, in fact, either help to make it occur or harden in their opposition to it."

Increasingly processes for reconciling divergent interest in the SD debate will be required. The first signs of steps in that direction have emerged. In the Australian context, the Ecologically Sustainable Development process involved government, industry, conservation groups, unions, social justice groups and scientists. As such it represented an important first step towards developing a basis for broad based policy formulation. In Canada the Round Table on Sustainable Development at the national level has provided a model for regional and provincial forums with similar agendas. Similarly the New Zealand Resource Management Law Reform saw the establishment of regional governance where environment and development agendas could become more closely aligned. Now Local Agenda 21's are providing the context for community based debate on their future and other community processes inevitably are involving SD concepts (see Stocker and Pollard 1993 and the Landcare and catchment management initiatives in rural areas and, to some extent, urban areas of Australia).

Global and regional government organisations similarly are heavily involved in the SD debate. The UN, ECE, OECD, APEC, ASEAN and the World Bank are all involved. Even the Vice President of the USA, Al Gore (1992) has written a book on the topic, entitled "Earth in the Balance" which spells out his interpretation of the prerequisites for a sustainable future. Thus the concept of SD is very much here to stay.

Critical to all the political debate on SD is the notion that local communities are central to the detail of what SD means. In political terms the whole process of
sustainability is one of moving from representative to participative (Crombie 1991) or possibly associative democracy (Hirst 1994). The development of Local Agenda 21 strategies in particular are beginning to build on these approaches (ICLEI 1995). This thesis will try to draw out what these processes are starting to mean for the urban water sector.

3.8 Summary

The preceding discussion has presented a brief outline of where SD came from and what it is trying to achieve. The discussion has also provided an idea of what SD is, and what it is not. Some of the key features of Agenda 21 have been introduced, as have some of the principles upon which policy should rest.

While it is recognised that there is significant divergence of individual or collective views about what SD is, what is important is that it is not simply an academic concept. Sustainability is very much a political idea and a movement of global and local significance. As Norgaard (1988: 613) suggests, "sustainability is replacing the idea of progress as the clarion of a new age." Thus it will tend to underlie much of the value systems of each new generation as it becomes ingrained within society. The main task for those interested in seeing reform take place during the so-called 'turn around decade' of the nineties, is for the principles of SD to be institutionalised into the fabric of society. This is particularly important for professionals who tend to dominate the policy process.

What appears to be clear from the growing literature and practice of sustainable development is the need for significant change - or as some have asserted - 'transformation'. The dimensions of that change and the mechanisms by which it might be achieved are the topic of ongoing debate and in practice will be determined by the political climate of the location it is attempted in. However, one the strongest underlying tenets of all of these debates is an increased recognition of uncertainty and
the need for systems and technologies, both hard and soft (or social) that are more responsive to change and adaptation (i.e. 'learning to learn' - Cocks 1992: 272 or 'learning by doing' - Walters and Holling 1990). This will undoubtedly require new forms of social organisation (Cock 1991, Carley and Christie 1993). New institutional arrangements and partnerships between stakeholders will be important features of how to make progress towards sustainability. These issues will be pursued in the following chapters.
CHAPTER 4
COMPLEXITY: A BIOPHYSICAL REALITY

In the natural world (complex adaptive systems) include brains, immune systems, ecologies, cells, developing embryos and ant colonies. In the human world they include cultural and social systems such as political parties or scientific communities. Once you learned how to recognise them, in fact these systems were everywhere. But once you found them they all seemed to share the same crucial properties. Each of these systems is a network of "agents" working in parallel. The control of a complex adaptive system is highly dispersed. There is no master neuron in the brain, for example, nor is there any master cell within a developing embryo. If there is to be any coherent behaviour in the system, it has to arise from competition and cooperation among the agents themselves. A complex adaptive system has many levels, with agents at one level serving as the building blocks for agents at higher levels. Further more complex adaptive systems are revising and rearranging their building blocks as they gain experience. At some deep, fundamental level all of these processes of learning, evolution, and adaptation are the same. All complex adaptive systems anticipate the future.

John Holland 1992

4.1 Introduction

This chapter briefly explores the 'emerging science' of complexity, which views the world in terms of 'patterns' and 'process', not 'states' or 'mechanics'. The 'science of complexity' has become the umbrella term under which a range of scientific and wider academic endeavours have begun to be clustered. As Goerner (1994: 12) explains:

"... it is more than a single theory, various cohorts of the revolution rally around a variety of broad and sometimes rather loose labels. The most well-known labels are: chaos, the sciences of complexity, dynamical systems, dissipative systems, far-from-equilibrium systems, fractals, modern nonlinear dynamics and self-organising system theory."

After presenting the basic features of complexity theory the focus of the chapter turns to the relationship between these concepts and SD and to a lesser extent how these concepts might influence the emerging paradigm of sustainable urban water management. The purpose of the chapter is to point out that this 'new science', with its very different view of biophysical realities is in fact beginning to shape world

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views, professional praxis, socio-political context and even artefacts and technical systems.

4.2 A Way of Seeing

Over the last two or three decades a quiet revolution in science has been occurring. Its significance cannot be understated. The Newtonian view that the world and nature is a machine has collapsed and been replaced with a view that nature is made up of self generated patterns, and that there is "order out of chaos" (Prigogene and Stengers 1984).

This revolution exhibits all the characteristics that Jeans (1958: 1) suggests when he says:

"Science usually advances by a succession of small steps, through a fog in which even the most keen sighted explorers can seldom see more than a few paces ahead. Occasionally the fog lifts, an eminence is gained, and a wider stretch of territory can be surveyed - sometimes with startling results. A whole new science may then seem to undergo a kaleidoscopic rearrangement, fragments of knowledge being found to fit together in a hitherto unsuspected manner. Sometimes the shock of readjustments may spread to other sciences; sometimes it may divert the whole current of human thought".

The complexity paradigm is just that type of revolution. This new science is increasingly providing a unifying framework for many areas of physical and human sciences (see for example Gleick 1987, Briggs and Peat 1989, Davis 1989, Hayles 1991, Waldorp 1992, Kauffman 1993, Dalenoort 1994). It is influencing a whole new way of seeing and understanding in fields as diverse as physics, biology and economics. Some have suggested a whole new politics is even emerging (Jantsch 1980, Thompson 1987). For example Goerner (1994: 15) explains:

"The nonlinear revolution destroys the science-supported vision of domination and control by showing that many if not most systems cannot be fully predicted even with equations of motion and precise initial conditions. This means the
dysfunction that comes from a controlling master-of-the-universe mentality can now be challenged on a pragmatic/scientific basis as well as a social/humanistic one."

A core feature of this view of the world (both human and natural) is that there is no longer, from a scientific point of view, a need to imagine the 'ultimate heat death' associated with using the second law of thermodynamics as a basic 'model' for the earth (and even the universe). Ever since Prigogine and Stengers (1984) began to recognise that the second law had major weaknesses, that is that it really only applies to equilibrium systems and does not apply to the natural and human systems, entropic inspired limitations have begun to lift.

Coveney (1992: 205) points out physicists have come to realise that:

"... all processes take a finite time to happen and therefore, always proceed out of equilibrium. Theoretically, a system can only aspire to reach equilibrium, it will never actually reach it. It is, therefore, somewhat ironic that thermodynamicists have focussed their attention on the special case of thermodynamic equilibrium. For the difference between the equilibrium and non-equilibrium is as stark as that between a journey and its destination, or the words of this sentence and the full stop that ends it."

As Albrecht et al (1995: 19) point out, the entropic view of "Newtonian order ... produced a view of universal systems heading towards equilibrium" and ultimate heat death. By contrast "complexity theory has changed the nineteenth century view of entropy as a destructive force." As Davies (1989: 20) explains:

"Scientist have tended to deny that the universe is progressing - through the steady growth of structure, organisation and complexity - to even more elaborate states of matter and energy. This unidirectional advance we might call the optimistic arrow, as opposed to the pessimistic arrow of the second law."
Davies (1989: 20) goes on to assert that the scientific community has "tended to deny the existence of the optimistic arrow" suggesting that while the second law is "inescapable", progress in nature is also an "objective fact." Thus the study of "complexity, self-organisation and cooperative phenomena has revealed how the two arrows can indeed co-exist."

In this vein commentators, such as Ruth (1993: 90), have pointed out that a self-organising view does not discount the laws of thermodynamics, suggesting it has provided a basis for understanding that ecosystems are open systems, able to use material, energy and information flows across their boundaries, at least temporarily, to provide opportunities for self-organisations. But as Gleick (1987: 304) points out that second law of thermodynamics, based on an equilibrium perspective, has been "one piece of technical bad news from science that has established itself firmly in the non scientific culture" and was used as a foundation for disciplines and arguments to which it should not have been applied. Thus theoretical frameworks in many disciplines have been constrained by its limitations.

Since the emergence of these ideas there has been a substantial shift in many areas of science. Jantsch (1980) built on the work of others (particularly Prigogine) and pointed out the potential of understanding the world in terms of self-organising systems theory. Prigogine and Stengers (1984) coined the term dissipative structures for systems in disequilibrium; systems capable of maintaining their identity because "they maintain continuous entropy production and dissipate accruing entropy" (Naveh and Lieberman 1990: 62). Thus dissipative structures maintain order by remaining continually open to the flux and flow of energy and the cycling of material from their environment. As Briggs and Peat (1989: 138) suggest, once this world view began to emerge, interested parties started to see these dissipative structures "everywhere: in biology, in vortices, in the growth of cities and in political movements, in the evolution of stars." Increasingly it became recognised that simple systems give rise to complex
behaviour. Complex systems give rise to simple behaviour and most importantly, the laws of complexity hold universally, caring not at all for details of a system's constituent atoms. In this view of the world, science is a "process rather than state, of becoming rather than being" (Gleick 1987: 304). Thus the focus becomes identification of process and emergent patterns.

Albrecht et al (1995: 23) highlight a number of interrelated characteristics of complex adaptive systems, including:

- There is order in what appears to be chaotic; order arises from fluctuations within the system.
- The sensitive interaction of local and global levels of complex systems determines their properties.
- Local interaction can produce global order and global order can affect local behaviour.
- Interactive causal relationships exit within and between entities.
- Complex systems can form patterns around attractors and follow predictable paths of development.
- The whole is greater than the sum of the parts.

A picture of the significance of these concepts is presented in Figure 4.1. It is based on the work of Chris Langton (cited in Waldrop 1992), one of the influential researchers involved in the emerging science of complexity.
4.3 Applications of Complexity

These concepts are important because theories from physics play an important role in establishing new perspectives and world views which ultimately influence wider society. In the context of this thesis, they influence all the dimensions of the technology framework. As Goerner (1994: 13) points out:

"We're not talking about a breakthrough concerning a particular question - say, how the human gene works. We're talking about a breakout of new tools, concepts and approaches that can be applied to all sorts of questions ... The nonlinear revolution is startling, precisely because it applies to the everyday world not just near-light speed or at subatomic levels."

Increasingly complexity is being applied in diverse fields. Two excellent examples of the application of these theories to sustainable water resource management are Hollick (1991) and Hengeveld and Geldof (1993). Philips (1995) is applying these theories to understanding innovation and economic change, while Hall (1992) and Dalenoort (1994) have provided edited texts which cover issues as diverse as psychology,
engineering, economics, physics and chemistry. Kauffman (1993) has developed a seminal interpretation of evolution from a self-organising perspective.

In recent times chaos and self-organising systems theory has also been applied to examinations of SD methodology and policy (Slocombe 1990, Galloway 1994) and provides a useful way of presenting the related concept of ecological integrity (Regier 1993). It has been significant in influencing perceptions of sustainability. For example, most definitions of SD easily located within the literature, provide a relatively "static view" of the world or as Hollick (1991) points out, they are "pervaded by a sense of limited resources, absence of opportunities, and the risk of change."

Fortunately this is not the case with Agenda 21, which expresses the need for a continuously evolving framework. Few definitions, however, of sustainability are more set in the dynamic and co-evolutionary paradigm of complexity theory than that of Slocombe (1990 - see Box 3.1 above). The value of this perspective according to Hollick (1991) is that it focuses on understanding "how a system came into being, how its structures are maintained and the process of structural change." Cowan (cited in Waldrop 1992: 356) points out that most discussion about sustainability often refers to:

"... transitions from the state A, the present, to a state B that's sustainable. The problem is that there is no such state. You have to assume that the transitions are going to continue forever and ever and ever. You need to talk about systems that remain continuously dynamic, and that are embedded in environments that themselves are continuously dynamic..."

As Waldorp (1992: 356) reflects: "Stability is death; the world has to adapt itself to a condition of perpetual novelty, at the edge of chaos."
From an ecological perspective one of the key 'structures' that is perceived as vital for maintaining this dynamic opportunity, is the maintenance of ecological integrity. Like perspectives of SD, the concept of ecological integrity starts with the recognition that present development patterns of industrialised society (technoeconomic systems) negatively impact on the ecological integrity of the biophysical environments that they are located within. If the negative impact of development is too great it has the tendency to create situations where ecological integrity (and socio-economic integrity) are lost. If this occurs, the self-integrative ecosystem processes essential for the maintenance of the system are also eroded (Kay 1993: 203). In human dominated ecosystems the tendency has been for ecological integrity to be lost or at least put at risk. Figure 4.2 presents this notion diagrammatically.

*Figure 4.2 Ecological Integrity and SD in Self-Organising Terms*

Notes: The Ovoids refer to three multi-dimensional ecosystem domains: left vertical ovoid reflects the fully natural state; central diagonal ovoid reflects different levels of ecosystemic degradation due to cultural abuse; right horizontal ovoid reflects a healthy natural/cultural ecosystem or landscape mosaic. The state of healthy self-integration is high at the top of the figure and low at the bottom. The intensity of cultural influences is absent at the far left and intense at the far right. The arrows illustrate pathways of self-organisation (Source: Regier 1993)
In this view, if a continuous process of self-organisation is to be achieved, ecological integrity must be maintained at various levels of human interaction. For example, intensive agriculture can reach a dynamic equilibrium with a higher level of human interaction than a shifting pattern of cultivation; cities represent even higher levels of human interaction which can be directed towards sustainable outcomes. Or as, Regier (1993: 9) suggests, policy and decision-making processes must be directed towards maintaining or rebuilding self-integrative processes which allow dynamic fluctuations and stresses to be absorbed and provide the basis for creative self-organisation. Therefore the maintenance or rebuilding of ecological integrity (and for that matter cultural integrity) should become a key priority. Figure 4.2 illustrates that corrective action directed towards rectifying the disintegrative stress, may provide reintegration (or a higher level of ecological integrity) to be achieved, even though the full range of self-organising states may be lost within a healthy human dominated ecosystem (right horizontal ovoid). Thus in policy terms, maintenance of a system’s ability for self-organisation, in ecological and human terms appears to be an imperative. This illustrates a complex systems theory overlap with the sustainabilitity principles.

In terms of technological systems (such as water systems), complexity theory highlights that the various artefacts and knowledge systems form highly interconnected webs, where one innovation or technology is highly dependent upon another. As Arthur (cited in Woldorp (1992: 119) explains:

"Once one technology starts opening up new niches for other goods and services, the people who fill those niches have every incentive to help that technology grow and prosper. Moreover, this process is a major driving force behind the phenomenon of lock-in: the more niches that spring up dependent on a given technology, the harder it is to change that technology - until something very much better comes along."
This process has increasingly been referred to as 'path-dependency' and has a significant effect on processes of innovation and economic activity. Philip (1995: 56-57) points out that an evolutionary self-organising economic framework can be distinguished from a reductionist neoclassical framework in the following way:

"The driving force of an evolving (economic) system is the characteristic of diversity. We may characterise the micro level of the economic system as being in a continual flux as agents engage in localised behaviour. Thus, these long periods of 'stability' are characterised by much activity at the microscopic level. Fluctuations at the macroscopic level are the manifestation of the dynamic activity at the micro level. However, both these levels interact in a co-evolutionary, though non-deterministic, and highly nonlinear manner ... Local interactions yield emergent global behaviour and structure which, in turn, feedback onto behaviour at the local level."

The key question in terms of developing more environmentally appropriate technologies is finding a way of developing technical solutions that maintain flexibility and become attractors around which the opportunity for change is more rewarding than staying with the status quo.

These interpretations of the nature of ecosystems and technoeconomic systems provide a recognition that there are processes of transition and periods of relative stability that may be influenced by complex relationships and interactions at global and local levels. This can be useful when considering policies and mechanisms for shifting society towards sustainability. For example, Slocombe (1990) asserts that change can take three forms within the self-organising framework: i.e., change - minor adjustments without real substantive change, restructuring - modifications, more like reshuffling the deck chairs, or transformation - with transformation presenting a real cultural, technological and environmental shift. These processes or shifts can have negative as well positive outcomes. Galloway (1994) asserts that positive transformation processes towards sustainability require "enculturation" of appropriate
value sets within individuals and society, providing alternative world views. These shifts in values or world views may inspire new artefacts and technical systems, but for a transformative process to occur these need to be institutionalised within professional praxis and the socio-political dimension of the framework. In complexity terms, new patterns of behaviour and technologies are required to establish a shift (or bifurcation) onto a continuously evolving path towards sustainability.

As much as anything, complexity theory also provides a hopeful outlook. As Siroli (1995: 169) points out the predicability and control of the Newtonian paradigm can be shed. He suggests:

"Now we truly belong to the cosmos. We exhibit the same irrational behaviour, the same randomness, the same frenetic activity of the rest of the natural world. Chaos is not bad though for it created us, and those who study chaos, are telling us a story which should please us. They are saying that even small fluctuations in complex systems can lead to dramatic change in the overall structure. Such is the interconnectedness of things. We as individuals, are not insignificant in the universal scheme. Our actions and thoughts can certainly make a difference between creating Hell for ourselves and others; and being able to celebrate life and reduce the level of misery on the planet. In our extremely complex socio-economic system, changes which are hardly noticed at a microscopic level have the power to create massive perturbations in the overall economic system ... Ripples caused by barely discernible events can become a flood which can turn the planetary tide."

4.4 Limitations of the New Science

While much can be said in favour of this emerging 'new science', a caution is also warranted. Like all previous breakthroughs, its time will come. As Mathews (1989: 218) points out, recent study into the history and philosophy of science have revealed that society needs to lose its "epistemological innocence" and recognise theories for what they are: models of the world, human constructs which help us to intervene in the world, and that they are not the only way of viewing a particular problem. Thus all
theories or models need to be seen for what they are: tools to help praxis, not an end in themselves. Another key point is that it is necessary to recognise the disciplinary context within which they emerged and recognise they may have real limitations when applied outside of their original context.

E. F. Schumacher is reputed to have said when he pondered Newton's discovery of gravity: "If Newton had tried to figure out how the apple got there in the first place, instead of trying to find out how it fell, we would have had a very different science today." It should always be remembered physics and philosophy are never really far below the surface in world affairs (Jeans 1958).

But Martin (1993: 39) also offers a warning about making too much of the new paradigm, especially when the 'new science' is interpreted as part of the so-called 'new age' thinking. He has pointed out:

"Different people can draw different conclusions from nature ... Darwin saw competition, while Kropotkin found cooperation or mutual aid ... The trouble is that 'nature' doesn't speak with its own voice. It must be interpreted, and there is plenty of scope for different interpretations. And not all interpretations are ones you might like. The Nazis, remember, made a big thing of links with nature .... And remember, a new paradigm isn't always a good thing."

A healthy scepticism should be applied to any virtuous claims about a new scientific paradigm. But with complexity at least there is a clear link, with its focus towards understanding of 'patterns in nature' and human interaction with them of cultures older than that of the present technoeconomic system (see for example Schweck 1965, Mollision 1988: 70-102). This can create humility as well as clues about how to shift our culture towards more sustainable outcomes which accept the need for dynamic change. Maybe complexity is not such a 'new science' after all.
4.5 Summary

This chapter has illustrated that in parallel with the shift from 'progress to SD', the emergence of the 'new science of complexity' - based on the nonlinear dynamics, chaos and self-organising systems theory - provides a very different view of biophysical realities than the mechanistic and reductionist approaches provided by Newtonian paradigms. These concepts have begun to transform a diverse array of science and academic thinking. At its heart is the view that nature is made up of 'patterns' and has provided a "vision of a directed order-producing universe." A universe where "life, civilisations and consciousness are not accidents but logical products of an unfolding order-building process" (Goerner 1994: 21).

In human systems these theories have been useful as away of picturing the complex adaptive nature of the economic system. The interconnected web of the technoeconomic systems has been referred to as having a 'path-dependency' dictated by linkages and relationships within the systems. The potential for change in the trajectory of an economy or technological system is seen as occurring at three levels - change, restructuring or transformation. Transformation occurs only when there is a substantial discontinuity or bifurcation in the system. The emergence of complexity theory, as 'a way of seeing' has provided new insights and creative opportunities in the sciences and humanities (Hayles 1991). The concept points more clearly to the idea that sustainable development must not be seen as an end point but a process and that the world needs to be viewed in terms of a continuous process of transition. In this context, human systems (and their technologies) need to be able to remain continuously dynamic and responsive to stress, as do the nature systems they are embedded in. Thus economic diversity and flexible technologies in human systems and maintenance of the ecological integrity and biodiversity in ecosystems appear to be key principles for a more sustainable world. The concepts of complexity, chaos and self-organisation also point to the potential and reality that small 'ripples' can and do have global consequences.
CHAPTER 5
NEW MANAGEMENT - CHANGING PROFESSIONAL PRAXIS

Companies that create more elegant ways of doing things, that create material and energy flows that are exponentially more efficient will become inefficiency arbitrageurs. They’ll force internalization onto their competitors because these companies will achieve efficiency at negative or nearly negative costs, which will set the standards for the rest of the industry. This will be the wedge, the foot in the door. It’s not going to begin with legislation or regulation; it’s going to begin by imagination.

Paul Hawken 1995

I don’t care how much you know until I know how much you care!

Participant at a public meeting 2

5.1 Introduction

This chapter focuses on the new forms and approaches to 'management', as an element of professional praxis. These changes have come about at least in part because of changing world views and changes in artefacts and technical systems, and their interaction with the socio-political context. The discussion also includes consideration of the organisational and institutional changes that are occurring as society moves into what is often referred to as a post-industrial era. Brief discussions based on perceptions from Commerce, Environmental Management, Administration and Governance are provided. The importance of these insights in the way the sustainable urban water management paradigm emerges cannot be understated.

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2 This sentiment was originally expressed at a public meeting and was reported as a key principle around which public participation must be based during the conference recorded in van Engen, H., Kampe, D. and Tjallingji, S. (eds) (1995) Hydropolis: the role of water in urban planning. Proceedings of the International UNESCO-IHP Workshop, Backhuys Publishers, Leiden, The Netherlands.
5.2 New Management and Commerce

One of the most dominant themes in both the academic and popularist literature on the changing shape of commerce and production is the growing debate about the nature, extent and shape of the "industrial divide" (Piore and Sabel 1984). In the context of this review it matters little about the specific features of this debate, as it is apparent that all agree change is occurring at a rapid rate and that commerce, the firm and industrial relations all need to change. The direction of that change and how it is played out will differ depending upon the disciplinary starting point and value base of the analyst. What is consistent, however, is a basic agreement that a new global economy is forming which constitutes a "decisive break with the post-war era of mass production, mass consumer markets, mass welfare state and Taylorist work organisation" (Phillimore 1994: 10).

Bamber et al (1992: 2-3 cited in Phillimore 1994: 10) suggest there are at least four broad pressures for change:

- In the general economic climate, especially the crisis in Keynesian macro economic policy-making after the oil price shocks of 1973 and 1978 which ushered in an era of stagnation and recession followed by more liberal economic policy measures in many countries
- In product markets, which have seen mass production techniques adopted in newly industrialising countries, while domestic markets in the advanced industrial economies have become much more volatile and, in some cases saturated and subject to increasing competition and instability
- In technology, especially in terms of micro-electronics, computers, telecommunications and the workplace in all their forms
- In politics, away from an interventionist role for the state and towards a greater concern for micro economic reform aimed at promoting markets
A fifth important driver not often captured in the management literature is that of "enoughness." Weinberg (1993: 1) uses this term to point out that the energy utility industry needs to recognise there is a world-wide shift in values "from exploitation and consumption of resources to enoughness and sustainability". Thus, values in the market place are shaping industrial change.

Recognition of all of these drivers is beginning to mean that industry in general (including the water sector) is increasingly seeking out more flexible solutions to meet economic efficiency and environmental performance obligations set by the market place and, in some situations, new regulatory frameworks. Effectively, what is transpiring is a shift from a mentality of mass production, in which economies of scale and low unit costs of production are the criteria of economic 'common sense', to organisations driven by the logic of 'flexible specialisation', in which economies of scope and responsiveness to customer needs drive the organisations' methods of operation (Piore and Sabel 1984 and Phillimore 1989). In addition, as a recent review article in New Scientist on the 'nature of work' in the electronic age pointed out, "offices are ceasing to exist and job security has gone the way of lamplighters" (Arthur 1994:28).

These changes are perceived to be widespread. For example, Scarbourgh and Corbett (1992:2) point out that during the 1980s there was a "trend towards disorganisation of industry and corporations." They suggest that:

"Large-scale bureaucratic organisations fragment and deliquesce into loosely connected networks of production and innovation. There are extensive moves towards the subcontracting of activities and more flexible forms of interorganisational relationships and alliances emerge."

As Naisbitt (1994: 50) puts it:

"The bigger the world economy, the more powerful its smaller players, and the big players are getting smaller ... The mind set that in a huge global economy the
multinationals dominate world business couldn't have been more wrong. The bigger and more open the world economy becomes, the more small and middle-sized companies dominate ... Competition and cooperation have become the yin and yang of the global marketplace. Cooperation is taking the form of a vast array of economic strategic alliances. Products can be produced anywhere, using resources from anywhere, by a company located anywhere, to a quality found anywhere, to be sold anywhere. This is being done through webs of strategic alliances. One reason for the growth of strategic alliances is companies avoiding getting bigger."

Thus the commercial world is seeking ways to innovate and respond to an uncertain market place. Bigger is seen as a commercial risk: small and medium sized firms are seen as better able to respond to the market. Networks or alliances are seen as administrative or organisational 'tools' for competitive advantage.

All of these perceptions and 'realities' are forcing a change in management. But the shape and nature of institutions has a significant influence on that innovation process. As Johnson (1992: 23) points out, "institutions are normally quite rigid and do not change easily: a tension often occurs between changing technology and institutions and a pressure for institutional change is often provoked." Engaging in 'institutional learning' and "thriving on chaos" have become the catchcry of management consultants (Peters 1989). Customer focus and quality management cycles which incorporate workers in management are seen as tools for efficiency. The role of the entrepreneur and facilitation of business development is now increasingly seen as a 'winner' over government inspired business development programs for improving local economies (see for example Sirolli 1994). Thus developing meaningful plans and processes for managing change has become an essential part of management (Benveniste 1989).
It appears that economic realities are changing as fast as the degradation of the biophysical environment is being recognised. Only a few see the explicit link between these two apparent realities of this era. For example, Hawken (1993: 2) sees the question of environmental collapse as not a management problem, but a design problem, "a flaw that runs through all business". Therefore Hawken argues, business has a major role to play in devising alternative strategies, and suggests:

"business is not just a reasonable agent for change; it is the only mechanism powerful enough to reverse global environmental and social degradation ...

Business people must either dedicate themselves to transforming commerce to a restorative undertaking, or march society to the undertaker".

The question therefore becomes: how? The most common theme seems to be to develop a commercial sector which is responsive to change. Innovation and learning are seen as the key to successful business strategies, as are the acceptance of diversity and difference, both in markets and cultural terms. Networks and alliances are seen as essential features of competitiveness. These ideas have become the focus of management and have replaced technical proficiency as a key requirement for management.

5.3 New Forms of Environmental and Resource Management

Management pressures are little different in the environmental and resource management arena. Increasingly there is recognition that sectoralised society with its compartmentalisation of the environment into different spheres of management has not served society well. The organisations responsible for environmental and resource management are seen as needing to change.

The fragmentation of resource management is a reality in many areas and none more so than in land and water. Recognition is emerging that conceptually land and water cannot be separated even if administratively they are. Thus the focus of
environmental management in recent years has been towards "boundary and co-
coordination issues" (Mitchell 1990: 12). For example Mitchell (1991a) undertook a
review of these issues in Western Australia and pointed out that at least some of the
senior 'players' involved in the move towards integrated resource management and
decision making have observed a 'quiet revolution' in the movement towards new
approaches and programmed work plans.

There is, however, an inertia built into the bureaucracies based on a history and
organisational culture that supports fragmentation. To overcome these problems,
processes of coordination and integration are needed. As Patterson (1989: 46)
asserts, there is a need for clear definitions of jurisdictional boundaries between
agencies and levels of government, many of which may need to be redefined and plans
of management (i.e. catchment plans) to coordinate action at local levels are required
to ensure that public bodies perform effectively and know what their missions are.
Often the public perceive the importance of these shifts in organisational style and
operation. The following quote about urban land and water integration from a
community representative at a workshop that was part of the Melbourne Water
Resources Review (1992:93) reinforces this point:

"... urban planning is currently done by one set of people, while design and supply
of particular services is done by others. There is a need for these processes to be
better integrated".

If the public perceive the problem, what in practice can be changed to assist in getting
integration to happen? This is a common problem as Brown (1995) points out in her
review of communication patterns of coastal zone managers, which included
professional colleagues, local government, state government, federal government,
education, the conservation movement and industry. Brown (1995: 18-19) has shown
that "all policy sectors are recycling the same information, with little new information
entering from other sectors, education or research." This finding helps to confirm
Mitchell's (1991b: 269) assertion that "government resource management organisations were not designed to deal with the ecological problems which are characterised by inter-linkages and inter-relationships". The response to this management failure has been the emergence of what has become referred to as 'Ecosystem Approaches' (for a review see Slocombe 1993). In the Australian context this notion has seen the emergence of Integrated Catchment Management initiatives (for a brief history of ICM in Australia and Western Australia in particular, see Hollick and Mitchell 1991).

Lee (1992: 73) takes the argument for institutional reform in the name of sustainable resource management further by suggesting that:

"Institutionalisation of sustainable resource and ecosystems management practices will require better information about the appropriate scale and form of social organisation ... (but)... Small, flexible institutional units may be best suited for the adaptive learning necessary to achieve sustainable resource management".

This position echoes some of the key concepts that are emerging in the environmental and resource management field (as they are in business management). That is, the notions of being 'adaptive' and 'of learning' represent essential tools in coping with complexity and uncertainty.

The concept of adaptive environmental management as a way through uncertainty has developed over a period of time and can be traced at least in part to the work of Holling (1978). In that document the concept of Adaptive Environmental Assessment and Management (AEAM) was outlined and illustrated with case studies from a cross section of resource management areas. Since that time AEAM has evolved into a management process which revolves around the use of highly structured workshops involving all stakeholders, decision makers and 'experts' in a process which builds quantitative computer models of 'systems dynamics'. This becomes a framework for assessing management options and scenarios (Walters and Holling 1990). The
strength of the process lies in the involvement of the community, resource managers, and decision makers and an appropriate cross section of experts. The computer model serves two important functions:

- It ensures that there is a clarity of communication between 'experts' and those with 'local knowledge' in a way that helps to simplify the 'system' into a core understanding which can be built on and changed as knowledge grows.
- It provides the opportunity for the various management options to be tested before they are put into practice and once decisions are made the focus is on 'Learning by Doing' and adapting policy responses (Walters pers com).

Whether adaptive management utilises the core process and computer focus of the AEAM technique is of little importance, the concepts of 'learning by doing' and 'adaptation' of resource programs have increasingly become endorsed as a logical response to uncertainty.

In a water resource management context, Hollick (1991) has extended the 'adaptive' philosophy and used insights from self-organising theory, suggesting that this new ways of understanding the world demands new strategies, including:

- Viewing water resource management as part of a sociobiophysical system which has the capacity to trigger major system changes.
- Cultivating a capacity of the system for self-organisation rather than attempting to control it.
- Learning to live with change and uncertainty and seeking to understand the processes that may amplify fluctuations.
- Exploring possible alternative futures rather than seeking to predict the future and maximising the number of options available.
- Prolonging processes which seem to run in creative directions, stopping those which appear to be uncreative.
- Making frequent incremental adjustments rather than major changes.
- Using technologies for water and wastewater which harmonise with the natural and social systems.
- Developing more flexible and adaptable, decentralised water and wastewater systems.
- Viewing all citizens as 'managers' of the system and encouraging participation and information sharing.

Above all, this self-organising perspective seeks to encourage adaptation and change, through flexibility of management and technologies. Risk and uncertainty is off-set by cultivating opportunities for creative change. Thus it can be seen that this view of the world contrasts greatly with traditional modes of management which have arisen out of Newtonian or deterministic world views.

These views point to the need for environmental issues to be dealt with in a cooperative, strategic and integrated way, emphasising community responsibility and participation. Martin (1991) suggests the need for a "communicative approach" which emphasises communication between individuals as well as within and between institutions. In this mode of management, Martin (1991: 773-783) suggests:

"People are encouraged to take responsibility for their own resource care and to learn about their environment in an experimental way. This style of learning and problem solving promotes hazard resolution and is opposite to planning imposed from governments. The role of government organisations becomes one of facilitation, education, support and linkage rather than planning and decision making."

Another question being posed in the transition to new styles of environmental and resource management is: what is the role of disciplinary knowledge and the professions when learning is, at its core, cutting across all disciplines? Who weigh up the importance of different knowledge on resource issues? Should such ultimate questions of balance rest with the 'community' rather than the specialist? Confronting
This issue is essential to the task of pursuing more sustainable resource management. Increasingly new modes of professional practice are required that can incorporate a range of disciplines.

Perhaps the most appropriate way of describing the shift needed is to consider the distinctions between a single discipline, multidisciplinary, interdisciplinary and transdisciplinary approaches. Dorsey (1991), Albrecht et al (1995) and Meeth (1987) see the progression as:

- **Single discipline** - a problem tends to be defined by what single disciple thinks it to be and insights tend towards specialised knowledge and reductionist approaches.

- **Multidisciplinary** - is seen as a process by which relevant aspects of problems are addressed by different disciplines, but integration between disciplines is not common. Often when studies are undertaken in this manner there is a segmentation of the knowledge sets into separate parts of a report. Hard disciplinary boundaries are often placed to expose different facets of the problem.

- **Interdisciplinary** - is seen as a process which helps to integrate several disciplines in a way that brings interdependent parts of knowledge into a form which relates part to part, part to whole and whole to part. Other aspects of the problem from disciplines not involved are left out. But often this approach relies on only minor revision of the theoretical base of each discipline throughout the process of a study or investigation.

- **Transdisciplinary** - is seen as beyond disciplines, where the problems or issues are the starting point and solutions are developed directly through a process of problem solving. This involves the knowledge of relevant disciplines and the tacit or local knowledge of non-experts is given a legitimate role in developing the conceptual framework and problem solving process. The outcome of such approaches is the linking of disparate information systems into new forms of integrated knowledge or 'models' of the problem within which better solutions are found.
This transition from 'single to trans' illustrates that there has been a growing recognition of the need to move away from relying on specialist knowledge to solve environmental and resource management issues, towards an approach that has sometimes been referred to as 'community science' (Roby 1984, Stocker 1994).

Community science is where science is focused by the community on their needs and driven in a partnership between scientist/specialists and the community. It also takes seriously science which is developed on the ground by non-specialists like farmers, naturalists and others who collect data and experiment with their local environments. It suggests that there is much to be learnt from local sources of knowledge rather that just 'expert' knowledge from 'laboratories'.

This brief review of the environmental and resource management field has shown a great similarity to the review of management in the commercial sector provided above. Common themes are flexibility, adaptability and learning. There is an apparent link between the ideas of increased worker involvement in the management of the 'firm' and the literature in the resource management field which points to the need for transdisciplinary frameworks that focus on the problem(s) at hand, not an approach framed by a particular disciplinary context. Increasingly, the community or resource users are seen as partners in the policy, research and management process. Learning by doing and iterative processes are at the core of new management in this field.

5.4 New Administration and Governance

In the implementation of new management there is also an emerging theme that governance must also change. The political, administrative and welfare state are increasingly under pressure to change. The relationship of that change to the governance of land and water should never be far from mind and is best illustrated by remembering that the early 'hydraulic societies' prospered because of the link between governance, administration and their water technologies. Part of the decline has been attributed to the tendency of those societies to use their water technologies and
political authority to enforce social structures which became increasingly oppressive (Saha and Barrow 1981 cited in Dorcy 1991: 544).

The relationship between water, technologies and politics in today's society is little different. Both cities, with their large intakes of water from afar, and the irrigation districts that serve them, rely entirely on maintenance of coherent and responsive political, social and administrative structures. But the ability of modern bureaucracies to respond to a rapidly changing world and still serve community life is increasingly being questioned (Handler 1990). As pointed out above there is much to learn about appropriate institutional arrangements for sustainable management practices. A key question raised by Paehlke and Torgenson (1990) throughout their text serves to highlight this point:

"Is the environment an administrative problem or is administration an environmental problem?"

Paehlke and Torgenson's (1990: 292-297) answer is to assert the need for a new form of administration - what they refer to as Environmental Administration - which would be characterised by the following features:

- Non-compartmentalised - a form of administration which resists the typical bureaucratic tendency to compartmentalisation.
- Open - the hallmark of conventional administration is secrecy and needs to be replaced by 'discursive designs' and communicative processes.
- Decentralised - decentralised in a way that can both think and act globally and locally at once - not a total collapse of central systems but a hybrid.
- Anti-technocratic - meaning a distinct shift from elitist professional supremacy to a clear recognition of the legitimate role of the generalist and interactions where citizens and experts forge partnerships.
- Flexible - in approach to problem solving and service delivery.
Although Paehlke and Torgerson's argument appears to be focused towards 'environment', their analysis crosses all elements of administration and has relevance in all areas of public and private administration.

Another common theme in administration, whether it be in the public or private sector, is the shift of focus to networks and alliances as a new form of administration (Rowe 1994). As Carley and Christie (1992) point out, partnerships and networks are forming within the resource management sector and between industry, government and community. In technical terms, Carley and Christie (1992: 169) suggest that networks are non-hierarchical social-systems which constitute the basic social form that permits an inter-organisational coalition to develop. Brown (1995: 41) refers to networks as "a linked system of free-standing participants learning through shared goals, ideas and interests." In this view networks are seen as encouraging self-reliance and acceptance of responsibility (i.e. self-organising) whereas traditional administration is seen as having rigid information barriers and fixed territories and tends to stifle inventiveness and encourage buck-passing. This has often been a common feature of traditional approaches to land and water management.

Governance is also changing. Paehlke and Torgenson (1990: 298) and Goodin (1992: 95) suggest that the first wave of 'green' politics has tended to be absorbed and smoothed over with modest reforms by administration and governments. But with a 'self-organising environmental movement', recognition of the need for a new politics is also emerging. Eckersley (1992) and Goodin (1992) and others do much to point to the collapse of left and right arguments. The green political movement often argues that it is neither right or left, but further ahead.

Naisbitt (1994: 41-51) takes these arguments much further in his consideration of what he refers to as the "Global Paradox" and makes a number of telling assertions about the future of politics, including:
"The G-7 Tokyo economic summit (1993) had all the appearance of a bunch of mainframes talking to each other in a PC world."

"Whether prime minister or CEO, if you are an old mainframe thinker you are no longer relevant."

"The idea that the centralist government - one huge mainframe - is the most important part of governance is obsolete."

"The world today is about the individual, not the state. It is about self-organisation, just as business has experienced the shift to self management."

"Political parties are dead. Haven't their leaders noticed? No one joins a political party anymore (at least in a tribal sense). Tribal affiliations - cultural and professional - are much more important."

"In post-representative democracy, people represent themselves, and ultimately everyone becomes a politician."

"The new age mantra 'think globally, act locally' is therefore turned on its head. It is now: Think Locally, Act Globally. Think Tribally, Act Universally."

"Politically the world has shifted from left vs. right to local vs. global, or universal vs. tribal. New leadership must help us sort this out as politics begins to re-emerge as the engine of individualism."

Naisbitt's (1994: 41-51) arguments are well grounded as he points out that representative democracy was developed because of the scale and the distance between events and the time people found out about it - "the information float" - was so great. Now telecommunications has destroyed the need for such a process. People are thus taking up the challenge to have their own say, at least in those countries that are able to have a say through the communication technologies Naisbitt refers.

Other, more communitarian thinkers recognise similar trends. Barns (1991: 910) points to the dramatic changes occurring in "technoeconomic systems" but sees the need to search for a more "communitarian social ethic" in which "civil society" is the "social space within which we learn to become selves, to form associations with others, to
experience participation, to learn to resolve conflicts and so on". Thus
"communitarians argue that the appropriate response to the crisis of the state is not to
extend the domain of the market, but to reground the activities of both market and
state in the more basic logic of community and voluntary association" (Barns 1991:
910).

Mathews (1989) has developed the theme of 'associative democracy' as a concept for
democratising the state, the firm and even technology. Hirst (1994) has extended
these ideas further and argues that 'associative democracy' can address the problems
of overloaded government by empowering civil society through self governing voluntary
associations. The property rights of liberal democracies are not eroded but enhanced
and used as tools to ensure that both government and commerce is more accountable.
Co-operation and trust and the pursuit of quality market economies are seen as
possible.

The institutionalisation of these themes is still to fully happen, but the more people
begin to realise that power is not something you have, but an action, (Latour 1986
cited in Mathews 1989: 215) the more likely these forms of governance will take hold.
Thus power should be seen as a 'verb' (i.e. a doing word) not a 'noun', and
'empowerment', as these thinkers assert, is a process enhanced by association and
networks.

5.5 Summary

This review considered briefly the changes taking place in commercial management,
natural resource management and governance. A key element of the changes occurring
is that management has needed to shift from a focus on technical proficiency to
establishing at least a broader awareness of cultural difference and most significantly,
uncertainty. In line with the increasing understanding of the 'complexity' involved in
environmental and resource management there has been an emerging awareness of the
need for transdisciplinary approaches, where new frameworks of understanding and
action rely on synergy between scientific and tacit knowledge. Thus the importance of community knowledge and scale is emerging through all these literatures.

Another key feature which appears to tie these diverse fields together is the notion of "learning and adaptive management" as the response to uncertainty and complexity in a time of rapid change. For these learning processes to be more responsive to change, new forms of social organisation, both in terms of administration and governance, will be required. A more participative and even associitative form of democracy is on the horizon.

All of these changes present a very real challenge for the shape and future of professional praxis. Sirolli (1995) has one of the best developed insights about the changing role of professionals when he explores questions like:

- Can bureaucrats become servants of the public instead of public servants?
- Can professionals become client centred and find ways to foster the client centred solutions, instead of being self serving?
- Can passion, skill and basic business management be combined to make profit and local economic development in contrast to top down planning?
- Can organisation be more self organising and less hierarchical?

These are but a few of the questions that are central to the future shape of professional praxis. Answers are still emerging, but one thing seems sure - the dominant belief of the professional as the 'expert' is no longer valid. Professionals may have specialist knowledge but recognition is finally emerging that any one professional 'lens' or even numerous professional lenses are not necessarily the only way to look at a problem. Increasingly the need to integrate across fields and in a community context is vital.

The notion of focusing on problems from a transdisciplinary perspective has emerged. Questions remain as to whether at a professional level, or in terms of institutional form a transdisciplinary praxis is emerging which can be sustained. They also raise the question whether a new form of city may emerge from such changes.
CHAPTER 6

SUSTAINABLE CITIES MOVEMENT

The form of urban development which we call ‘modern’ started in Europe and the United States and has been taken up (around) the world - in some form ... I hope you see modernity for what it is - just another culture. Many people raised in modernity don’t see this. They subscribe to the myth of progress in which they believe that modernity as an inevitable transformation to which all culture must ultimately submit.

David Week 1995

6.1 Introduction

In this chapter the focus is turned towards cities and the sustainable cities movement as an expression of the world views that are being influenced by the concept of sustainable development. The discussion draws on insights provided from complexity theory and new management discussed in Chapters 4 & 5. In addition the discussion illustrates that the choice of technologies influences the shape of cities and assets that since new technologies are likely to be needed to meet the needs of the 21st century, the question is raised as to what form of city may emerge. Thus the aim of the chapter is to ground the emerging sustainable urban water management paradigm in the socio-political context of what a sustainable city might be like.

Initially the chapter provides a brief critique of the exiting city and the new challenges faced by urban dwellers searching for sustainable solutions to city form and character. It is also argued that as the city becomes increasingly viewed as an ecosystem, the focus of policy needs to shift towards both repairing and preventing strategies. The important relationship between decision making processes, urban planning and choice of infrastructure (technology) are presented in a way that illustrates the need to democratise these processes, again highlighting the need for new approaches to professional praxis.

1 David Week is an Australian planner with an interest in heritage planning in Asia. The quote is taken from an article by Ward, P. “Australian planners helping to protect Hanoi’s heritage” in Weekend Australian - Property Section, June 10-11, 1995, p 8.
6.2 Cities and Sustainability

Increasingly it is being recognised that for SD to become operational, policies and programs must be targeted towards cities (see for example MacNeill, Cox & Jackson 1991:196, Roseland 1992: 21, Yanarella & Levine 1992: 767). Part of this recognition is due to population pressures. It is predicted that by the turn of the century nearly half the world's population will live in cities; as the present population of about 5.3 billion doubles during the next century, up to 90% of that increase will occur in urban conglomerations (Roseland 1992: 21 & Hahn & Simonis 1991: 199). But population itself is not the problem, it is the rate of resource use, associated degradation and pollution that is the major issue. Over 70% of resource use occurs in cities (Wachernagel et al 1995). As MacNeill et al (1991: 196) put it:

"The excessive rates of resource use, and consequent waste generation, typical of OECD urban areas, cause them to be significant contributors to global environmental degradation. And yet, the economic, social, and cultural dynamism of cities and metropolitan areas throughout the world, developing and industrialised countries alike, is fundamental to a development process without which the economies of most would not survive."

So, on the one hand cities are conglomerations of people and artefacts, wastefully using resources and polluting the environment and, on the other, they are the economic and cultural hearts of modern society. Thus the sustainability of cities is central to global sustainability.

Agenda 21 presents a broad suite of programs and strategies required to make human settlements more sustainable. The first and most important of the issues to be tackled is simply the provision of adequate shelter, since 1 billion people out of the 2.4 billion people who live in cities don't have access to safe and healthy shelter. Another high priority is that 1.5 billion people do not have access to clean water and 2 billion people don't have adequate sanitary conditions. Therefore the human or built water
system needs to embody the principles of SD outlined in Chapter 3. In addition the massive growth of urbanisation that will occur over the next 20 or so years, will place significant stresses on the management of urban areas. Often large urban conglomerations extend over several political or administrative boundaries, hindering the development of comprehensive growth management and environmental programs (Sitarz 1993, Keating 1993).

The integration of environmental and development programs is nowhere more necessary than in urban areas. Agenda 21 stresses the need for innovative partnerships between government, community and private investment in a bid to meet the types of needs outlined above and to generate employment which is environmentally sound and protective of human health. Equally important will be the need to instigate sustainable energy systems and energy efficient programs. Another important feature stressed within Agenda 21 is the need to ensure that land use and transport planning should encourage development patterns which reduce transportation demand and support alternatives to the car (Sitarz 1993, Keating 1993).

A major thrust of agenda 21 is its emphasis on the need for community-based strategies to the problems of the urban environment. The remainder of this chapter sets out to present some of the emerging concepts about how cities might be transformed. An ingredient in that change will be how professional praxis is transformed.

6.3 The Challenge Ahead

One of the most characteristic features of our age is an increased acceptance of uncertainty. As Newman (1994) points out, the clear, simple set of ideas, technologies and universal solutions about urbanisation (and suburbanisation) of the modern period are being challenged. Schnieder (1979) and Newman (1994:2) pointed out that "modern" urban form has been characterised by:
• Segregation of major urban activities.
• Two dimensional organisation of activities.
• Non clustering of buildings separated by lots and blocks.
• Non intensive land use.
• Long distance travel for employment, services and recreation.
• Elaborate access arrangements between places (road hierarchy).
• Concrete and steel CBD office blocks.
• Green fields, low density housing in planned suburbs.
• 'Individualised' mass-produced homes.
• Strong regulations governing how and what could be built.
• Cars and highways for transport.
• Infrastructure provided mostly by the State with large scale power, water, sewerage, communications.

These ideas (or world views) and the artefacts and technical systems that transpired were seen as 'value free', rational and technocratic and 'progress' was the inevitable outcome. However, the status quo is no longer acceptable and a 'post-modern' era is emerging. Newman (1994: 3) goes on to suggest that:

"Many people now share the post modern feeling of uncertainty about the future and in urban matters they see high rise glass towers as being inhuman, low density suburbs have become monotonous sprawl with environmental, energy and social problems, the car is recognised as being the biggest polluter on the planet, the highway is now a symbol of monolithic modernism, regulations are seen to be stifling architecture and urban creativity and there is considerable uncertainty about infrastructure provision which is now seen to be inappropriate, costly and increasingly out of the question to even replace in old cities. At the same time we must live somewhere, use transport and infrastructure and try to improve the world, but the ease with which progress used to be defined is no longer there."
There appears to be a change in world view occurring. Often professionals (and the community) are caught between those who are pushing for a "last gasp" of the old paradigm and those trying to find their way to a different paradigm for doing things (Newman 1994: 4). The search is now rapidly occurring for human settlement patterns which are sustainable, more self-reliant and capable of adapting to pressures and change. Essentially urban planners, designers, architects and engineers are being asked by their clients, the community and their political representatives to ensure that the ecological integrity of their local and regional environment is maintained (or even enhanced) as part of the development processes.

A significant feature of this change is where some of these ideas or "threats" to long entrenched traditions are coming from. While the urban sustainability movement has a long history (Newman, Mouritz and Burke, 1994, Haughton and Hunter 1994) it has mushroomed since the late 1980's, with substantial promotion, research and demonstration of what a sustainable city or "Ecocity" might look like around the world.

The question of the sustainability of our cities has now become an international issue. In 1990, the First International Ecocity conference was held in Berkeley, California, where many of the long term environmentalists expressed a new concern for the city. Two years later the 2nd International Ecocity conference was held in Adelaide, Australia and drew international and local activists, researchers and professionals. In 1996 the 3rd International Ecocity Conference occurred in a village in West Africa

As well as these grass roots forums there has been a growth of more mainstream recognition. For example the United Nations Centre for Human Settlements (Habitat) now has a Sustainable Cities Program; similar programs are also run by the ECE, World Bank and APEC. OECD have developed environmental policies for cities since 1990 and have now embarked on an Ecocity project designed to establish indicators
that measure progress towards achieving Ecocities. In 1994, OECD held a major conference in Melbourne on the economic performance of cities, which recognised the importance of environmental integrity of cities and city regions as part of a city's competitiveness. In 1996 the UN Habitat II: City Summit in Istanbul will hear of progress of the world's cities towards sustainability and establish a global action plan for the first two decades of the next century.

A key element of this movement towards focusing on the sustainability of cities has been expressed by Anders (1991: 17) in a global review of the "Sustainable Cities Movement" when she pointed out:

"The sustainable cities movement seems united in its perception that the state of the environment demands action and that cities are an appropriate forum in which to act."

In fact others such as Yanarella and Levine (1992) suggest that sustainable development initiatives should be centred around strategies for designing, redesigning and building Sustainable Cities.

6.4 An Emerging Framework - The City As An Ecosystem

Throughout this century the city has been conceived by sociologists, planners and engineers as a "bazaar, a seat of political chaos, an infernal machine, a circuit, and more hopefully, as a community, the human creation par excellence" (Brugmann and Hersh 1991, cited in Roseland 1992). But as these authors suggest, these views of the city shape and constrain the programs and policies offered to serve the needs of urban people.

To counter this perceived inadequacy one of the strongest themes running through the literature on urban sustainability is that of viewing the city as an ecosystem and the emergence of urban ecology as a framework for exploring solutions. This is an urban
ecology approach and by virtue of its holistic nature requires the examination of the relationship between human systems and the biotic and abiotic world.

At the abiotic level, interpreting the city as an ecosystem allows us to view the city in terms of input-output models. A simple ecosystem model of the city, illustrating the current practice of 'solving' internal problems by increasing supply and discharge (or sources and sinks), is shown in Figure 6.1.

As Tjallingii (1993a: 7) puts it:

"The city is (now) conceived as a dynamic and complex ecosystem. This is not a metaphor, but a concept of a real city. The social, economic and cultural systems can not escape the rules of abiotic and biotic nature. Guidelines for action will have to be geared to these rules."

Like all ecosystems, the city is an open system, having inputs of energy and materials, but unlike natural ecosystems the city relies on large additional and often external inputs and outputs. The main environmental problems (and economic costs) are related to sustaining the growth of these inputs and managing the increased outputs (Tjallingii 1993a). By looking at the city as a whole and by analysing the pathways along which energy and materials (and pollution) move, it is possible to begin to conceive of management systems and technologies which allow for the reintegration of natural processes, increasing the efficiency of resource use, the recycling of wastes as valuable materials and the conservation of (and even production of) energy (Hough 1984).
Thus urban ecology initiatives (sometimes referred to as ecosystem approaches) have emerged as the dominant framework for introducing ecological considerations into urban planning and management. A definition tentatively offered by Hoyer and Naess (1990) for the term urban ecology is:

"The science of how human activity connected with towns and cities influences natural resources and the environment, emphasising conditions for urban development that takes care of biological diversity and the quality of human life, locally, globally and for the future generations".

Although this definition is tentative and there may be ongoing academic debate about what constitutes urban ecology or an ecosystem approach (see for example Slocombe 1993) what is clear is that many strategies and programs around the world have begun to apply such notions both for new and redeveloping situations. For example Wachernagel and Rees (1995) have developed the concept of the Ecological Footprint
to examine the extent of the resource use and waste impacts from cities. The thrust of this approach is to warn the world about the impossibility of continuing to expand cities on the same high resource consumption / waste production pattern of the past 50 to 100 years.

A good proportion of the research and literature on urban ecology has turned its attention in the direction of urban redevelopment, simply recognising the vast areas of cites that have occurred in the last 40 or so years that now need to be transformed. Urban ecological initiatives thus have potential to be applied for "repairing" as well as "preventing" and both at a "partial" and "structural" level as has been suggested by Hoyer & Naess (1990) (see Table 6.1).

<table>
<thead>
<tr>
<th>PARTIAL</th>
<th>STRUCTURAL</th>
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<tbody>
<tr>
<td>REPAIRING</td>
<td>SD principles partially incorporated into local renewal projects</td>
</tr>
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<td></td>
<td>Application of SD principles changes urban form and infrastructure to reduce energy and material flow</td>
</tr>
<tr>
<td>PREVENTIVE</td>
<td>SD principles partially incorporated into new development</td>
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<tr>
<td></td>
<td>Planning and infrastructure design which incorporates SD principles to reduce energy and material flows</td>
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Table 6.1 Potential Focus For Urban Ecology/Ecosystem Approaches (Adapted from Hoyer and Naess 1990)

6.5 But What Might a Sustainable City Look Like?

The debate about what a sustainable city might look like, or what constitutes a sustainable community, is still wide open. However, in a seminal book on the topic, Sim van der Ryn and Peter Calthorpe (1986: ix) present a sketch of some of the key features:

"Sustainability implies different solutions for different places. Like the word "appropriate", "sustainability" is qualified by its context. Sustainability implies that the use of energy and materials in an urban area be in balance with what the region can supply continuously through natural processes such as
photosynthesis, biological decomposition and biochemical processes that support life. The immediate implications of this principle are a vastly reduced energy budget for cities, and smaller, more compact urban pattern, interspersed with productive areas to collect energy, grow food, fibre and energy, and recycle wastes. New urban technologies will become less dependent on fossil fuels and rely more on information and a careful integration with biological processes. This will mean cities of far greater design diversity than we have today, with each region developing unique urban forms based on regional characteristics that have long been overridden by cheap energy, the great leveller of regional diversity and unique character of place. A sustainable community extracts less of its inhabitants in time, wealth and maintenance, and demands less of its environment in land, water, soil and fuel”.

All this may seem utopian (or some would say misguided), but most of the literature on sustainable community design echoes the flavour of these images. What is clear is that a sustainable city or community should aim to be less exploitative of its resource base and environment while at the same time it should aim at developing a truly regional character, which enhances the local natural environment as well as the livability of the built environment.

In respect to urban form many commentators point to the idea of ecologically orientated neighbourhood development (see for example Hahn and Simonis 1991). In a physical form this can take many shapes but probably the most well developed examples are the concepts of Urban Villages, Pedestrian Pockets, Transit Oriented Developments, Traditional Neighbourhood Development, Planned Urban units, and Transit Supportive Developments (Calthorpe 1993, Hocking & Assoc. 1993). These have been summarised as the New Urbanism by Katz (1994). These are essentially nodal forms of development or redevelopment which can be characterised by:

• Human scale
- Mixed density and use
- Pedestrian focus and quality design
- Distinct local identity and character

Within these nodes a more pedestrian friendly environment should be aimed for, providing residential accommodation as well as local employment opportunities and having the necessary critical mass (population) so as to permit the establishment of desirable amenities. But it should not be so large as to lack a comprehensible human identity. These more nodal forms of development would be ideally linked by electric transit systems to minimise dependence on the automobile (Newman et al 1992).

Thus the overall morphology of the city might shift from a centralised central business district and monocultural suburbia, to more mixed use nodal developments, each linked by transit and interspersed with small scale integrated employment areas such as industrial parks (possibly based on green industries). Ideally these areas should be separated or linked by a network of linear parks and restored waterways providing an adequate provision of local and more regional recreational facilities.

### 6.6 From Scale to Scope

Another and related feature of a more sustainable city would be a dramatic shift in focus in the way key infrastructure might be developed and applied. A significant factor is the change of focus from a perpetuation of supply side and often single objective solutions to more integrated and often localised solutions, enabling local environments to be better understood and enhanced. These infrastructure concepts for stormwater, wastewater, energy and transport are presented in Figures 6.2, 6.3, 6.4, & 6.5.

These diagrams illustrate the shift from the traditional technological solutions (or simple set of modernist ideas) which focused on the large scale solutions to the
provision of major urban infrastructure, to more flexible localised solutions. But these
shifts are also being driven by the changing economics of supply side approaches.
Gradually a shift to more integrated least cost solutions is emerging (Marvin 1992). As
well, there is a motivation for change coming from the social aspects of new
management styles which emphasise flexibility and more local responsibility (Naisbitt
1994). As Flavin and Lenssen (1994: 72) point out for the energy sector:

"The traditional utility model - and the structure of today's (energy) industry - is
based on the assumption that large centralised stations are the most economical
way to provide power to customers. The advent of more decentralised power
plants (new technologies) along with the option of investing in improved energy
efficiency, has already turned conventional wisdom into a myth. The move to a
distributed power system which relies on a broad mix of large and small generating
plants could dramatically improve efficiency and lower the environmental burden
of today's electrical power systems."

These changes which are becoming evident in the energy sector (Devine et al 1987,
Weinberg 1993) have also been echoed in the water sector by Thomas and McLeod
(1992: 1) who suggested the need for a "rethinking of the basic system-wide design for
water provision and wastewater disposal."

6.7 But How Do We Get There?

The challenge for urban communities taking up the urban sustainability quest is to
distil the essential elements of this thinking and examples and to translate them into a
foundation upon which the existing community (and newcomers to the area) can enter
into a 'learning process'. This foundation will need to set in place a framework for
local development which involves 'implementable green solutions' today, while leaving
open the opportunities for innovation and adaptation. That is, a process needs to
begin which can open out in this new direction.
Figure 6.1 Transition from Scale to Scope: Stormwater

Figure 6.2 Transition from Scale to Scope: Wastewater
Figure 6.3  Transition from Scale to Scope: Energy

Figure 6.4  Transition from Scale to Scope: Transport
As Hough (1984: 244) points out, the contemporary urban landscape appears to be very much a product of an acceptance of technological determinism (in infrastructure terms) and gardenesque traditions of design (in landscape and amenity terms). Hough calls not for the dismissal of established and useful design criteria, but for an emphasis on the functional and ecological basis upon which they must rest. Hough (1984: 244) calls for an 'understanding of the nature of the place' and a rejection of uniform standards and points out that "through diversity there comes the opportunity for greater social health and thus the creation of a landscape vernacular for cities." But if contemporary urban form has been allowed to be dictated by the 'forces' of technology: who drives technology and how might an ecologically responsive design ethos be facilitated?

On the question of challenging the acceptance of technological determinism, Latour (1988) points out that technology now has such a "force and power" in shaping our lives that it can even be conceived as the "Prince", in a Machiavellian sense. Each day a whole range of technologies, such as transport, water, energy, communication and building technologies and systems, influences the lives and actions of urban dwellers. These technologies all express certain values, which are 'coded' into the design and regulation of their implementation. So Latour (1988) suggests that technology needs to be seen as a form of politics in disguise.

Urban infrastructure is generally long lived and capital intensive. Decisions about these types of major capital investments are often controversial and they should be. They can both disrupt lives in the short term, for example for those in the impact zone of a freeway, but more importantly they exhibit a capacity to continually shape society at the day to day level. Thus Latour (1988) suggests if democracy is to be pursued, we need to get inside the place where science and technology shape society and ensure that the process of technology choice is open. Ellul is reputed to have said "technology is a good servant but a bad master" (see for example Ellul 1964).
Therefore it seems that it is critically important for individuals and the community to invoke their right, or more importantly their responsibility, to shape technology for the wider community good and not allow the present technological trajectory of society to dominate this or future generations. Mathews (1989: 139) points out that it needs to be recognised that:

"The hard and soft technologies which shape our lives are all designed, whether openly or not, implicitly or explicitly; and that the criteria guiding this process can be arrived at and imposed, in a democratic and associative manner."

However, considering the problem created by the 'path-dependent' nature of technologies, in this case urban technologies, it suggests that the fabric or built form of the city and its infrastructure needs to be inherently more adaptable to change and uncertainty in a post modern world. But can urban technologies and infrastructure once in place maintain opportunities for choice? It would appear that this is only the case if they fundamentally exhibit flexibility as a characteristic of their design.

To achieve this objective it would seem that the soft technologies, for example the knowledge systems that surround infrastructure design, the engineering, the planning system itself and most importantly the decision making process, require a new and uncharacteristic, in today's terms, openness. In addition the major institutions which play a big part in how the city is shaped need to develop a greater willingness to 'learn to learn', as this is increasingly being recognised as an essential feature of dealing with complexity, change and uncertainty of natural resource management and development (Davis and Weller 1993).

A key element of that learning is gaining an appreciation that the shift to urban sustainability will require the simultaneous emphasis on efficient use of urban space and infrastructure; reducing resource consumption; improving community livability
and developing administrative and planning processes to facilitate sustainability (Roseland 1992). Of these, the last point about process is probably the most important need to be addressed if the challenges of urban sustainability are to be taken up. As Crombie (1992: 46) has suggested:

"If we want to improve the kind of decisions we make, we are going to have to change the way we make decisions."

In response to these there is evidence that changes are beginning to emerge in the form of a new generation of network structures (Carley and Christie 1992) and open decision making processes which aim to focus the interests of the stakeholders on integrated solutions. In Australia some important examples include:

- Planning Charettes or workshops aimed at developing more integrated design solutions for urban areas (Morris 1992)
- Integrated Local Area Planning as promoted by the Australian Municipal Association (Australian Local Government Association 1993).
- Urban Integrated Catchment Management processes (see Chapter 9).

An important feature of these new processes is their attempt to provide avenues for intersectoral decision making, balancing so-called bottom-up and top-down approaches. This is illustrated in Figure 6.6. As such they provide an avenue of hope for better decision making about the shape of cities and the technologies that dominate them. But any form of planning is political and mastering the politics of planning to achieve meaningful plans is an art as much as a science (Benveniste 1989).
IF WE WANT TO IMPROVE THE KIND OF DECISIONS WE MAKE, WE ARE GOING TO HAVE TO CHANGE THE WAY WE MAKE DECISIONS

CONTRAST DECISION MAKING PROCESSES

Fragmented

Round Table

Figure 6.6   Ecosystem Based Decision Making
To facilitate such changes Brooks (1988: 246) suggests:

"The urban planning profession needs a new generation of visionaries, people who dream of a better world, and are capable of designing the means to attain it. That, after all, is the essence of planning: to visualise the ideal future community, and to work towards its realisation."

However, realising this better world will only be achieved if the 'designing' is a participative process, involving the community and all stakeholders in a way that provides opportunities for those involved to become informed about the issues, in a bid to develop integrated solutions. It is often the generalist or lay person, unconfined by professional moulding that can often find the innovative solutions and see the relationships between actions (Engwicht 1992: 71). Thus professional praxis needs to place special emphasis on 'designing' processes that constantly usher in opportunities for more debate and participation, not less, in the quest for the sustainable city.
CHAPTER 7

PRESENT MILIEUX OF PROFESSIONAL PRAXIS AND URBAN WATER

Put yourself in the position of a future archaeologist sifting through the material remains of our culture some hundreds of years from now. What will (s)he make of the curiously shaped ceramic bowl in each house, hooked up through miles of pipe to a central factory of tanks, stirrers, cookers and ponds, emptying into a river, lake or ocean? ‘By early in the twentieth century urban earthlings had devised a highly ingenious food production system whereby algae were cultivated in large centralised farms and piped directly into a ceramic food receptacle in each house.’ Our future archaeologist would need to be a genius to guess at the destructiveness and irrationality of our present-day ‘sanitary engineering’.

Sim Van der Ryn 1978

7.1 Introduction

This chapter explores the link between water, cities and the challenge of SD, providing an account of the existing milieux of professional praxis in the urban water sector.

This is supported by summarising the main points that Agenda 21 makes in terms of urban water management. The aim of this review is to provide an account of pressures faced by those involved in urban water management. It illustrates the dynamic nature of the sector providing insights into the range of responses already occurring, before outlining some of the key features of the emerging sustainable urban water management paradigm. In the main the discussion focuses on Australian examples, however, it is suggested that the issues are not unusual to other countries. This review highlights the global significance of establishing a sustainable urban water management paradigm.

7.2 What Are The Urban Water Sustainability Issues?

The importance of adequate water and wastewater provision for urban sustainability was introduced in Chapter 2. Here those issues are expanded: firstly as they are presented in Agenda 21 (based on a review of Sitarz 1993 and Keating 1993) and, secondly, in the Australian context (based on a wide cross section of sources).

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7.2.1 Agenda 21 and Water

Agenda 21 recognises the emergence of a global scarcity of water and the increasing potential for conflict that it might present. The three most significant objectives presented by Agenda 21 are:

- To maintain the ecosystems of drainage basins world wide.
- To provide safe drinking water supplies and sanitation to all humanity.
- To strengthen and localise water management programs.

These three objectives must be interlinked and seen as integral elements in any program of development. Some of the key programs and activities are outlined below (based on Keating 1993: 69-76):

- Technological, social, economic, environmental and human health considerations must be integrated into a dynamic approach to water management which stems from local community needs and priorities.
- The full participation of the public, especially water-user groups and indigenous people, must be encouraged.
- Water management must occur at the lowest appropriate level, involving local and district water communities and river basin authorities.
- Research world-wide must be enhanced to help decision makers understand the long term implications of loss of vegetation, land restoration, water consumption and other water-related issues.
- Control programs should be pursued to reduce the prevalence of water associated diseases.
- At a global level, all nations should aim for the protection of water quality and aquatic ecosystems. Countries should participate in international water quality monitoring and management programs.
- The effective protection of water resources and ecosystems from pollution requires the considerable upgrading of most countries' present capacities.
• New technologies are called for in the area of water saving, pollution control, waste treatment, recycling and in the area of flexible and adaptable infrastructure, particularly for developing nations.

• Effective local and traditional sanitation methods must be integrated with latest technology and developed in such a way that local communities are able to implement, maintain and repair the systems.

• The principle that decisions should be made at the lowest appropriate level should be applied to water management.

On the environmental front Agenda 21 calls for the protection of remaining wetlands and for the reduction of pollution at source, and establishment of safe pollution treatment processes. Rehabilitation of degraded water environments is seen as important, as is the protection of freshwater fishery resources. In addition it is stressed that water conservation programs must become an integral element of water supply strategies.

On the economic and financial front Agenda 21 calls for the application of the "polluter pays" principle and the need for water tariffs to reflect the true value of water, including the economic and environmental costs of water. New and innovative options for water charging need to be explored, as do economic incentives for increased efficiency. An underlying prerequisite for management of a scarce natural resource must be the acknowledgment of its true value. Planning considerations must incorporate the actual economic and environmental cost of water use.

To achieve these and the wider range of priorities set by Agenda 21 there is a substantive call for education and training of professionals, technical people and the broader community in the full gambit of water management. Building the capacity of local communities to be informed and involved in water management in a participative manner is seen as essential, as is the diffusion of water resource technology throughout the world. But in order to meet the goals of safe water and sanitation by the year 2000, low-cost pollution control and
waste treatment technologies must be developed in a way that enhances local communities’ ability to implement and maintain these systems.

Above all Agenda 21 stresses that the provision of safe drinking water and basic sanitation must be seen as an important and integral part of protecting the environment, alleviating the effects of poverty and raising living standards world-wide. Ecosystem health and human health are seen as indivisible, but deep changes in attitudes and behaviour are seen as necessary to affect the outcomes desired.

7.2.2 Australian Urban Water Sustainability Issues

In the Australian context the nation’s cities are exhibiting a range of broad management problems in the water sector. These problems have both environmental and economic dimensions and are summarised below:

- **Increasing costs of a growing and ageing water infrastructure**: For example - deteriorating and sometimes collapsing infrastructure in older Melbourne and Sydney and increasing recognition that as urban areas expand excessively the marginal cost of additional urban infrastructure is placing financial pressure on the community and government. Approximately $3 billion is invested on urban water infrastructure each year (Thomas and McLeod 1992).

- **Increasing per capita and total water consumption**: For example - population growth and per capita increases in water consumption in Perth between 1985 and 1992 required a 28.5% increase in total supply, from 319 GL to 410 GL per annum (Werner and Humphries 1994). Ongoing increases of this magnitude are unlikely to be sustainable.

- **A reduction in the number and quality of urban and near urban water environments**: For example - virtually every Australian city is presently undertaking extensive investigation into the water quality and ecological integrity of their near urban water environments, as an appreciation has emerged about the importance of these environments in their own right and their value to urban dwellers becomes more obvious.

- **Significant disruption to the natural water balance**: For example - the process of urbanisation drastically modifies hydrological regimes, often causing downstream
flooding problems. Traditionally these problems have been addressed by developing hard engineered drainage to convey stormwater away as fast as possible. The result is flood protection at the expense of urban waterways, creeks and rivers.

The significance of the problems facing Australia's expanding urban systems is illustrated when it is appreciated that current predictions suggest that the Australian population is set to double in the next 20 to 30 years and most of that growth will be in and around the major metropolitan centres. But these problems are not just isolated to cities. Some projections by Graham (pers com 1993) suggest the following:

"In the next 20 years, there is likely to be an additional 2 million people living beyond the existing metropolitan boundaries in Australia's coastal zone. This equates to some 600,000 dwellings, 50,000 hectares of land for housing, 40,000 to 50,000 hectares of land for associated non-residential development, 30,000 to 40,000 hectares of impervious surfaces and some 400,000 megalitres a year of water. To supply and provide wastewater services for all this will involve $18 to $20 billion in public investment for infrastructure and human services."

And this is non-metropolitan growth. If population and settlement trends continue, most of the population increase is likely to be in and around our major urban centres where the economic, social and environmental stress will continue to be exacerbated. It is only in recent times that an appreciation has emerged that, in all their guises, urban water systems represent a major interface between human activity and regional ecosystems. It is becoming increasingly acknowledged that the 'natural capital' values of the water cycle and water environments are under threat, and basic rethinking is required of how water management and technologies are applied in the urban landscape (Thomas and McLeod 1992).

In a bid to illustrate the relevance of the breadth of Ecologically Sustainable Development related issues to the Australian water sector, Fisher and Kinrade (1993) have undertaken an assessment of the issues faced by Melbourne Water in the context of Agenda 21 and the
Australian National Strategy for Ecologically Sustainable Development. Table 7.1 provides a summary of the issues Fisher and Kinrade (1993) believed to be relevant to Melbourne Water. This table includes a priority ranking for the degree of significance that needs to be given to an issue on the basis of its relation to Ecologically Sustainable Development principles and the degree to which the water sector can influence outcomes. While this assessment has only been undertaken for Melbourne Water, it presents a useful guide to the key issues and the key capacity building elements that the Australian Urban Water sector needs to be addressed.

7.3 What Are The Origins Of These Issues?

The causes of these problems are complex and many of the origins of these issues have been outlined in Chapter 2. Here the historical, political, social, technical, financial and institutional origins are summarised.

7.3.1 History and politics

The provision of adequate water, wastewater and drainage systems has historically "...been a primary determinant in the growth of large and densely populated cities. It has provided a means for controlling disease, raising public health standards and effectively fighting fire. At the same time, abundance and the security of supply led to the perception of water as a free good, and resulted in misuse, wastage and environmental pollution" (Hough 1984: 74).
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Table 7.1 Summary Of Issues Relevant To The Water Sector Based On Agenda 21 And The National Ecologically Sustainable Development Strategy
(Note: Priority ranking from A to C - with A being most important. Adapted from Fisher and Kinrade 1993 - )
Little more than one hundred years ago the link between the poor, filthy conditions and water borne epidemics were discovered (Goudert 1989). As a response governments established boards of works which have evolved into the substantial water utilities which service cities today. There has always been a strong social welfare and public health element in how these organisations have viewed themselves. For example the Melbourne and Metropolitan Board of Works was established in 1891 with the original motto "Public Health Is My Reward". The organisation's primary function was to overcome the "Smellbourne" characteristics of early Melbourne (Morganson 1991: 3). Thus the provision of water services and particularly wastewater became part of an egalitarian drive to provide a common level of social welfare to all urban inhabitants. It is reported that the American census of the early part of the century provided data on the number of flush toilets as a measure of this egalitarian idea of dissolving the 'classes' through the provision of sanitation (Van der Ryn 1978).

Since the early part of the century, the utilities that provided these services have evolved into powerful bureaucracies dominated by an engineering profession, with their own cultural and managerial style. This has played a big factor in shaping the way the systems have evolved (Beder 1993a). The water systems they established have served cities well, but now face new challenges.

At a technical level the need for ever more water as cities have grown has traditionally been met by augmentation of supply, with more and larger dams and in some regions growing use of groundwater. The removal and treatment of wastewater has been based on a philosophy of dilution and a set of standards devised at the turn of the century (Beder 1993a). Stormwater management has been dominated by a conveyance approach which has been adequate at keeping the streets dry, but little attention has been given to water quality or the aesthetic value of urban waterways.
This predominantly demand side approach which evolved out of 19th century responses to
provision of urban water services has been termed the "big pipes in - big pipes out" by
Newman and Mouritz (1992). (See Chapter 2, Section 2.3.1 Box 2.1 and 2.2). Gradually
there is a recognition for a need to change. As Jay (1994: 19) puts it:

"After decades of persistence with nineteenth century technology, and reliance on ageing
water management systems, city water authorities have at last been jolted into the
realisation that there are not unlimited supplies of fresh water which can be endlessly
tapped for once only use in expanding metropolitan conurbations."

But developing alternative approaches requires considerable appreciation of the interface
between the urban water system and urban development in general.

7.3.2 The Water System and Urban Form

The evolution of urban water technologies and management systems has occurred as cities
have grown in response to the main shaping mechanism of transport technology. As the
modern city has evolved from a walking based, to transit, to automobile based urban form,
water technologies have acted as servant mechanisms to that development providing a
framework as essential as the transport system for urban development to occur (Newman
and Mouritz 1992). The city can only go where the pipes go. Water technologies have thus
had substantial influence in shaping the form and character of cities even if the evidence of
this shaping force, the water infrastructure, is hard to see primarily because it is hidden from
view.

The location of a main water or sewer line has directed the shape of sub regional
development of cities. Equally the lack of this infrastructure can impede development. For
example, in Perth there has been a delayed process of redevelopment in the 27% of Perth
which was established in the post war years on septic tanks, which are now considered to
be an inappropriate technology due to pollution problems. It has only been with the advent
of adequate small scale alternatives to the septic tank, and more recently the State
Government's infill sewerage program, that the redevelopment potential of these areas has become realised.

But the perpetuation of the 'big pipes in - big pipes out' approach to the provision of water and wastewater services, "conceptualised as separate from its operating environment" (Browne 1993: 27) has resulted in systems which continue to place stress on receiving environments. Gradually there is a recognition that the price of adequate water supplies and human health is an erosion of the ecological integrity of source and sink environments. In addition the economic consequences of this path are increasingly being realised.

The interrelatedness of these issues was recognised in the Australian Ecologically Sustainable Development Intersectoral Report discussion on water which concludes with the following two paragraphs:

"The water industry, in common with its overseas counterparts, has identified our degrading water supply and sewerage treatment infrastructure as a major issue over the coming decades, both in urban and irrigated areas. This is likely to represent a multi billion dollar investment. The current mix of investment (85 per cent for the distribution network and 15 per cent for treatment) may not be the most appropriate, nor the most efficient and effective means of meeting demands.

Thus, the problems of infrastructure should be seen as an opportunity for actually restructuring much of the unsustainable pattern of Australia's water practices. In most cases a whole range of technological options are available. The notion of technological choice and appropriate technology within the context of social reorganisation for sustainability should be considered as an essential part of any decision making about infrastructure (investment or) refurbishment" (Ecologically Sustainable Development Working Group Chairs 1992: 122).
If that investment ratio could be balanced, much of the debate would come out of the age old argument that the solution to these problems is simply a matter of the community's 'willingness to pay'. But a changed infrastructure investment ratio would require a substantially greater integration of land and water planning and would almost definitely have consequences for arrangement of land uses and urban form in general, as well as having implications for institutional arrangements. Thus the real issue is to what degree is there a 'willingness to integrate' across agencies and the community.

7.3.3 Institutional

Water management in the urban context is fragmented and complex. Across Australia there is no common model of management and responsibility, which may not necessarily be a bad thing. However, often the 'poacher and the game keeper', in terms of resource manager and resource user or utilities, has not been clearly defined. This is a function of local political and historical processes.

Notwithstanding this diversity there is essentially one common problem. That is, that the traditional bureaucratic and political boundaries at state and local levels have not been designed to deal with "inter-linkages and inter-relationships" of ecological and catchment issues associated with the management of natural resources (Mitchell 1991). Traditionally there has been little integration of land planning and water management, particularly in terms of water quality and pollution management. Often there are both policy and management voids simply because the institutional and regulatory setting has not adapted to the environmental integrity or economic realities faced by expanding city regions.

7.3.4 Financial

Although this historical perspective provides a useful context to explore new solutions, probably the most often used reason for the problems faced in urban water management is the low monetary value placed on water. For example it has been suggested that average Western Australian households pay 1.8% of average weekly expenditure on water services as compared to 2.5% for fuel and 5.1% on alcohol and tobacco. Around Australia annual
domestic water service charges range from about $480 to $560 per year (Werner and Humphries 1994). Clearly water is a very cheap good, but its provision has been part of a broader social welfare and development ethos as outlined before (Synnott 1991).

The other significant financial issue faced by water utilities is the ongoing costs associated with an expanding infrastructure. As cities spread out the costs of infrastructure provision to the fringes has increasingly been questioned. Although significant contributions are made by developers, in the form of headworks charges and actual provision of infrastructure, the cost per dwelling unit is significant and forms part of the economic argument for urban consolidation. Approximately $3 billion per year is spent on water infrastructure annually in the Australian urban context (Thomas and McLeod 1992).

A looming financial issue faced by water utilities is the asset replacement and repair costs of an ageing infrastructure. In the Australian context this is often a little considered issue. But British experience provides a few warnings. There have been reports that leakage of water from the ageing British infrastructure is as much as 34%, requiring major investment by the now privatised British Water Utilities (Pearce 1993: 44). In addition it has been estimated that it will cost £10 billion to upgrade British sewerage systems to European standards for discharge of wastes to rivers and coastal environments (New Scientist 1993).

The whole issue of infrastructure and asset management (and replacement) needs to be viewed in a fresh light. If it is not, the potential exists for Australia to continue to overcapitalise in these areas beyond any economic and social benefits (Burns 1991:3).

7.3.5 Stormwater

The most basic link between water and urbanisation is creation of impervious surfaces which restrict local infiltration and recharge processes and substantially modify rainfall runoff characteristics. To accommodate these changed hydrological characteristics of runoff, substantial stormwater systems have been developed. The traditional approach to stormwater has been to encourage stormwater away as quickly as possible: the
so-called conveyance approach. These systems economise on space and are functional from the technical perspective of flood mitigation, but increasingly it is being recognised that other values and features of the urban water environment need to be considered.

Since the 1970's recognition has grown about water quality problems associated with urban stormwater. As a response to the increasingly demanding regulatory environment and a recognition of the wider benefits of multi-objective stormwater management, solutions have shifted to a storage approach, where the focus is on detention, retention and recharge. In addition substantially more attention is now going towards retention or design of urban waterways as habitat and wildlife corridors. Gradually a more water sensitive approach is emerging (see Moran et al 1993). In the last few years considerable attention has been given to reforming the institutional setting of stormwater and catchment management in urban centres around Australia. Box 7.1 provides a brief overview of some of those changes.

**Box 7.1 URBAN STORMWATER AND CATCHMENT MANAGEMENT INITIATIVES AROUND AUSTRALIA (1995)**

- In Sydney an Urban Stormwater Pollution Task Force, a Stormwater Forum and government White Paper have all contributed to resolving issues associated with administrative and statutory requirements of local and state agencies, planning, funding, establishment of Best Management Practice guidelines, water quality monitoring and research, education and training.

- In Melbourne the Port Phillip Regional Catchment and Land Protection Board has been established to oversee catchment management initiatives for the whole of Melbourne. This Board operates under the Catchment and Land Protection Act and will act to facilitate local action for catchment protection and repair.

- In Adelaide a new catchment water management bill has been presented to parliament to instigate urban catchment water management boards. These boards will cross local authority boundaries and have the ability to establish a drainage rate system to provide funds for water quantity and quality management. The first major initiative being undertaken is the clean up of the Patawalonga waterway.

- In Brisbane the Brisbane River and Moreton Bay Water Quality program is getting underway. It aims to better understand the water quality problems in the waterways and work towards establishing the necessary administrative and practical responses to resolve the issues.

In summary, around Australia significant policy, institutional and practical reform is underway to deal with urban stormwater and catchment management issues. In most states this has also involved legislative reform.
7.3.6 Urban Form and Water Consumption

The relationship between water consumption and urban form is not straightforward. Two factors appear to be density and landscape character. In relation to density, studies carried out in Perth have shown that areas with larger lot sizes have higher water demands, and medium density is more economical in terms of water use than single residential. There is of course substantial variability due to socio-economic factors, occupancy levels and maturity of the suburbs under investigation (Water Authority of WA 1987). However, Sumner (1990) has been able to show a positive relationship between higher density dwellings and lower water consumption in metropolitan Perth.

The landscape character and traditions in garden style in Australia's vastly diverse urban environments also need to be considered as part of the water consumption and urban form issue. Most of Australia's public and domestic garden style is based around gardenesque traditions of design and by international standards includes substantial domestic open space and large tracks of public open space in the form of passive and active recreational areas. This has occurred at the expense of retention of urban bushland. Many of the early gardens were products of a period when Australians were busily trying to mimic the landscapes of their European origins. The demand for leafy, high water consuming suburbs continues unabated. It is only recently that the importance of local identity and landscape character has begun to emerge to the point that a truly responsive, Australian urban landscape and garden character has begun to develop.

7.4 Contemporary Responses And Comments

7.4.1 Water Law and Administrative Structures

At a national level the Australian and New Zealand Environment Council and the Agricultural and Resource Management Council of Australia provide the environmental and resource management policy focus and coordination. However, in the urban water service delivery sector each State Government provides the policy setting for their activities.
During the 1980's the water industry throughout Australia went through a substantial change (Mulligan and Pigrim 1989) and is continuing to do so in the 1990's. An influence on this process has been the Industry Commission's review of the water sector (Industry Commission 1992). This review and subsequent state based reviews of the water sector have meant continued change to the character of the Australian urban water sector. This is leading to both legal and institutional changes. Some commentators have suggested that this is not before time, as much of Australia's water related legislation is outdated, in terms of current perceptions of how the most efficient use of Australia's water resources can be achieved. As Paterson (1989: 45) explains:

"Different legal doctrines often coexist uneasily within a common legal framework, dealing inconsistently with:

- divertible surface water resources
- resource attributes of unconfined flows
- drainage or nuisance attributes of surface flows
- divertible groundwater resources, lakes and wetlands
- water quality
- powers and duties of authorities.

Within and between each of these facets of water the boundaries between public and private rights, legal standing of public interest, and even the basic definition of the subject of the law may be haphazardly drawn."

Paterson (1989: 45) goes on to insist that before many of the market and government failures can be resolved "the legal foundation of water resource management must capture the subject, that is the terrestrial path of the hydrological cycle, in a single vesting framework". Clearly there is a need to press for further legislative reform as "laws and legislation represent the formalisation and codification of policy" (Pigrim 1986: 308).

In the context of sustainable resource management, a central aim of any legislative reform in the water resources sector should be the maintenance (or enhancement) of biodiversity and
ecological integrity of water environments. If the sustainability of the natural water system is to be taken seriously, the stock of water related natural capital must not be allowed to continue to decline. In this context there will need to be a clarification of water rights for the so-called in-stream water uses, possibly at the expense of consumptive uses (Pigrim 1986: 308). However, the process of legislative reform in the water sector is slow and increasingly linked to other reform processes, particularly the shift to commercialisation.

7.4.2 Institutional Setting - The Shift To Commercialisation

As micro economic reform continues to bring changes in the way water utilities are focused, considerable uncertainty exists about the future shape of the water industry (Johnston and Rix 1993). Under the rubric of economic efficiency the concepts of corporatisation and privatisation of water service organisations are gaining momentum. Increasingly this is seen as the most economically efficient form of water service provision. However, environmental and social considerations should be dealt with simultaneously, although there is little evidence that this is happening.

The arguments for and against increased commercialisation and privatisation of the water sector are beyond the scope of this discussion. But as this debate unfolds and the reforms proceed it needs to be recognised that commercialisation also represents an opportunity to operationalise ESD principles in the water sector, to achieve both the efficiency and the environmental performance gains that the consumer and governments are looking for.

There are a number of key issues which must be addressed by governments. These primarily revolve around the need for national and state government to establish an appropriate regulatory environment and adequate mechanisms to ensure that the so-called Community Service Obligations of urban water management are met, within this increasingly competitive setting. Maintaining public accountability for achieving these objectives will be especially important (Fisher and Kinrade 1993: 65).
In parallel, there is an increasing recognition that the legislative arrangements for water resource protection and management need to be clearly separated (and strengthened) from the service provision functions. This move has often been argued as appropriate, even without the push for commercialisation. If this separation is to occur water resource managers should ideally be required to focus more on identifying the water related biophysical constraints within city regions. As these constraints become more clearly defined they will become the 'non-negotiable' ecological integrity constraints which the service sector will be required to perform within. Within these constraints, the service sector would increasingly seek out more flexible solutions to meet economic efficiency and equity performance obligations which should also be identified in the regulatory framework that would govern a commercialised water sector.

7.4.3 National Water Quality Management Strategy

Probably the most important Australian initiative in terms of sustainable water resource management is the National Water Quality Management Strategy (ANZECC and ARMCANZ 1994). This has been developed as a partnership between the Australian Water Resources Council (now the Agricultural and Resource Management Council) and the Australia New Zealand Environment and Conservation Council. This strategy aims to provide a policy framework for achieving Sustainable Water Resource Management. This strategy has begun to provide a framework of guidelines and ultimately action by each state and territory in a whole array of water quality areas. The overall objective is:

"To achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development (ANZECC and ARMCANZ 1994: 6)."

This policy objective provides the national context within which state based initiatives are developed and initiated by drawing public and political attention to the fragile condition of Australia's water resources and environments. As part of the process of developing the strategy, discussion papers and guidelines have been drawn together for water quality
management in an array of areas, including: sewerage systems, groundwater protection, water quality in rural environments, and stormwater.

Although the development of the strategy has been one of consensus building and awareness raising, the mechanisms through which the strategy aims to deliver the desired results is unclear. The most direct influence of these policies is how they affect Commonwealth funding priorities. In recent years Commonwealth funding arrangements to the states have increasingly required the submission of proposals in a multi agency manner and more importantly in a way that aligns with national policy objectives. This approach has begun to ensure that the emerging ethic of integrated resource management is reinforced in program planning and initiation. Hopefully the development of this water quality strategy will not be a policy without a program or at least adequate mechanisms within which to deliver.

7.4.4 Pricing Reform

As pointed out earlier (see section 7.3.4) water pricing is a key element of any sustainable water resource strategy. In this context, there has been a gradual shift from rate based water service fees to user pays schemes, in all or most Australian urban centres and in many places around the World. However, there are substantial cross subsidies and market imperfections in the water sector. This is highlighted by the following comment in an article by Jay (1994: 19):

"The previous charging system was a property tax masquerading as a water charge. The classic example is a pharmacy in Circular Quay (Sydney) with a hand basin and toilet, paying $20,000 a year for water."

Removing these cross subsidies and establishing user pays charging systems will help to provide a market signal to consumers. Although policies that aim for full cost recovery in the provision of water services are widely endorsed, there has been little debate about introducing resource rents for water. As Warner (1993: 3) puts it:

"no water prices in Australia include an element specifically and explicitly designed to capture social or environmental costs... there is a long way to go before water and related
services are priced on a basis that reflects the private costs to suppliers of making it available, let alone the environmental cost.”

This is understandable given the political and equity implications of rapid price escalations. As Piggrim (1986: 302) points out, "increasing the cost of water too quickly, or with too little regard for possible social and economic repercussions, may cause unacceptable disruption to local economies and communities". But there is a need to recognise that too conservative an approach to pricing adjustments will have limited effect. For example the Victorian policy of increasing water pricing at inflation plus 2% will not achieve the goal of full cost recovery for 50 years (Young et al. undated: 12). As Synnott (1991: 2) pointed out "in calculating the price of water only the cost of development and delivery is counted; the water itself is a free good." Introducing a resource rent component in pricing and even discharge fees should be seriously considered as it would provide "a ready benchmark against which future water augmentation, demand management and wastewater treatment" can be made (Warner 1993: 5). However, the key to successful reform in this area is for water managers to involve the community in debate about the relative environmental costs trying to be valued. Thus trade-off mechanisms and processes of distributive justice which are responsive to community needs would be an essential ingredient of any reform in this area (see for example Syme and Fenton 1992 and Handler 1990).

Another area of pricing reform is the issue of stormwater rates. Around Australia there is a variety of administrative arrangements, but most commonly local drainage is provided by local governments, with regional or trunk drainage provided by urban water utilities. Pricing for drainage has most commonly been incorporated in local authority rates or as a percentage of gross rental value.

As the problems of poor water quality associated with stormwater have increasingly been recognised, the need to develop new institutional arrangements and use pricing mechanisms to stimulate changes in practice emerged. One of the most popular alternative pricing
mechanisms used in parts of North America and Europe is one based on the area of impervious surface, thus providing an incentive to develop localised infiltration mechanisms. This form of pricing arrangement has often gone hand in hand with the establishment of stormwater utilities, who have a charter to provide drainage and stormwater quality management. In the Australian context substantial debate about stormwater management arrangements is ongoing, for example the Stormwater Task Force established to review stormwater issues in Sydney. Hopefully new institutional arrangements and pricing mechanisms will evolve to deal with this significant problem.

7.4.5 Consultative Processes in Water and Wastewater Planning

Around Australia in the last few years there has been a range of investigations and processes devised to encourage public input into long term water supply and wastewater strategies (e.g. WAWA 1994a & b and Reynolds and Usback 1993).

These processes aim to solicit widespread community input to complement the technical investigation into supply and sewerage options. These processes illustrate a new level of maturity in water planning and management, but as these policy processes unfold it will be interesting to see how substantive the changes are that are adopted as there has not been a strong tradition of these processes in Australia.

As the wider processes of reforming the institutional arrangements under which water resources are managed occurs, the opportunity should be taken to enhance the ability of the community to have a say in the way water resource decisions are made through the creation and enhancement of appropriate institutional structures. Synnott (1991: 5) asserts the need for information from individuals and groups to be channelled through structures such as:

- Integrated catchment management groups.
- Consumer consultative committees (as in the UK).
- Water resource councils (e.g. Western Australian Water Resource Council).
- Ad hoc dispute resolution forums.
The use of these mechanisms in parallel with state water planning is seen as "extremely useful for plotting a course for sustainable water management" (Synnott 1991: 5). Strengthening the requirements for community participation with transparent and non-discriminatory public processes is an essential element of sustainable water management. The key reasoning behind this is that traditional solutions to Australia's water resource problems have, and to a large extent continue to reflect, the "professional policy definition and intent" of water resource professionals (usually engineers), often at the exclusion of alternative problem definition and policy responses (Laffin 1989: 46-47). As Reynolds and Usback (1993: 4) suggest, there is a 'consultation void' that must be filled, but the real challenge is "the implementation of appropriate processes for the community to be involved, to make choices and to develop commitments to those choices."

7.4.6 Demand Management and Water Conservation

Water conservation is seen by Postel (1992) as the "last oasis." She points out that continued augmentation of supply in many areas of the globe is leading to both water scarcity and increased conflict between users. In the Australian context the development of demand management as a significant policy theme for the water industry was first formally acknowledged in 1986 with the holding of the National Workshop on Urban Water Demand Management. At that forum a definition, description of the role and recommendations for urban water demand management were developed (AWRC 1986). Since that time there has been a moderate level of attention given to demand management, with the major utilities preparing demand management or conservation programs of one kind or another (see for example Norwell 1991).

Water conservation programs, however, are often hampered by a fear that the instigation of such programs will incur a loss of revenue for the utilities involved, through loss of sales. This is the so-called "revenue forgone" argument (Diver and Mouritz 1994: 14). While there is a continued tendency for this type of thinking to dominate, increasingly it is being recognised that long term savings can be won from instigating efficiency measures, principally from offsetting the need for supply augmentation, water and wastewater
treatment costs and reducing peak demand loads on the supply system (Rocky Mountain Institute 1991). For example, a review of demand management programs by Dziegielewski and Bauman (1992: 10) suggested that well developed efficiency programs have achieved benefit/cost ratios in the order of 3.7: 1 for utilities and 16.5: 1 for the community.

A testimony to the growth in recognition of the importance of water conservation in North America is the 2000 page (190 papers) proceedings of the conference called "Conserv 93: The New Water Agenda" (American Water Works Association 1993). It documents a vast array of water conservation programs and initiatives mainly from North America. Four important observations can be made from a review of the proceedings and other literature from North America:

- Water conservation has been institutionalised into the North American water sector to such an extent that it appears to have equal weight or more weight than traditional supply side approaches. A whole new profession appears to be emerging, both within utilities and through consultants working for utilities.

- Water conservation makes good business sense for utilities, even to those in parts of North America which have traditionally been thought of as water rich, because it increases the 'sustainability' of the infrastructure, i.e. economic efficiency (REIC Ltd and Associates 1991).

- The water conservation program developed in North America involves substantial partnerships with community groups, often to the extent of resourcing environmental groups to undertake some elements of the program.

- In designing programs, behavioural science and incentives are seen as key elements, rather than regulation, in ensuring that "individual self-interest is also in the best interest of society as a whole" (Freeman 1993: 345).

In the Australian context, pricing reform has been the major feature of water conservation programs to date. However, planning studies such as the 'Perth Water Future' project being undertaken by the Water Authority of Western Australia, are beginning to demonstrate an
institutionalisation of demand management. This has been achieved to the extent that a policy directive within that organisation now requires that all water supply planning must evaluate demand side strategies against supply side options. In this context a number of water efficiency consultancy projects have been undertaken for regional centres in Western Australia, and an efficiency program is being developed for metropolitan Perth.

Although water demand management, in the Australian context, has been recognised as a significant component of urban water resource management for about a decade, it is fair to say that it is only just beginning to receive the attention and resources it deserves. A new water "agenda" is beginning to emerge in Australia and the country has the opportunity to learn from others' experience.

7.4.7 Environmental Management Systems in the Water Sector

All major institutions are beginning to respond to the environmental challenge by instigating environmental management systems of some form or other. This is equally applicable to the water sector as any other industry and gradually the water industry is responding to this requirement. In the Australian context probably the most well developed environmental management program in the water sectors are those developed by the Sydney Water Board and Melbourne Water and of these the Melbourne Water program is widely available for public scrutiny via an annual environmental performance report (Melbourne Water 1993). Increasingly other Australian water utilities are recognising the need to develop comprehensive systems.

One of the most significant motivating forces for improving environmental performance of organisations is the legal concept of 'Environmental Due Diligence'. Like the concept of 'duty of care' in the occupational health and safety area, this concept requires organisations to have in place adequate systems and processes to implement, monitor and upgrade, in this case environmental management performance. As with the concept of 'duty of care', the main thrust of this concept is towards an organisation's ability to prove that it has been
"duly diligent". This means a documented and widely understood environmental policy and program or system. The key elements of such systems are:

- Environmental Management Systems (or program)
- Environmental Audits
- Environmental Improvement Plans
- Systems Audits

Figure 7.1 illustrates an idealised process for implementation and review of environmental management systems.

![Diagram](image)

*Figure 7.1 Stages of Implementation and Review of Environmental Management Systems*  
(adapted from O'Brien 1994)

In terms of the water industry in general, the development and incorporation of environmental management programs as elements of corporate activity has mainly been a response to statutory requirements, as has been the case for most industries. The challenge for the water sector in this area will be to develop these programs to a point where environmental performance is weighted equitably with economic efficiency in terms of a measure of institutional performance. The Australian water industry has responded to the
challenge to the extent that it has instigated a research program designed to develop environment management guidelines specifically for Australian water authorities.

**7.5 Emerging Opportunities - Towards Sustainable Solutions**

**7.5.1 Introduction**

While the preceding discussion has outlined some of the initiatives being undertaken or initiated in the water sector, this section aims to sketch out some of the emerging possibilities. They are presented to illustrate the range of responses which have yet to be adequately explored, particularly in the Australian context. The discussion below provides examples of both the 'hard' and 'soft' technologies which represent the main elements of the emerging sustainable urban water management paradigm. These examples are presented here as an introduction to the following chapters which explore and apply these concepts and techniques in more detail.

**7.5.2 Integrated Catchment Management**

Water management has historically focused on water supply, sewerage and drainage management and has operated with a centralised administration, with little cross over between other natural resource issues. However, since 1988 when the Australian Water Resource Council and the Australian Environment Council held a conference on Integrated Catchment Management (ICM) each state and territory has progressively developed some form of integrated catchment management program. ICM provides an alternative water management response\(^2\). It focuses on water quality, flood control, ecological/environmental factors and the devolution of management responsibility.

In the urban context these processes have gradually emerged as a tool to bring various perspectives to a common forum, in a bid to develop catchment management strategies for

\(^2\) Integrated Catchment Management can be considered to be both an Existing Response - Section 7.4 and an Emerging Opportunity - Section 7.5. It is included in section 7.5 as it represents the first step towards Integrated Urban Water Management.
urban watersheds. Collett (1992) has suggested that the main objectives for ICM in the urban context should be:

- To improve the urban environment and the quality of life.
- To optimise energy and resource use in urban areas.
- To minimise soil erosion and sedimentation, especially during the construction phase of development, by application of appropriate controls.
- To minimise adverse downstream effects of urban areas by the use of appropriate runoff management methods.

These objectives are highly commendable. The first two appear to be higher order objectives, while the latter two are more narrow or technically focused. Achieving even the lower order objectives is likely to be a complex task as intensity of land use in urban areas and the land and water interactions are possibly more complex than in rural areas. This is because of the range of jurisdictional boundaries, fragmentation of responsibility and the potential range of land and water conflicts. This is likely to make the process of developing a "catchment plan" more problematic. However, the potential for implementation of preventative or remedial action is likely to be simpler because of the range of development controls available via land use control and other statutes and the inclination of urban people to accept these controls by comparison to rural communities.

This is illustrated by Gardiner (1993) who comments on the ingredients of integrated catchment planning in the British context, suggesting that ideally it should involve a combination of:

- Land use policy
- Development control
- Strategic environmental assessment
- Economic instruments, and
- Legislation
In the Australian context considerable effort has been expended on developing a high level of community participation in these processes. A couple of notable examples of participative catchment management processes include the Throsby Creek in Newcastle and the Bayswater Urban Integrated Catchment Management process in Perth (see Chapter 12). These processes offer potential to evolve new forms of decision making, as well as provide a focus for community ownership in local water management. Enhancing the potential of these processes and mechanisms for improved urban water management should be a high priority if a sustainable urban water system is to be achieved. These approaches are closely linked to the emergence of Integrated Urban Water Management outlined below.

7.5.3 Integrated Urban Water Management

One of the most apparent features of any new approach is the need for far greater attention to be given to the integration of land and water planning. This integration is required at all time horizons and scales of the urban planning, design and development process. The provision of water and wastewater services can no longer be viewed as a servant mechanism for development. Increasingly the term given to this approach is Integrated Urban Water Management (IUWM). Significantly these approaches build on the basis provided by ICM type approaches, but extend integration focus from administration and into design and choice of infrastructure. Integrated approaches are required which:

- Are planned with the total water cycle
- Use a storage or retention approach rather than a conveyance approach to stormwater
- Provide multiple use of water facilities
- Apply water conserving strategies in the built form as well as landscape techniques
- Seek to shift from centralised wastewater systems to decentralised systems which provide enhanced opportunities for reuse and recycling options to be incorporated.

Opportunities exist at every stage in the urban development and redevelopment process, from the most strategic to the house lot level, to enhance the water environment. Policy guidance is required to ensure that, as investment occurs, the public interest is also served in terms of the water environment (Bulstrode 1993). Ideally the choice of land allocation for
urban development needs to be considered on what might be referred to as a ‘water capability’ basis. Such decisions need to factor in consideration of the ecological integrity of urban and near urban water environments. In redevelopment processes opportunities need to be found to re-establish urban waterways as integral parts of the urban landscape. This may require allocation of space, but increasingly it is being recognised that enhanced urban water environments have wide social and economic benefits to urban communities.

Under an IUWM approach the design of new urban development would incorporate water balance, water quality and water conservation as explicit design criteria (Water Sensitive Urban Design Research Group 1990). Performance based policy or regulatory frameworks need to be developed to incorporate these factors into the planning and design processes for urban areas, ideally on a catchment basis. At the subdivision and building level, detailed stormwater systems can be devised to achieve these objectives. During redevelopment similar processes can occur. At the building stage building by-laws can require the use of water efficient plumbing fittings and even provide increased opportunities for localised use of recycled water. On-site stormwater management can be facilitated at this stage also.

An example of a mechanism through which this type of approach might be achieved is through the concepts such as Water Sensitive Urban Design (WSUDRG 1990, Moran et al 1993). This idea has evolved from a concept, to a discussion document, to a set of guidelines for urban development and now is becoming institutionalised into urban land and water planning in the Perth metropolitan context. The Water Sensitive Urban Design (WSUD) guidelines are not an isolated example of a new approach but build on work undertaken in other parts of the world (see for example Livingston 1994 and Geiger and Dreiseitl 1995).

In the Australian context, however, WSUD has emerged as a useful tool for urban catchment management both in new and redeveloping areas. While the initial focus of WSUD has been stormwater management, conceptually the concept has the potential to provide a basis for
fully integrated solutions. As one of the most significant features of the emerging sustainable urban water management paradigm an examination of IUWM approaches becomes the central feature of the remaining chapters. In particular Chapter 10 outlines the conceptual framework of Water Sensitive Urban Design as an example of an IUWM approach. In Chapter 11 a case study of the processes involved in introducing Water Sensitive Urban Design is provided. Chapters 11, 12 and 13 provide case studies of its application.

7.5.3 Emerging Technologies

The emergence of IUWM planning and design frameworks (like WSUD) present real opportunities, however, they rely on the successful selection of appropriate technologies. One of the most significant issues facing managers and recipients of urban systems is the question of what the next generation of wastewater technologies will be. A whole range of technologies have emerged to challenge the need for centralised systems. At the on-site scale:

• Modified septic tank systems with soil amendment around leach drains to neutralise nutrient contamination (e.g. Eco max)
• Aerobic Treatment Systems (e.g. Biicycle)
• Composting Toilets (the potential of this technology in cities should not be dismissed as this form of technology provided sanitation for cities over thousands of years, see for example Stadtentwasserung Zurich 1992).

At the community scale all of the traditional primary, secondary and tertiary processes are available at small scales, however it is more likely that combinations of emerging high tech and low tech solutions will out-compete these older approaches. Some examples include:

High tech

• Physico - chemical technologies (e.g. Memtec Filtration and Sirofloc)
• Anaerobic - bio gas technologies
• UV Disinfection
Low tech - ecological engineering techniques

- Wetland systems (e.g. the CSIRO developed vertical flow wetland)
- Solar Aquatic Systems (e.g. aquaculture, hydroponics and wetland type systems condensed in glasshouses presently being developed both in America and Europe).

There is also an emerging range of wastewater reuse opportunities which need to be integrated into strategic land and water planning, including:

- Aquaculture
- Silviculture
- Agriculture and horticulture
- Industry
- Urban parks and gardens
- Recharge to aquifer

The task of wastewater infrastructure is no longer simply a water engineering problem, but more a question of the integration of land and water planning under the new set of goals. For these challenges to be met substantial investment in programs of research and development are required. But as outlined, this research must be guided within frameworks which are no longer sectoralised into engineering problems and urban design problems. The two must be combined. This will only occur if concepts like Water Sensitive Urban Design are encouraged to provide the basis for linking and exploring the potential of these emerging technologies. To illustrate in more detail the potential and constraints placed on some of these emerging technologies (artefacts and technical systems) a small cross section of these technologies are reviewed in Chapter 8.

7.5.4 Least Cost Planning

At a technical level the elements of the emerging paradigm appear to be feasible. However, the question that remains largely unanswered is their economic viability.
The growth of the idea of 'servicing' the public's wants has led to development of an expanded 'tool-kit' of techniques to evaluate the most beneficial way of meeting these service demands. The most widespread adaptation to utility planning techniques in recent times has been the formulation of the concept of least cost planning (LCP), a relatively new resource management instrument that is gradually gaining acceptance in planning fields as diverse as traditional utility planning (Greene 1992), alternative energy planning (Pears and Versluis 1993), water management (Fisher and Kinrade 1993) and the development of strategies to contain global warming. As an energy policy instrument, the underlying concept of LCP is referred to in the literature under a variety of titles including least cost utility planning, least cost planning, integrated resource planning and integrated least cost planning (Greene 1992). The term LCP will be used in this document.

LCP differs from supply side utility planning in a number of ways including:-

- **LCP does not separate the supply side and demand side issues of resource planning.**
  While both approaches begin with a set of basic assumptions relating to demand forecasts, predictions of population and economic growth etc., LCP examines the way in which energy and/or water is used rather than merely the quantity in which it is supplied (Greene 1992).

- **LCP evaluates all available options** (both supply and demand side) for meeting the utility's requirements and the customer's needs, by comparing the effectiveness and cost of these options within an equalised framework, usually a "whole of life cost" or "levelised cost" basis (Pears and Versluis 1993).

- **LCP analysis does not seek to meet an incremental increase** in demand with a single increase in supply as the "traditional" approach does. Rather LCP seeks to incorporate all available means of meeting customers' requirements in incremental stages at, as the name implies, the least cost of supply.
The LCP framework often factors in the largely ignored concept of internalising externalities such as environmental degradation. It thus attempts to gauge the various planning options in terms of total costs.

The effect of these key differences is often reflected in the findings of LCP analysis. It is not unusual for LCP solutions to lead to customer requirements of a utility recommending an efficiency or conservation program rather than an expansion of supply capacity, as it is often cheaper to conserve than to produce (Greene 1992). LCP analysis is able to consider the trade-offs between traditional supply side approaches, integrated solutions, policy instruments such as increased efficiency, conservation, customer information and education. But it is not primarily an exercise in Demand Side Management because it also incorporates analysis of the supply augmentation options open to the utility.

As such, the role of LCP is to assess each of the options to determine its ability to contribute to fulfilling a part of the prevailing resource requirements and then to rank them in order of cost with the cheapest option being fully deployed before the next cheapest is considered. Thus LCP approaches provide the basis for the analysis of alternative technologies, efficiency programs and supply side options.

In seeking the lowest cost option it needs to be pointed out that the use of LCP is likely to produce a spread of benefits for the consumer, the utility and the wider community. The relative merits of LCP for the utility are largely dependent upon the strategic position of the utility with regard to total consumer demand and the ability of the utilities to satisfy this demand. In many situations the stream of benefits may be wider than the traditional focus of the utility. For example LCP analysis may illustrate a lowest cost option which has factored in externalities not traditionally included in other analysis techniques. These benefits are often subject to greater variation and thus require greater clarification.
However, for tools such as LCP to be institutionalised, utilities must successfully negotiate the transition from functioning as providers of goods, to functioning as providers of services. This fundamental realignment of corporate goals is consistent with the least cost planning approach to utility planning. Adoption of the LCP strategy will create added benefits to the utility customers through the provision of the services at the least cost of supply. It also has the potential to create benefits for the utility through avoided capital costs from the postponing of supply augmentation programs or reducing them through instigating a process where choices about technology and policy mixes can be assessed (for a more detailed discussion see Diver and Mouritz 1994). The concept of LCP is used, although only tentatively in the case study presented in Chapter 11.

7.5.5 Utilities As Service Providers

The emergence of fully integrated solutions, which demonstrate multiple objectives of the sustainable urban water management paradigm, is not likely to occur unless utilities move away from viewing their role as a provider of goods and towards the belief that the utility should actually be a provider of services. To illustrate this point, people are largely ignorant and/or ambivalent to either the unit of measurement of the product provided by the utility (the kl, kWh, MJ etc) or its unit cost. What people are interested in is the service these goods provide (a hot shower, cooking, a green garden etc.) and the total cost of the bill received for these services (Greene 1992).

This shift in focus for utilities, from suppliers of goods, to suppliers of services also reflects the wider shift for utilities and the manufacturing sector in general, from development strategies focused around economies of scale, to business strategies focused around economies of scope in an effort to increase financial security through diversity of operations. Effectively, this will require a shift from a mentality of mass production, in which low unit costs of production are the criteria of economic 'common sense', to organisations driven by the logic of 'flexible specialisation', in which economies of scope and responsiveness to
customer needs drive the organisations’ methods of operation (Piore and Sabel 1984 and Phillimore 1989).

While it is acknowledged that many of the modern management techniques, such as total quality management, which are part of the flexible specialisation concept, are embraced within the Water Industry, there is considerable distance for the industry to shift for such a transition to occur. The technological approach, work practices and the mode of service will all need to be transformed. The establishment of discrete business units and out-sourcing of some service areas within many Australian water utilities, as part of the commercialisation focus, represents a shift in that direction. But as pointed out above, simply replacing a public monopoly with a private monopoly is unlikely to provide the performance gains being sought. Integrated and flexible solutions which revolve around partnerships with local authorities (Clark 1993), community groups (American Water Works Association 1993) and other service providers (Jones and Dyer 1992) have the potential to replace sectoral approaches and increase business and environmental performance.

The concept of utilities as service providers is not explicitly incorporated into any of the following chapters. However, as a significant management concept it represents an underlining feature of the shift towards the sustainable urban water management paradigm and the delivery of Integrated Urban Water Management services.

7.5.6 Constraints

While the preceding discussion has outlined some of the opportunities which have presented themselves as part of an emerging new era in water and wastewater provision, there are constraints. Probably the most significant is the simple inertia of the existing system, technically, institutionally, professionally (professional praxis) and at decision making and wider societal levels (socio-political context).

As Browne (1993: 61) asserts, even presented with an adequate supply of information about the potential benefits of changed approaches and ways of doing things, "decision
makers can down play the relevance of information which contradicts their own views ... (and often) ... down play or ignore conflicting evidence". It seems that humans, "interacting with the totality of information available, filter out certain information and give undue regard to other information ... (and) ... use only that information that confirms existing beliefs."

These views are supported by Brown (1995: 18) who illustrates the strongest barrier to innovation and integration in the broad area of coastal zone management is the existence of what she refers to as "closed communication circles within and between policy sectors." She goes on to point out that most communication about policy or implementation takes place "between workplace colleagues in the same occupation in the same organisation," highlighting the insular nature of most professional and decision environments.

Overcoming this inherent feature of decision making processes can only be achieved by participative processes which highlight the differing perspectives, thus offering opportunities for inclusion rather than exclusion of new information and perspectives. For example a recent 'specialist stakeholder' workshop held as part of the Wastewater 2040 process in Perth, highlighted the divergent views of those inside and outside of the water authority (CSIRO 1994). By highlighting this fact, opportunities for examining approaches outside the traditional focus of the utility are at least enhanced.

To overcome these problems of closed decision making Brown (1995: 10) asserts the need for integrated solutions which involve the four dimensions:

- **Policy Integration** - vertical integration which involves the formation of policy communities of all levels of government and community who become involved in long standing processes of negotiation about strategic directions.

- **Practical Integration** - horizontal integration which involves developing multi-skilled teams where decisions are made in concert rather than sequentially or in opposition.
• *Problem Solving Integration* - which applies holistic thinking to synthesise all the evidence within a multi-skilled context.

• *Integration by Scale and Place* - the development of a local vision or focus and the act of working towards community goals.

While these types of processes are essential, there are still structural barriers to be overcome (Kemp and Soete 1992). As Woldrop (1992: 119) explains existing technologies are locked-in because "the more niches that spring up dependent on a given technology, the harder it is to change that technology - until something very much better comes along."

For the take up of the sustainable urban water management paradigm to be successful it will require a combination of at least some or all of the following factors:

• There needs to be changed world views, particularly in the professional arena.

• The new paradigm must produce suitable and reliable technologies capable of replacing and in fact out-competing existing solutions.

• There needs to be a policy and institutional environment which facilitates innovations rather than discourages these changes.

• There must be adequate incentives and markets ready to absorb the innovations developed.

• There needs to be broad social and political acceptance of the new solutions.

Thus the process of reform is likely to be slow, even though it is clear that progress on many fronts is being made. What is needed in the short term is practical demonstration and evaluation. As outlines a culture of 'learning to learn' and enhancing the ability of the 'system' to adapt to change and uncertainty must be the hallmark of the sustainable urban water management paradigm.
CHAPTER 8
EMERGING ARTEFACTS AND TECHNICAL SYSTEMS

The engineers and scientists who implemented the human control of nature in Australia viewed the continent as a sphere of pure externality, a stage-set for the display of human activity. 'It is clear,' summarised C. H. Munro, Emeritus Professor of Civil Engineering at the University of New South Wales in 1974, 'that in Australia, Nature has set a very poorly-furnished stage for man to act upon, at least as far as water resources are concerned. Accordingly, engineering, particularly water engineering, must 'overcome the curses invoked by Nature.'

William Lines 1991

An ecologically oriented technical imagination must seek to discover the "way" of things as ensembles, to sense the subjectivity of what we so tacitly call "natural resources", to respect the attunement that should exist between the human community and the ecosystem in which it is rooted ... Only when our technical imagination begins to take this appropriate form will we even begin to attain the rudiments of a more "appropriate" or better, a liberatory - technology. The best designs of solar collectors, windmills and watermills, gardens, glasshouses, bioshelters, biological machines, tree culture, and solar villages will be little more than new designs rather than new meaning, however well - intended their designers. They will be admirable artefacts rather than artistic works. Like framed portraits, they will be set off from the world - indeed, set off from the very bodies from which they have been beheaded.

Murray Bookchin 1982

8.1 Introduction

As pointed out in the previous chapter (Section 7.5.4) there are a range of emerging technologies, particularly in the wastewater area, able to be utilised within the sustainable urban water management paradigm. This chapter presents an analysis of a small cross section of these artefacts and technical systems (refer to definitions in Chapter 1). It does this with a two fold purpose. Firstly the aim is to illustrate the processes and difficulty faced by those involved in developing alternatives to existing practice, showing how the existing culture and institutions of professional praxis and the socio-political context can mediate and inhibit change. Secondly, these examples provide the opportunity to illustrate the relationship between artefacts and technical systems and the values or world views from which they are derived. The technologies


are drawn primarily from Australia and the USA, thus enabling some further comment about their cultural context.

This chapter has three further sections. Section 8.2 provides a background and context to the discussion. This sets the basic framework for the examination of the emerging technologies which are described in Section 8.3. A discussion of the key findings of the review is provided in Section 8.4.

8.2 Background and Context

In this chapter use is made of concepts emerging from the literature on technological innovation and its relationship to institutions and society. It is shown that processes of innovation in the water sector are mediated by the ideologies and taboos of professional praxis and the socio-political context of any innovation. It is also shown that it is possible to examine emerging technologies in terms of the values or world views that are embodied in their design. These concepts are outlined below to set the context for the examination of the six examples reviewed in Section 8.3.

8.2.1 Innovations and the Barriers of Path-Dependency

Increasingly recognition is being given to the 'path-dependent' nature of technological innovation (Philip 1995, see also Chapter 4, Section 4.3). Research has shown that dominant artefacts and technical systems (in this case, the dominant water technologies) establish a pattern of inertia which is difficult to change (Blauwhof and Leydesdroff 1993: 422). In its broadest context the issue of inertia has also been referred to as 'technological trajectories'. This terms refers to the cumulative and evolutionary features of technologies and does not explain what particular technologies get selected but more to the so-called 'long and short wave' processes of innovation; where long wave changes refer to the major societal shaping technologies such as steam engines, electricity, and micro electronics, and short wave changes are all those technologies that build on the basic framework that the broader
technoeconomic system provides. The contemporary shift from electric stoves to microwave cookers is an example of short wave innovation.

This path-dependent nature of technology, means that new or radically different artefacts capable of fulfilling a similar function to those already in place have an almost impossible task of entering the 'system' or market place. This is particularly evident in the context of emerging wastewater artefacts and technical systems. As pointed out in Chapter 1, Kemp and Soete (1992:437) have noted that the transition to "green technologies" is likely to be hindered by technical, economic and institutional barriers, since the new artefacts and technical systems have not yet benefited from a "dynamic of scale and learning effect" that is evident in the existing system and because the "selection environment is adapted to an old regime".

The selection of any particular technology is influenced by a complex mix of knowledge, economic, institutional, political, cultural and social factors. At the most basic level any particular invention must be supported by an adequate framework of knowledge. Without adequate 'know-how' in terms of technical knowledge and operating procedures, no invention can hope to become an innovation accepted in the 'market place'. Innovations also need to 'fit' into the institutional, as well as technical elements of the selection environment. Increasingly it is being recognised that a significant part of the inertia of any 'old regime' is also related to issues of power and control. For example, Scarbrough and Corbett (1992: 24-25) have analysed the link between technology, organisations and ideology, pointing out that:

"... the design and application of technology within organisations is also influenced by the perceptions and meanings that are attached to that development. Within this 'circuit of meaning', powerful groups may draw on widely held ideas or ideologies to influence the development of technology by shaping the way in which it is understood, alternately mystifying it through technical jargon to retain control or relabelling it to jettison negative connotations."
Thus, those that have control over the selection of technologies, usually professionals, have significant influence over the shaping of the technology and tend to embed technologies within their ideological focus.

The relationship between ideology, power relations and technology innovation is particularly evident in the wastewater area (Beder 1993a, see discussion in Chapter 2). It is argued that a strong hold on the direction of any innovation process is maintained by the sheer inertia of professional praxis. A by-product of this process has been the development of social stigma about the very question of human waste disposal or sewage. Part of that stigma or taboo about what is 'appropriate' appears to be because those that have power over the system wish to maintain their control. A good example of the way constraints are placed on innovations because of these difficult to break taboos has been provided by Meier (1994a). He explains that in California although research into alternative wastewater management systems is providing positive results, full scale uptake of these innovations is constrained by processes that tend to reinforce the status quo. Meier suggests:

"Wastewater cannot be returned to the river without being treated by a technology that is unnecessarily energy-intensive (i.e. conventional wastewater plants). The use of solar energy for the treatment of sewage and industrial wastewater is allowed to be demonstrated, but not imitated ... (For example) ponds can now be designed that produce methane as well as high quality effluent. There is enough energy to operate the facility and leave a surplus, but it will be resisted by the profession inside and outside the Government ... (The designer of such a system) does not dare to suggest (that he borrowed) the technology from China and India ... The reason Asian eco-technology is unthinkable in North America is that we are protected from nausea created by our taboos by the professionals. The taboos are so strong that they are dealt with by euphemisms, so that it is difficult to collect
data (on innovative processes) for design purposes ... Efficient recycling is frustrated."

This example illustrates that while development of alternative technology is occurring, it appears that the innovations that fit within the existing 'system' are more likely to succeed than 'departures' which utilise knowledge sets that are outside of the frame of reference or paradigm of existing practice. This provides an in built inertia tied to professional praxis. This example also illustrates how a different world view (i.e. Asian inspired ecotechnology) has provided an insight for innovation, but is believed to be constrained because of cultural and professional 'taboos'. These 'taboos' form the part of the link between professional praxis and the socio-political dimension of the technology framework (outlined in Chapter 1). They are associated with perceptions of what is appropriate in terms of sewage and wastewater disposal and how society values the by-products of human activity.

The following historical perspective helps to illustrate this point further. Van der Ryn (1978: 14) provides a comparison between the cultural nuances of sewage disposal in nineteenth century Japan and Europe. He points out that at that time in Japan, 'night soil' or human excrement was valued as compost to the extent that in poorer tenement houses, if three people rented a room together, the sewage they generated paid for the rent of one. If five people occupied a room, the room was rent free. In rural Japan it was also common for farmers to vie with each other by building the most beautiful roadside privies in the hope of attracting the favours of travellers. This can be contrasted with the Western approaches of the same period, where chamber pots where emptied into the backyard or streets, which where (some times) designed with gutters to carry the 'filth' away with rain. It was during this period that the link between these filthy conditions and disease was established (Goubert 1989) but it took substantial social and political reform before the solutions were found. The suite of innovations including the flush toilet, drains and sewers and limited wastewater
treatment were introduced as part of sanitary reforms and a range of alternative approaches were rejected (Beder 1993a). Thus, the water carriage of human waste eliminated direct contact with excreta and it would appear a psychological and technological "die" was cast (Van der Ryn 1978:14). Or as Waldorp (1993:119) refers to it, technological "lock-in" occurred.

As a consequence a whole set of institutional arrangements and social norms became institutionalised into professional praxis and the socio-political context. Probably the most significant of these cultural norms is the acceptance that government has the responsibility for provision of water and wastewater disposal, particularly with respect to the health implications of these services. While 'state' responsibility for such an important issue is essential, a negative consequence of this process has been that individuals and the community divested themselves of any significant responsibility or involvement. Bureaucracies were formed to fill the egalitarian ideal of health for all. This ideal was so strong that the number of flush toilets installed was a census statistic in the United States until the 1960s as a measure of its progress (Van der Ryn 1978). But it appears that because of the relationship between the technologies chosen and the institutional arrangements required to manage them, what was once part of an egalitarian drive has almost become a form of despotic control.

8.2.2 Innovations and Values

The preceding discussion has highlighted the link between the dimensions of professional praxis and socio-political contexts and their relationship to the path-dependency of technology (i.e. the constraints of selecting an artefact and technical system). The focus now turns to how the interaction between world views and biophysical realities shape the contemporary challenge to develop alternative forms of water and wastewater system (artefacts and technical systems). This is important because it is more likely for transformation to occur if the philosophical dimension of any technological innovation and choice process is openly debated and considered along with the technical and economic issues. For example Weinberg (1994a:2) has
suggested that to shift to a greener form of technology it is essential to be clear about "one's philosophical view of the relationship between human activity and the environment" as it "conditions one's understanding of the relationship between human activity and the environmental 'problems' that technology can potentially address."

Weinberg (1994a) presents three alternative "technological paradigms" which help to clarify the relationship between world views and biophysical realities. These three paradigms are:

- Environmental protection - where the environment is recognised as an externality and the principle concern is effect of pollution on human health and welfare. Technology is used to reduce the quantity and toxicity of wastes and progress is measured in terms of efficiency of energy and resource use, but 'conservation' is measured from an anthropocentric perspective.

- Resource management - where the main focus is to economise ecology and aim to ensure that the true price of environmental services and pollution is ascribed, i.e., the price of material inputs into the system would reflect their demand on environmental services, thus providing signals to technologists and designers. Again progress is measured in terms of efficiency of energy and resource use; 'conservation' is still measured from an anthropocentric perspective.

- Eco-development - where the focus is a recognition of the coevolution of human society and ecosystems on an equal basis - progress is measured not in terms of efficiency, but in terms of the health of regional ecosystems as well as human health. Both soft and hard technologies are designed to optimise the production/consumption system from this wider perspective.

The point of presenting these technological paradigms, Weinberg (1994b) suggests is to illustrate:

"That over the past twenty years, environmental policy has been fundamentally reactive in character - the industrial countries have basically responded to
environmental problems in piecemeal fashion (e.g., clean air act, clean water act, super fund, etc. - the environmental protection paradigm or maybe resource management!) An eco-development paradigm is, in contrast, fundamentally proactive in character. It implies fundamental change in the direction of technology development, and radical change in the very goals that society sets for itself. This of course would necessitate the creation of new institutions and methods for addressing problems. Incrementalism as expressed in the environmental protection and resource management paradigms is better than nothing, but will probably not do the trick."

Thus the first two paradigms of environmental protection and resource management appear to represent different shades of the existing systems, while the eco-development paradigm represents a big shift. In essence what Weinberg (1994a) provides with these three 'technological paradigms' in the context of this chapter is a form of classification which helps to differentiate the underlying values embedded in the broader sociotechnical systems that will influence and be influenced by any particular emerging artefact or technical systems.

This categorisation, although difficult to apply directly to individual technologies provides a means to identify if any of the artefacts and technical systems reviewed are displaying any characteristics that might be part of the so-called eco-development paradigm. These may represent potentially significant shifts leading to transformations. However, these eco-development oriented artefacts may have significant difficulty finding a place in the existing built water system, due to its physical rigidity and to the constraints placed on innovations by the taboos or paradigm of existing professional praxis. On the basis of the critique presented in the previous chapters, existing professional praxis can be thought of as being part of environmental protection and/or resource management paradigm(s). The key point of
this analysis is that the insights provided by differing world views illustrate the significant scope for creative solutions, the 'system' potentially restricts uptake.

**8.3 Examples of Emerging Artefacts and Technical Systems**

This section presents a small but divergent range of examples to show how artefacts and technical systems are linked to world views and to illustrate the constraints posed by the values embedded in professional praxis. To do this the examples considered include five emerging wastewater systems and the experience of the companies that have developed them. The examination is thus biased toward the experience of those trying to enter the market, rather than those trying to manage the systems. These examples provide a description of the emerging wastewater treatment systems, the origins of the concept and how they have been developed. It examines in particular the various barriers, approval processes and organisational / business issues associated with bringing a new product into the market and the 'system'. Four of the examples are wastewater systems drawn from Australia, while the fifth is from North America. To compliment the discussion, the last example is focused on the technical system of emerging approaches to stormwater management.

The discussion below is based on a combination of literature, interviews and participative observation of the processes involved in implementation and commercialisation of these artefacts and technical systems. In each case the source of information used for the analysis is provided. Where adequate information was available the discussion is organised under the framework of:

- History and Description
- Research and Development Process
- Barriers and Approvals
- Analysis and Success Factors
In some of the examples not all of these issues have been able to be addressed but throughout, the analysis aims to address the core purpose of this chapter: to illustrate problems faced by those involved in the innovation process and highlight the link between world views and emerging artefacts and technical systems. The final discussion also includes a synthesis of comments from those interviewed in regard to how the innovation process can be enhanced.

8.3.1 Biomax

**History and Description**

Biomax™ is the trade name for the Aerobic Treatment Unit (ATU) developed and marketed by Durrant and Waite Pty Ltd, a Western Australian, 'two family' owner company. The information presented below is derived from an interview in May 1995 with Mr Ian Waite, the Marketing Director and partner in the firm and from conference papers presented by staff of the company.

Biomax™ is an ATU system consisting of a two stage biological treatment process with a separate clarification section and includes automatic disinfection with the added benefit that the effluent is of quality suitable for spray irrigation of passive landscapes (See Figure 8.1). The units can be sized for 5-10 person equivalents suitable for private domestic use, or can be sized for up to 500 person units, suitable for housing estates or accommodation complexes, such as hotels. The relevance to this thesis is primarily that it is a technology developed to operate at a community scale.

The Biomax™ systems developed, marketed and serviced by Durrant and Waite Pty Ltd have been developed to fill a growing market niche of the provision of adequate wastewater treatment facilities for areas without traditional sewerage systems and where septic tank systems are no longer acceptable due to environmental and groundwater protection regulations. Their application to the developing world situations is apparent and if community scale approaches to wastewater become more acceptable then this technology would be highly appropriate.
The Biomax™ technology has as its origin a joint American and Japanese design competition held in 1975 in Cleveland, Ohio, USA. This competition was run as a part of a joint conference program of the professional water and waste water associations of the two countries. The focus of the competition was the development of alternatives to septic tank technology for both blackwater and greywater treatment. Early ATU systems were developed and entered by Japanese competitors. What evolved from this process was the development of a range of ATU systems which represent a 'miniaturisation' of the larger scale biological treatment process commonly used in wastewater treatment processes. Thus the reduction in scale is the most significant innovation involved in ATUs. The ATU was developed further in Australia and the methodology has been approved for use in Europe and New Zealand, as well as Australia and Japan.

The company has developed significantly in the process of taking the original design from the late 1980s to the present commercial model, traded as Biomax™. The skill base of the company has diversified during the period and now includes technical skills such as wastewater engineering, plumbing and draining. In addition specific staff have been employed because of their explicit knowledge of the regulatory environment (i.e. environmental health and water authority regulations) and the urban development process. The organisation also has a strong business skill base with experience in management, marketing, and small business. In fact the organisation is owned and run by people with a business rather than technical background. The organisation has 16 full time employees (has had up to 20) and in physical terms consists of an administration and sales office and a factory and warehouse.

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3 The Japanese have been acclaimed for their skills at reducing the scale of technologies through reverse engineering techniques.
Figure 8.1 Biomax

Research and Development Process

The ATU that is now traded as Biomax™ is an "enhanced hybrid of the original" Japanese design that was imported initially into New South Wales and then into Western Australia in 1987 (Ivery 1994:8). Since bringing the original design to Western Australia, Durrant and Waite Pty Ltd have invested significantly in research, development and marketing of the product. They have not kept specific accounts of research and development expenditure, but estimate something in the order of $100,000 is spent annually on continually developing the product range.

The research and development of the product has involved both in-house development and specific project focused research undertaken by environmental engineering and science staff and students at Murdoch University. The primary aim of the research and development process has been to achieve and exceed, wherever possible the Health Regulations which govern the use of these systems in Western Australia. The
in-house research and development has been focused towards improvements in all elements of manufacture, electronics and computerisation, plus improving the effluent reuse and irrigation techniques, such as subsoil disposal of the effluent. The university collaboration has been focused towards reduction of nitrogen and phosphorous loads in the effluent. Further research and development is aimed at developing systems for a wider range of applications, including larger residential settings and directed at obtaining approval to reuse the effluent in second class water uses, such as toilet flushing. Throughout the seven year development process no outside funding has been sought for research and development primarily because of the belief, based on past experience, that there is too much "red tape" and therefore time involved in meeting funding bodies' requirements.

**Approvals and Barriers**

The mix of skills within the company has been seen as essential to both develop the technology and effectively negotiate a path through the regulatory environment. The process of obtaining approval for the use of this ATU was exhaustive. It took almost three years of trials, demonstration, monitoring and reporting of performance before the earlier version of Biomax™ was approved. As well as the time taken for the technical assessment, a significant proportion of this time was taken up by the process of modifying the Health Act and Regulations⁴ to provide the legal framework for licensing of these types of systems. The resulting regulatory framework now requires the purchaser of this or similar systems to obtain an ongoing maintenance contract.

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⁴ These regulatory changes were initially recommended by a Western Australian State Government Parliamentary Select Committee, titled On-site Effluent Disposal in the Perth Metropolitan Region, which reviewed the so-called infill sewerage issue in Perth, a situation where approximately 25% of the city of Perth, developed in the post Second World War period uses septic tanks. That review recommended modifications to the Health Act and the State Sewerage Policy to allow for approval of alternative sewerage technologies in the short term and identified the longer term options for provision of sewers to those areas without sewerage systems. The development of the regulations involved a working party from the Water Authority of Western Australia, Environmental Protection Authority and the Health Department. These officials inspect application and regulation of similar systems in the Eastern States of Australia. Western Australia now has the most stringent regulatory requirements for these types of systems.
with the supplier and report the system's performance to Local Authority
environmental health officers.

From their commercial perspective Durrant and Waite Pty Ltd believe the process of
obtaining approval was long winded with little support or encouragement provided by
the agencies involved. The general perception from the company's perspective was
that the development and approval of these technologies was tolerated, but not
encouraged. The main form of support was the provision of space at a Water
Authority sewerage treatment facility for trials⁵. A feeling of "suspicion rather than
support" was an underlying peculiarity of obtaining the approval for the system. It
was indicated that the suspicion appeared to go beyond the need for the regulatory
agencies to press for high standards. It was perceived to be a function of the
bureaucracies resisting change, possibly ideological opposition and the fact that the
agencies are not focused towards facilitating innovation. As Ivery (1994:7) asserts:

"The acceptance by the public of this water conserving technology has exceeded the
expectations of many in authority. As with the introduction of many new
innovations, unfamiliarity can (and in this case has) led to reservations and
misconceptions regarding the technology's significant advantages. These
advantages relate to both public health and environmental improvements when
compared with traditional septic tank and leach drain systems as an on-site
disposal method for domestic and commercial wastewater."

Although these "misconceptions" may have been the case during this process the
company now views the tight regulatory environment as an important contributor to
the development of their system. They are quick to point out that other systems
imported from other parts of Australia do not adequately meet the regulatory
requirements. Thus Durrant and Waite Pty Ltd believe that they have a superior
product and a market edge that has been achieved by working to meet and exceed

⁵ The same location has been made available to all organisations attempting to get approval
for their technology.
tight requirements. They see the chief reason why people use their systems is because there are no or only limited alternatives available in the market. "It's better than septic tanks and main sewerage for all sorts of reasons - cost, real cost that is, environmental - you name it" was a comment offered during the interview.

Durrant and Waite Pty Ltd have worked hard to gain credibility in the regulatory environment, in the market place and within their professional fraternity. They have established what they see as strategic relationships with appropriate professional organisations such as the Australia Water and Wastewater Association, the Environmental Management Industry Association, as well as with Housing Industry groups and the Master Plumbers Association. Through this networking they are able to market their product and influence industry and professional perspectives on the role of ATUs generally and the need for encouragement of alternatives to the traditional sewerage systems.

Durrant and Waite Pty Ltd have installed 600 ATUs in Western Australia since obtaining approval in 1991 and have begun to develop export opportunities for the technology in South East Asia.

**Analysis and Success Factors**

In relation to Weinberg's technology paradigms this artefact and technical system seems to exhibit very little in terms of a shift in basic thinking in wastewater processing apart from the original miniaturising of the process. While this appears to be the case, the technology does provide for water reuse and is small scale. These factors depart significantly from the dominant traditional large scale approaches. The system has a small energy and ongoing chemical and maintenance requirement. In technical terms the process was easy for the regulatory authorities to understand because it relies essentially on the same knowledge system of the larger scale technologies it is based on. However, the smaller scale approach appeared to be perceived as a threat to those involved in approving the technology.
The process of obtaining approval and commercialisation was long and expensive. The company was financially supported for a full three years by the owners. This is a situation few fledgling companies could endure. The approval barriers were overcome by the careful selection of technical and professional experience and knowledge of the 'system'. The knowledge system surrounding the artefact has continually been improved through research and development. This helped overcome barriers, opened up communication channels and helped with credibility. Ultimately the tight regulatory environment has meant that this artefact has been developed to a high environmental and health standard which now gives it an innovative edge.

The business skills of the management meant that this organisation has been able to strategically position itself in an expanding market. They have used strategic alliances with professional and commercial groupings to both lobby for acceptance of the technology and market the technology. While the company has successfully entered a difficult market, it is unlikely that it would have made as much progress without the investment of significant private capital and human resources required to navigate the approval process which was hindered by an entrenched bureaucracy.

8.3.2 Ecomax

History and Description

Ecomax is the trade name for a modified septic tank system that has been developed and marketed by Ecomax Waste Management Systems Pty Ltd, of West Perth, Western Australia. The information below is based on an interview in May 1995 with Mr Martin Bowman, co-inventor of the system and director of the company, as well as from published conference papers.

This system has adapted the traditional septic tank and leach drain by adding an amended soil filter around the leach drain, effectively providing a means of treating
the effluent which is known to contaminate ground water. The system is illustrated in Figure 8.2 and consists of:

- A standard septic tank(s) system where pre-treatment of wastewater occurs - sedimentation, flotation, anaerobic digestion.

- Two Ecomax cells, used in rotation, each comprising a storage and leaching vessel in a soak well or leach drain format, underlain by an impervious membrane, shaped in relation to the geometry of the leach drain/soak well by extension of a perimeter bund, to cause effluent to "pool" within a porous treatment medium.

- An amended soil, porous treatment medium consisting of an especially blended combination of red mud residue (an alumina process by-product) with gypsum, and sand.

- A perimeter subsurface drain and sump can be included to collect treated water for reuse or disposal elsewhere.

- A soil veneer and grass or vegetative cover to assist in gas exchange, evapotranspirative losses and conceal the system in passive recreational space (Bowman 1994: 22-23).

The treatment process involves:

- filtration
- pH adjustment
- ion exchange
- volatilisation
- biological water and nutrient uptake
- oxidation and reduction
- absorption
- chemical precipitation
- detention
- evapotranspiration

The effluent produced from the Ecomax systems is of a very high standard, beyond secondary treatment in terms of BOD, suspended solids and faecal coliform, in addition to significant reductions in phosphorus (> 99% removal) and partial nitrogen removal.

The systems can be scaled from single house use up to clusters and could potentially be scaled up to provide systems for 2 000 people. It therefore also is a community scale technology. It has the potential for polishing any poor quality effluent including effluent from animal feed lots, or for nutrient and heavy metal removal from industry.
Figure 8.2 Ecomax

As the commercialisation of the system has advanced the organisation and management of the company has become more sophisticated. There is now a full time manager, part time administrative support, a full time technical officer and two sales or customer representatives who also supervise installation. The actual installation is undertaken on a subcontract basis by trades people licensed to undertake the work.

The core skills involved in developing and commercialising the system have included according to the developer: determination, environmental and basic science know-how, practical construction skills and importantly the ability to negotiate with and be pragmatic with the state government officials in Health Department, Water Authority, Environmental Protection Authority in order to obtain approval.

The market for their product is where regulatory requirements dictate strict standards, both domestically and in the international market. These requirements are growing so the organisation is attempting to place itself in a position to capitalise on opportunities as they develop. The company sees its future as a provider of a
complementary range of waste management systems, potentially diversifying from its single product base.

**Research and Development Process**

Bowman (1994) pointed out that the Ecomax Septic System was developed in response to the need for wastewater treatment systems which can treat domestic sewage on-site, remove the principal contaminants at very high efficiency, are simple and cost effective to operate and maintain, and are economically realistic to install. Significantly, the design of the system arose out of the need to meet environmental standards. The Western Australian Environmental Protection Authority had placed restrictions on the use of septic tanks in new residential developments because phosphorous discharges would lead to aggravation of the eutrophication problems in receiving waters.

The concept emerged from a partnership between a builder and a environmental scientist. Thus practical know-how and scientific knowledge were combined to hybridise existing products and information into a workable system. The system and company involved in developing and marketing it - Ecomax Waste Management Systems Pty Ltd - is a partnership between an environmental consultancy firm and the builder. The scientific knowledge related to the use of red mud residue as a filtration medium has been particularly important. Approximately 10 years of research had been undertaken on the nature and properties of the red mud residue from Alcoa's alumina refining. Most of this work had been undertaken by environmental engineers and scientists at Murdoch University.

The initial phase of experimenting and trialing the system occurred over a three year period from 1989 to 1993, when the first commercial installation occurred after approval was granted for the system's use. At the time of interview approximately 300 systems had been installed in Western Australia and three demonstration units had been installed in New South Wales.
The process of research and development has involved an investment of approximately $100 000 in cash and $500 000 in time on the part of the partners. The process was substantially enhanced in 1992 by a $250 000 Generic Technology Grant provided by the Environmental Technology program run by the Commonwealth Department of Industry, Technology and Regional Development. Part of the research agreement required a trial to be undertaken in New South Wales, where three trial systems have been installed in three homes in the Blue Mountains. Although these trials used red mud imported from Western Australia, investigations into alternative soil amendments are ongoing. The remaining development has occurred in Western Australia.

The research process has included in-house research supervised through the environmental consultancy, an ongoing partnership with university researchers and support from Alcoa, the supplier of the red mud used in the amended soil. The ongoing research involves one full-time technical officer and part time supervision by an environmental scientist from the consultancy, with assistance as required from the University researchers. The focus of the research is on optimising design and performance and development of high flow rate systems which may be able to operate in more confined spaces and for wider applications. There is a belief within the company that there is at least a second generation system to evolve. The main constraint to the research and development has been time and resources.

**Barriers and Approvals**

As with all innovations a core problem has been financing the development of the systems. Without the government research grant the company would have had significant difficulty in getting to where they are. The company has begun to investigate financing arrangements with banks and potential investors for a 10 year development program but has not yet finalised any arrangement. The organisation has the advantage that it is backed by two separate businesses with substantial
trading records. But the directors also have a strong belief that Ecomax Waste Management Systems Pty Ltd needs to be able to operate as a commercially self supporting entity.

The process of obtaining regulatory approval for the systems proved to be very time consuming, but there is a recognition by the Company that the authorities have a legitimate role in being vigilant in relation to health and environmental specification. However, the Company is critical of what seemed to be "red tape" delays and ultimately to expedite approval a representation was made to the Assistant of the responsible Minister. This helped to speed up the process.

**Analysis and Success Factors**

In relation to Weinberg's technology paradigms, this system does not appear to represent a significant shift from an environmental protection or resource recovery stance. It has involved hybridising existing technology to meet higher standards. Resource recovery is only a secondary objective. The septic tank system still acts as the primary treatment process and the solids from that process still need to be recovered and treated off-site. Although this is the case, the system is very simple and has low maintenance requirements and no energy requirement, apart from solids removal from the septic tank. It has significant potential to rectify the problems associated with leachate from existing septic tanks at a lower cost than replacement with conventional sewerage systems and potentially less environmental impacts.

The development of this system represents a good example of innovation driven by tighter environmental requirements. The linkage of scientific knowledge and the practical skill that provided the original concept is still a core strength of the organisation. The commercial experience of the parent companies that own Ecomax has provided the business expertise necessary to manage the commercialisation process. The research and development process has been significantly enhanced by the research funding and the ongoing support of researchers at Murdoch University.
The company is now positioning itself to further develop the systems and widen its product range. In terms of the approval process the system does appear to have had more problems that would be expected from a simple innovation to improve environmental performance of an existing technology. It appears, because of its potential scale of operation, to have challenged those who believe implicitly in big pipes sewerage systems for cities.

8.3.3 Memtec

History and Description

Memtec is the name of a public company involved in the research, development and marketing of membrane technology and filtration equipment used for water and wastewater treatment. The company is based in Sydney, Australia but operates internationally through a range of subsidiaries. The organisation is thus of a vastly different scale to the other innovation reviewed in this chapter but it has one common feature. The technologies Memtec Ltd supply are significantly different from traditional approaches and have the potential to operate at a community scale, offering opportunities for water purification and reuse at a community scale previously not considered possible. In this context Memtec has experienced similar barriers to the smaller organisation reviewed. The following account of Memtec's activities is based on literature provided by Memtec staff (Hanley 1991, 1995, and MacCormich, 1994a, 1994b) and periodic discussions between 1992 and 1995 with Mr Tony MacCormich, Marketing Manager for Memtec Ltd.

The original filtration concepts of memtec were developed by Professor Fell and Professor Fane of the University of New South Wales. The initial focus of the research was directed towards biomedical related filtration of blood and blood plasma products, but it was realised early on that opportunities existed for use of the filtration techniques in a wide range of industrial applications. Memtec Ltd came into being in 1984 to commercialise that research. Memtec in 1995 had over 1 000
employees and had an international annual revenue of approaching $200,000,000 and operates in Japan, North America, Europe, Australia and Asia Pacific region.

The filtration technique involves passing the influent through a tube tightly packed with fine polymer fibres which act as a membrane filament. These tubes are arranged in banks with flow and flushing computer controlled. An example of one of these units is depicted in Figure 8.3.

Research and Development Process

Memtec considers itself to be a materials science based company with core competence in the design and production of fine metal fibres, fine polymer fibres and products and systems made from those materials. Its range of products now extends from water and wastewater purification devices, to biomedical filtration facilities, to purification facilities for computer chip manufacture, to parts for automotive air bag manufacture.

Figure 8.3 Memtec Membrane Treatment System
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Figure 8.3 Memtec Membrane Treatment System
With an initial capitalisation of $5 Million in 1984, Memtec was able to quickly complete its initial phase of research, patent that research and commence marketing in Australia. The second phase of development involved demonstration of the product's worth in United States, Europe and Japan. This process led to floating of the company on the US stock exchange involving a $US 93 million rights issue. The success of this process allowed Memtec to purchase the two divisions of the Brunswick Corporation - their Filterite and Fluid Dynamics Divisions, which provided an international distribution network and substantial manufacturing expertise. Subsequently a Japanese company was formed and later a United Kingdom based water purification company was purchased to provide a European base for Memtec's ambitions.

All of these strategic arrangements were put in place by June 1989. A number of other significant restructuring processes occurred between 1989 and 1991, aimed at effectively placing Memtec into a position of being one of the ten largest filtration technology manufacturers in the world. As well as the expenditure occurring on acquisitions of companies and establishing the international business network, the healthy capitalisation of Memtec allowed research and demonstration of products in a number of locations. By 1991 Memtec was the holder of 389 major international patents in the fields of polymeric membranes, membrane processes, continuous micro filtration techniques, selective absorbency, textile filters, metallic filters and devices, metal filament products and processes and miscellaneous waste recovery systems. The diversity of the products and their existing applications and potential place Memtec in the position of being a leading edge technology company. Coopers & Lybrand's annual review of R&D expenditure suggest that Memtec expended $4.6 Million on R&D in 1994 with an Australian turnover of $167 Million; this places it 52nd in terms of R&D companies in Australia (Coopers & Lybrand 1995).
Approvals and Barriers

While these statistics seem impressive there have been significant barriers in the ability of Memtec to introduce their technology into the Australian and international water and wastewater market. Chief among those barriers has been the simple fact that Memtec is an Australian company attempting to operate in the global market, where the specifications and requirement of the various markets, be they the US, Japan or Europe are all different. Thus Memtec is in the difficult position of supplying international companies who make their research and development decisions at headquarters in their host country. Therefore the company established a long term strategy involving the acquisition of the US and European based companies and the establishment of the Japanese subsidiary. This structure has been essential to provide the distribution and market support for the Australian manufacturing base.

The second major barrier to Memtec is that its membrane filtration process involves a process not within the traditional suite of technologies used in either the primary, secondary or tertiary treatment. It potentially combines and replaces a number of processes and techniques previously used with a material saving in terms of coagulation chemicals and an ability to treat to very high quality, not usually required for wastewater disposal. In the wastewater area its potential is in the provision of high quality second class water for reuse schemes. As such the system was seen as outside the traditional approaches used within the industry and was viewed sceptically in both technical and economic terms.

Memtec identified early on the need to develop its indigenous market as the basis for its export program. Memtec perceived that their success in the global market hinged, at least in part on the successful penetration of their technologies in the home market. But Memtec were unable for a significant period of time to find Australian decision makers willing to accept the challenge of innovation. Their experience confirmed a long held criticism that Australian industry has a bias towards taking technology from
overseas and applying it to Australian needs, rather than risk supporting local innovation. Memtec found more receptive markets in international organisations that had a world focus. They have supplied their technologies to international companies which have subsequently used their equipment as part of projects in Australia. This example illustrates the classic 'cultural cringe' that seems to dominate the Australian psyche and business world - 'if its Australian it just ain't good enough'.

It also illustrates the problem of resistance to a new technology which is outside of the reference frame (paradigm) of the decision makers involved. The technology has applications for community scale applications with smaller scale management systems being appropriate rather than the entrenched, centralised bureaucracies of water utilities with their large scale systems.

Memtec now has a number of Australian and international projects which are effectively demonstrating the capacity of their technology in the water and wastewater reuse arena. Through this process they have been able to clarify their technical claims and gradually improve the economic competitiveness of their technology. Although sales in micro filtration technologies are relatively slow, Memtec has been able to develop a market position through its acquisition of companies operating and supplying products for the traditional technological approaches. It also has not had to rely on one industry to provide its cash flow. Its diversification and the cash flow generated from the traditional operating areas of the companies it acquired has provided the base for it to position itself as a leading edge innovator across a range of material science technologies. Its real application to major sewerage systems, however is yet to come

Analysis and Success Factors

In terms of Weinberg's technological paradigms this technology appears to fit into the resource management framework, providing opportunities for reuse and enhanced protection. These opportunities were quite limited however. This is essentially a
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**Analysis and Success Factors**

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product of the reality of the market place it operates in, constrained by an institutional framework that does not seriously want to change towards reuse - yet. No technology supplier can move beyond the market it finds itself in within the short term, although its innovations can point to possible future options. In this regard Memtec have made a significant contribution to the debate in Australia about the future technological options in the Australian water sector.

Memtec Ltd is a highly successful innovator and supplier of a wide range of material science technologies, including membrane technology in the water and wastewater area. For almost a decade there has been considerable resistance to their technology for economic and non economic reasons, including the fact the membrane filtration systems were outside the traditional approaches of wastewater engineering.

As a successful Australian innovator, Memtec Ltd represents an example of the potential of Australian science and technology to operate in the global market. Their success, however, has been as much based on skilful business acumen, as it has been based on their technological prowess. This has provided the capital base to develop into an influential player in the global water sector, to an extent far greater than any of the other examples considered in this review.

8.3.4 Dowmus

History and Description

Dowmus Pty Ltd is a name of a small but innovative resource and waste management company based in Mapleton, Queensland, Australia. They focus on the development and marketing of waste management technologies, in particular composting toilets and a compost filtration system used for resource recovery of all organic household wastes. This discussion will focus on the Compost Filtration system. The information is based on an interview in May 1995 with Mr Dean Cameron, Research Director for the company, published conference papers and company produced descriptive information on the system.
In developing this technology from a hobby to a business, significant entrepreneurial and research skills have had to be developed or brought into the organisation. At the time of interview the company employed six people, four of whom had a financial interest in the company. The skill base within the organisation includes business, marketing, production, manufacturing and research.

The artefact is essentially a purpose designed vessel containing a drainage medium and active composting beds. As part of the composting process a biofilm develops on the drainage medium which aids in 'treatment' of liquids that pass through the system. To activate the composting process a range of beneficial composting organisms are introduced, including composting worms, composting beetles, compost flies and various insects and arthropods typical of a soil litter layer. These organisms work with fungi, bacteria, protozoa, nematodes and other microbes. Essentially an environment is created to support a detritus process, similar to that found in natural break down processes. The compost also acts as a filter and 'treatment' medium for liquids. This approach differs from traditional composting toilet techniques which primarily rely on microbial breakdown and are dry systems. This system can accommodate dry toilet or water flush toilet systems, the grey water from a household and other organic waste streams from households, including green garden waste and paper. The system also has significant potential in the food industry. It can be sized for a single household or for clusters of houses or for the food industry scaled up to the required size depending upon volume. It is primarily a small community scale technology.

The vessel provides a structure within which a resource recovery process occurs for a full range of organic wastes. The by-products of the treatment process are high quality compost, worm castings and a secondary standard treated effluent suitable for
irrigation, toilet flushing or safe disposal. Figure 8.4 illustrates the basic layout of the system.

Figure 8.4 Dowmus Compost Filtration System

Cameron (1994: 48-49) points out that this system operates on very different principles to traditional wastewater systems. He differentiates it from traditional approaches in the following way:

"Aquatic breakdown of organic waste particles in suspension is the conventional approach to both on-site and centralised wastewater treatment. This approach has evolved from the historical reality that water has been developed as the means to transport organic waste material from human habitations. Careful observation of natural aquatic ecosystems however reveals that unlike the way conventional waste treatment systems operate, the bulk of the organic loading is processed out of the water and surrounded by air... The myth that water has a capacity for
treats organic waste is not consistent with observable reality, and has resulted in the inappropriate use of aquatic treatment processes for wastewater purification. Processes which attempt to decompose large concentrations of organic waste as found in wastewater are inherently unstable because of the natural properties of water. Oxygen makes up about 20% of the air, by comparison water can only hold about 0.001% oxygen at typical wastewater temperatures. To further compound the limitation of trying to organically combust aqueous organic wastes, oxygen is difficult to dissolve in water and once in water has a slower diffusion rate than oxygen in air. These three properties of water make it inevitable that aquatic treatment of organic wastes in wastewater will be aerobic and unstable despite considerable effort to aerate the liquid, or anaerobic and producing odours and the greenhouse gas methane.

Cameron (1994: 49) goes on to suggest why compost filtration is better:

"The process mirrors the way nature treats its organic wastes and wastewater. The bulk of the organic matter in applied wastewater is filtered out on to the surface of a porous bed and exposed to air, and organisms. The wastewater containing suspensions of organic matter is spread and trickles over the decomposing solid organic waste which accumulate on the surface, like wastewater through a trickling filter ... Billions of organisms find niches within this continuum of aerobic decay and rapidly convert the food contained in the wastewater to stable organic humus ... In the face of this sophisticated biological technology, air pumps and diffusers and pumps and mechanical mixers stand out as crude and unreliable".

Thus Dowmus have 'modelled' their technology on a litter and soil ecosystem to develop a decomposition and water purification system. From this insight and description of the process it can be appreciated that this technology illustrates a somewhat radical departure from traditional technologies. Traditional sewerage
treatment is based on a combination of biological, physical and sometimes chemical processes, using water as the breakdown media. This system mimics breakdown process of the detritus layer of soil, a far more aerated zone. While it is similar to the emerging use of vermiculture (earth worms) for decomposition of organic waste, the ecosystem developed within this system is designed to be more diverse and robust.

Research and Development Process

The process of developing the technology has evolved from an initial hobby or interest in 1988 in improving dry composting toilet design ("a hobby that got out of hand"). That investigation led to the successful development, manufacture and sale of a dry composting system in 1990. That product provides the primary cash flow for the business and development of the compost filtration system.

Since then research into the compost filtration system has been ongoing with regulatory approval and subsequent commercialisation in late 1995. At the time of interview the company operated out of a 60 square metre shed and was in the process of moving into more sophisticated factory accommodation. Space and capital requirements had been kept minimal through the contracting out of manufacture of the moulded plastic components used in the fabrication of the systems.

Research and development has mostly been in-house with specialist technical assistance and research as required. Paid brainstorming sessions have been organised with out-side specialists from universities and the professions. This has led to definition of research needs and technical improvement. Some specialist consultancy expertise has been used in the areas of electronics and product design and engineering.

An industry award from the Queensland State Government provided $5 000 cash, which was matched by the company with $5 000 in-kind support for a post-graduate research project. This research focussed on better understanding of the entomological and detritus process. Dowmus's investigations and research to date indicate there is
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very limited expertise in this area, particularly the "link between engineering and ecology - it is very much suck it and see, bucket science".

The most significant part of the development process has been a partnership with the Department of Defence which has provided Dowmus with a National Procurement and Development Grant of $240 000 over three years. This allowed Dowmus to establish a number of compost filtration systems as "beta stations" in Army installations. The Army provided technical and maintenance support and feedback on performance. Without this opportunity the development process would have been significantly delayed.

Coopers & Lybrand's annual review of R&D expenditure suggest that Dowmus expended $411 000 on R&D in 1994 with a turn over of $167 000; this places it 114th in terms of R&D companies in Australia (Coopers & Lybrand 1995).

**Approvals and Barriers**

To bring the compost filtration system to the verge of commercialisation many barriers have had to be overcome. Financial barriers have been significant. Dowmus have found that there is very limited funding support for such ventures. This is a common problem with all innovative processes and products, but Dowmus have found that available investment dollars and research funding tend to go to moderately successful establishments rather than start up ventures.

Without the Department of Defence's support considerable delays associated with getting approvals for trials would have occurred. The Army needs no local health or building approvals on Commonwealth land. Thus the process of establishing trials occurred free from any constraints presented by the 'reservations and misconceptions' of regulatory authorities. There are now 30 trial units in place in Army and other locations. This has provided the basis with which to develop a reliable data set on the performance of the system in different circumstances and settings. It is hard to
imagine how trials would have advanced so quickly, as the systems evoked considerable reaction amongst regulators.

Another significant problem in the approval process is that the existing approval documentation for on-site wastewater treatment and disposal facilities is prescriptive in that it is tailored to particular types of processes or technologies. These tend not to cater for variation from the norm, such as the compost filtration system. There are no provisions within the Health Act for household resource recovery systems. The original application for approval of the technology was submitted in May 1993. Thus more than a two year process of negotiation and provision of additional information has occurred because there was no testing or evaluation criteria available for measuring the performance of this type of technology. For example there are no formal Australian Standards for compost or worm castings, which are the by-products of the process. Effluent standards have been established on the basis of other types of technologies. Modifications have been needed to be made to the regulations causing a significant part of the delay.

Analysis and Success Factors

In terms of Weinberg's technological paradigms this technology appears to exhibit characteristics that place it more towards the eco-development paradigm. The system has been specifically designed as a full resource recovery system based on observations of how a forest ecosystem works. If integrated into the design of human settlements it would necessitate a structural change in the way water and wastewater services are provided. The other artefacts reviewed would also, but perhaps this is more obvious as it would be very small scale, significantly decentralising treatment and allowing for reuse of all the by-products.

This system is based on a significant conceptual shift from traditional wastewater treatment systems. It relies on a fresh appreciation of natural breakdown process, thus the knowledge and skill base it is dependent upon is very different. In fact
substantial basic research has commenced on managing and optimising 'litter' ecology processes. The example represents a good example of linking ecological and engineering skills out of which a viable ecotechnology is emerging.

In practical terms this system provides the potential to reduce total domestic organic waste loads, reduce the need for sewerage infrastructure and provide nutrient and resource recovery. This shift potentially provides an important break from previous practice. The regulatory environment has had to be revised and a new set of criteria has had to be developed to cater for the shift in approach.

A key feature of the development process has been the partnership with the Department of Defence, providing financial and practical support. Practical improvements have been possible, but importantly the partnership has provided a significant measure of legitimation of the value of the technology which was most unlikely from any other government source. Interestingly the technology has been developed in such a way that it still allows for the use of flush toilets, a cultural norm many people find hard to shift away from. Thus a balance has potentially been struck between a new approach and the cultural norm.

Downmus has grown from hobby in 1988 to a moderately successful small business involved in significant research. To survive and develop the compost filtration systems it has relied on sales of an existing product and research funding. Like the other organisations it has broadened its skill base along the way and has developed business as well as technical skills. The widespread application of this system in cities is some time away. Integration of the system into demonstration projects would help considerably.
8.3.5 Solar Aquatic Systems

History and Description

Solar Aquatic Systems is the trade name for a wastewater treatment facility developed in Massachusetts, United States of America and inspired by the work of Nancy and John Todd, authors of the 'radical' eco-design book "Bioshelters, Ocean Arks and City Farming". The material presented here is drawn from the literature, some of which was supplied as a result of correspondence with the present suppliers of the technology (Ecological Engineering Associates Pty Ltd). The review provided is not as extensive as that of the other examples. It considers the conception and development of a wastewater technology that has emerged from outside of the existing technical and institutional setting.

The genesis of the concept can be traced to Todd and Todd (1984: 98) who remind us that:

"Under every city there is a dark and hidden Venice, but we no longer celebrate our waterways out in the open. In its myriad cycles water is the source of all life, but when we, in our industrial societies, harness it for our use via plumbing and sewerage systems we keep it underground, in pipes as part of a system that is efficient for the user but displaces the problem to a distant site, where it either becomes a source of pollution or demands costly and energy intensive purification. Large sums of public money are spent to keep waste out of sight and out of mind."

To combat what would seem to be an intractable attitudinal and cultural problem they proposed what they referred to as a 'Solar Sewage Wall' which brought the issue right out into the open (see Figure 8.5). That idea has now borne fruit as a Solar Aquatic System (SAS) - (see Figure 8.6).
Figure 8.5 Solar Sewage Wall
(from Todd and Todd 1984)

Prototype of the solar aquatic facility in Warren, Vermont.

Figure 8.6 Solar Aquatic System
(from Todd 1988)
The SAS was developed as a joint venture between a government body, the Narragansett Bay Commission which is responsible for sewerage treatment for the City of Providence (among other things); Ecological Engineering Associates Pty Ltd, the company established to take ecological concepts and technologies to the market place; and Ocean Ark International - the research organisation that the Todds established (Todd 1987:141).

Research and Development Process

The SAS combines the processes and functions of an artificial wetland, hydroponics and aquaculture within a glass house. This ecological system provides biological treatment of wastewater, utilising nutrients and converting waste into biomass. The process of developing the technology involved the observation and adaptation of traditional fish farming wastewater systems from Asian cultures. Importantly this system has been developed in such a way that it produces marketable by-products ranging from flowers to acting as a fish hatchery for endangered species (Todd 1987:141). By condensing the biological treatment into the glass house the processes are more able to be manipulated. The system has been designed specifically to fit within the urban fabric, overcoming the space limiting problem of artificial wetland treatment systems.

The performance of the system from a technical stand point has been ongoing since its inception in 1987 (see for example Todd et al 1993). This has included reviews by Massachusetts Department of Environmental Protection. This found that the effluent from the system consistently met Class I drinking water standards, which is a standard required for a commercial wastewater treatment to discharge into a fragile environment (Teal and Peterson 1993). This system has now been developed to the point where it is marketed and sold in the United States and is particularly good at treating the septage waste from septic tanks (Teal and Peterson 1991, 1993).
It also needs to be pointed out that this form of waste treatment and resource recovery system is not unique, as similar systems based on utilising condensed wetland systems in glass houses are emerging in Europe (see for example Chan and Guterstam 1995) and in other parts of the United States (see for example Jewell 1994). Thus this example represents one of a growing array of ecologically inspired wastewater treatment systems.

Analysis

In terms of Weinberg's technological paradigms this technology appears to exhibit characteristics that place it within the eco-development paradigm. One of the most significant characteristics of these systems is that they provide a way of exposing those interested, to the process of ecological wastewater treatment rather than hiding the problem away, which has been the tradition of most wastewater treatment plants. Significantly, those involved in developing these technologies often refer to them as 'resource recovery systems' rather than waste treatment facilities. Jewell (1994) for example proposes establishment of these forms of resource recovery systems in park settings, where they can be part of education processes. Therefore a key feature of this form of artefact is that it potentially helps to remove the taboos about bodily processes, that appear to act as a powerful controlling ideology (see Section 8.2 above).

What is also clear from the review of information about this artefact is that the technical knowledge required to design and run such a system is vastly different from that available within the existing sanitary or environmental engineering skill base. Clearly for this form of artefact and technical system to be applied and sold into various locations, it would require significant local knowledge (i.e. an understanding of the nature of the place). Therefore what is transferable is the ecological design skills, or what has been referred to by Mitsch and Jorgensen (1989: 4-5) as ecological engineering (see Chapter 2).
This example also illustrates the way different perspectives can progress from fringe or what seem to be outrageous ideas to legitimate solutions. No more evidence for the legitimization of this perspective is required than the fact that John Todd, an acclaimed alternative or 'greenie' received the United States President's Award for environmental excellence for his work on this technology and other associated environmental repair projects from President Ronald Reagan, a staunch republican with conservative values. This helps to illustrate an earlier point that world views provide both a constraint and an opportunity to change. Numerous commentators have suggested that real change or transformation (as referred to in Chapter 4) comes from outside of the existing frameworks. However, a significant question remains as to how well this type of wastewater artefact and technical system is able to penetrate the market place when it is so far removed from current practice.

8.3.6 Stormwater Management: Confucian or Taoist?

History and Description

The last example is very different to the preceding examples. It does not focus on a particular artefact, but considers the values hidden behind the technical system of stormwater systems. It illustrates the link between the control of water and the socio-political milieux and uses a comparison between two opposing and long standing 'eastern' schools of thought on hydrological engineering and virtually every other area of human endeavour: the Confucian and the Taoist approaches. The comparison illustrate the difference noted earlier between modernist approaches and ecological or more sustainable approaches. This 'model' is used to illustrate the link between technical systems and world views in relation to how contemporary stormwater systems have developed and are changing.

The first part of the example is drawn from Lyle (1984: 236-7) based on the earlier work of Needham (1954) who explored the origins of science and civilisation in early China. This work pointed to the stark difference in the two approaches as illustrated graphically by Figure 8.7. Lyle points out the Confucians were disciplinarians who
believed in strict rules and strong measures of control. In terms of water engineering they advocated high and mighty dykes, set ever nearer. The result was an attempt to overpower water and resulted in simple systems with few interactions.

By contrast Lyle suggests that the Taoist or expansionists, were more inclined to let water take its own course as far as possible, giving water plenty of room to spread, the result in terms of engineered systems being very complex networks. The Taoist engineer, Chia Jang, wrote over 3000 years ago that "those who are good at controlling water give it the best opportunity to flow away: those who are good at controlling people give them plenty of chance to talk" (Lyle 1984: 236). The key word here is 'controlling' and it appears that the Taoists had a very different sense of control than that held by the Confucians.

Figure 8.7 Images of Confucian and Taoist Water Systems (Source: Lyle 1984)
Lyle (1984: 237) suggests that in ancient China these two opposing world views were in fact blended together, but that in modern western society, the dominant approach has followed the 'Confucian' path where stormwater typically has been managed by way of hard engineering, single objective solutions. This corresponds to the simplistic, modernist approach of water systems described earlier. Only in recent times are the virtues of a more ecological (possibly more Taoist-expansionist) approach of retention, detention and recharge becoming integrated with hard engineering solutions. This change is illustrated by a growing number of documents which provide guidelines on how to apply the more ecologically sensitive stormwater management system approach. Examples of this emerging technical system is outlined in Moran et al (1993), Tjallingi (1993b), Geiger and Dreiseitl (1995) and Horner and Skupien (1994) and the remaining Chapters. Collectively these represent examples of the shift to Integrated Urban Water Management with respect to stormwater.

Analysis and Success Factors
The wave of reform depicted above represents a clear shift from domination or mastery of nature to a mode of praxis which is beginning to shift across the spectrum of Weinberg's technology paradigms towards the eco-development mode. Two important observations can be made about this shift.

Firstly, it must be stressed that before the ideological shift can be exhibited in artefact form on the ground, substantial changes are required in the technical system of knowledge that supports urban stormwater management. In particular this refers to the design tools and standards used by practitioners. Until those changes are made and mediated through processes within the relevant authorities and institutes (professional praxis) nothing is likely to change, because of the inertia of existing practice.

In the Australian context this can be illustrated by the fact that stormwater design techniques used in urban settings are based on a technique referred to as the 'rational
method' which derives its origin from the mid 1800's (Walesh 1990). With this technique as its base the Australian Rainfall and Runoff Guide (Pilgrim 1987) has been developed and modified over time to provide a methodology for stormwater design based on water quantity and flood protection. The technique provides no consideration of the emerging issue of stormwater quality management. For water quality to be adequately incorporated into design, new design tools are required and are in fact being developed (Yousef et al 1986, Evangelisti 1994, Horner and Skupien 1994). In addition a characteristic of these emerging technical systems is that they rely on a greater understanding of what Hough (1984) refers to as 'the nature of the place' or understanding the ecology of the location. Thus design solutions require a more diverse knowledge base than traditional 'hard engineering' solutions involved in stormwater design. Leading examples of stormwater design and management now use ecological engineering and ecological planning to provide site responsive solutions, not uniform design standards.

The second point to be made about the emerging technical system of stormwater management is that it has often been coupled with a significant educational and community participation process (see Chapter 9). In fact empowerment and involvement with local communities has often been seen as a key to the success of these programs (see for example Landre and Knuth 1993). These approaches therefore may be as more 'Taoist' in a socio-political context than the hard engineering or 'Confucion' ways of the past century. The implications of this shift on the socio-political fabric of an urban setting are yet to be fully appreciated, but what this example serves to show is the clear relationship between world views and technical systems.

8.3.7 Enhancing the Innovation Process

Many suggestions were provided during the interview process on emerging technologies about how to assist and support the innovation process for companies attempting to
provide alternative wastewater technologies. The following points present a synthesis of the suggestions made.

- The approval of alternative wastewater treatment technologies should be undertaken in a wider framework than the present public health focus. Wider social, environmental and commercial considerations need to be reviewed to provide a basis for devising an appropriate approval and demonstration program.

- Ideally a program should be developed to facilitate innovations in the areas of research funding, linking researchers with companies, assisting demonstrations, identifying potential mentor companies and investors and assisting with training in business and entrepreneurial skills.

- Access to help in marketing and demonstration of the technology is needed. Marketing is a very expensive process, particularly in an international context.

- A collaborative approach to demonstrations involving all the relevant and vested interest is required. This should ideally involve a project team able to facilitate the demonstration. This needs to include all the relevant regulatory authorities so that the project team can understand and work through all the hurdles that the project may need to jump. Community input and education are mandatory if the technology being adopted directly impacts on their daily lives or their pockets.

- There is a need to bring together integrated designs utilising an array of technologies, new and old. What needs to be tested is their linking and the operating and monitoring of systems that are necessary to ensure ongoing cost effectiveness and reliability.

8.4 Discussion

The preceding discussion has illustrated just a few examples of the many emerging artefacts and associated technical systems in the water and wastewater area. There appears to be a highly active process of research and innovation occurring as the water related challenges of the urban expansion and renewal are faced. New design tools are emerging for stormwater quality design that have the potential to make inroads into
old ways of doing things. The examples reviewed illustrate that innovative
technologies are becoming available in the wastewater treatment and reuse area. Some
of these appear to augment the existing system and some show the potential to
radically alter the fabric of the way these services are provided. There is even
evidence that the emerging discipline of ecological engineering represents a shift in
paradigms towards an eco-development focus.

The review illustrated that all of the examples faced significant barriers in the process
of entering the market place. On the one hand this is justified as the public health and
environmental performance of new wastewater treatment systems needs to be
thoroughly scrutinised. On the other hand this sample illustrates the very low level of
support provided by the institutional structures of existing professional praxis for
innovation. While some of the examples accessed grants, without which they could
not have achieved their present level of market share, all experienced resistance that
can reasonably be described as the product of a paradigm barrier. Difficulties were
experienced beyond the normal bureaucratic process.

Institutional inertia and the 'system' supports the status quo and provides little
support for innovation in general. The opportunity for innovation and choice is
moderated by the existing technological trajectory, in particular the institutional
arrangements which support and reinforce that paradigm and its professional praxis.
Change which requires acceptance of a different paradigm is therefore doubly
constrained by issues which are, to a large extent, outside the direct influence of those
involved in the research and development of emerging artefacts and those involved in
the regulatory process. Community pressure based on an awareness of the need to
move towards a different paradigm is therefore important for the full innovation
process to work effectively..
In addition society's choice of artefact and technical system is particularly constrained by the shape of the existing system and the technical knowledge system that surrounds it. New artefacts and technical systems may not fit the existing fabric because of technical miss-match, but more often this is due to lack of technical know-how and institutional support. In addition, only some elements of society may be recognising the need for change in the technical system. In the case of the above technologies there is already a widespread acceptance of the need to move in a more sustainable direction, however, they still found the change very difficult. To overcome the 'locked-in' or path-dependent characteristic of technologies requires provision of adequate systems of support for any new artefact and/or technical system. This is especially important where there is a clear societal goal to shift towards Weinberg's (1994a) eco-development technological paradigm.

While the dominant view considers that there is relatively little wrong with the existing urban water system, there is an alternative view that these systems do not meet the needs of a world searching for more sustainable outcomes (Chapter 2). As these examples of emerging artefacts and technical systems illustrate there are potentially numerous alternatives to the existing mix of technologies used. Water systems are typically rigid once they are in place. Therefore opportunities for innovation and demonstration need to occur when new systems are installed. In addition opportunities for change occur during asset replacement or as part of redevelopment processes of the urban fabric (Clark 1990, Bulstrode 1993). As pointed out in Chapter 2 there is also a risk of continuing to transfer old ways of doing things to the developing world, to cities which cannot afford the cost of systems which are at the end of their technical and economic life.

Thus for any shift to be made, not only do artefacts and technical systems need to change, but so too do the other dimensions of technology. This implies new rules, new manuals, and a culture of learning by doing, possibly using more flexible and short
lived technologies where the central focus is integration of design solutions for outcomes negotiated with the community. These outcomes should reflect the economic, social and environmental goals of this era and not standards or rules based on perceptions from a century or more ago. Thus a key in shifting to more sustainable approaches will be processes that change the very context within which artefacts and technical systems fit. This is the topic of the following chapter which explores the emerging theme of Integrated Urban Water Management systems.
CHAPTER 9
INTEGRATED URBAN WATER MANAGEMENT:
CONCEPTUAL FOUNDATIONS

I once had a pleasant enough, but very pedestrian public servant boss, who felt threatened by ideas, particularly progressive ones. The better the idea presented to him, the more ridicule he would heap on it. He'd go to ultimate lengths of bombast just to win an argument and quash any need for change. So I knew I was onto a good thing when, at last, his patience ran out and he had me arraigned before a disciplinary panel for pursuing what, to him, was an endless series of unwanted ideas, which culminated in my notion that if we had more women in engineering we'd end up with products which were different; less aggressive more sociable perhaps.

Richard Clark

9.1 Introduction

This chapter outlines the emergence of a movement towards Integrated Urban Water Management (IUWM). The concept of IUWM was briefly alluded to in Chapter 7 (Section 7.5) and introduced in Chapter 8. In this chapter the concept of IUWM is expanded upon using the Australian examples of Urban Integrated Catchment Management and Water Sensitive Urban Design to present a clearer picture of the concept. These examples illustrate that IUWM has both technical and philosophical dimensions which provides a foundational component of the emerging sustainable urban water management paradigm and the potential of a new professional praxis.

9.2 Background

Recognition is growing that a new form of urban water management is required. Integrated Urban Water Management has become a generic term that has been applied to a range of techniques or approaches to urban water management which attempt to express a new way of doing things. It goes beyond artefact providing a new paradigm, a new thinking framework, a new form of praxis within which to design and select artefacts and systems.

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The push for new approaches has come from many directions and places. The primary reason for this is a simple realisation that all growing cities are exhibiting urban water management problems. These issues have been discussed in detail in Chapter 7, but include problems with both environmental and economic dimensions, such as:

- A reduction in the quality of urban and near urban water environments
- Increasing per capita and total water consumption
- Increasing costs of a growing and ageing water infrastructure
- Significant disruption to the natural water balance and nutrient balance.

There is also a very significant social dimension to the urban water crisis. As pointed out in Chapter 7, billions of people simply don't have adequate water and wastewater facilities.

The idea of developing integrated solutions to water management is not new by any means. In fact the idea of multi-objective and integrated water resources planning has been a theme in the literature since the 1970s (Dorcey 1991, Mitchell 1991). What has evolved since then, however, has been the increased focus towards developing techniques and approaches in the urban context. Water has long been recognised as a cross-sectoral issue which requires special processes to overcome the obstacles created by the division of society, institutionally, into various sectors. The "creation of intersectoral links, supporting cross-sectoral co-operations and integrated multi-disciplinary actions, represents the greatest challenge in implementation of integrated water management" (Geiger and Hofius 1995: 133).

To overcome these barriers various approaches to integration at an institutional and technical level have evolved. At the institutional level catchment or watershed planning is now common place. These approaches commonly attempt to develop a "flexible framework for integrating the management of all resources - land, biological,
water, infrastructure, human, economic - within a watershed" (Hornier and Supine 1994: 235). In the urban context the critical issue is integration of land use, water / runoff and infrastructure in recognition of the inter-related roles of these components in the water cycle.

The techniques of linking and integrating these planning and management processes and technology choice discussions are emerging in different cultural, social and political settings (Niemczynowicz and Krahner 1995). But for all the 'thinking' that has been done on these new perspectives, there remains a considerable amount of work to 'operationalise' and firmly entrench them into the workings of decision makers and practitioners at all levels (socio-political context and professional praxis).

The process of doing this requires some clearer picture of the dimension of the issues involved and the development of tools (or soft technologies /technical systems) that encourage or force integration. In the following Sections (9.3) a tentative conceptual basis for IUWM is presented from an urban ecological perspective. This is followed in Sections 9.4 and 9.5 with a descriptive outline of the emerging processes and tools (or technical systems) of Urban Integrated Catchment Management and Water Sensitive Urban Design.

**9.3 Urban Ecology and IUWM**

In simplistic terms the traditional approach to urban water management problems has been to increase water supply and discharge of waste without significant considerations of the adverse effect on the source and sink environments. In attempting to develop a new approach to urban water systems a starting point is to view the city as an ecosystem (see Chapter 6). Within this 'urban ecology' approach the examination of urban water systems, their nature, function and performance (in an economic, ecological and social sense), is particularly applicable because these systems
represent a major 'supply and discharge' feature of cities. As Roberts (1993: 38) suggests:

"The study of the urban ecological context of water management ... provides us with the necessary insight into the whole network of causal inter-relationships between the urban economic system and its physical setting. As such, it reveals the general environmental problem setting in which the water management system is embedded, and sheds light on the various contextual factors and components that have helped to determine it."

Therefore this approach has the potential to look for alternative management and technological solutions which resist the need for increased inputs into the city and retain flows out of the city (Tjallingii 1993a see Figure 6.1). By looking at the city as a whole and by analysing the pathways along which energy and materials (and pollution) move, it becomes possible to begin to conceive of technologies which allow for the re-integration of natural processes to increase the efficiency of resource use and minimise the impact of the polluting by-products of the productive processes which occur within the modern city. This approach also encourages an examination of the relationship and links between urban development and the biotic and abiotic world. In this context the processes of urban development and redevelopment can be seen to provide the opportunities to enhance rather than further degrade environmental systems, potentially improving ecological as well as aesthetic, recreational and cultural opportunities.

In a conceptual sense the existing water system of a city can be likened to a box, where substantial volumes of water are imported into the city, the effluent discharged, stormwater and rivers contaminated, with little thought about the stresses placed on the source and sink environments. This is illustrated in schematic form in Figure 9.1. Thus from an urban ecological perspective consideration needs to be given to an evaluation of the physical flows and relationships of water balance, water quality and
water consumption as a basis for understanding the urban water cycle (Hedgcock and Mouritz 1988). It is also essential to consider the relationship between institutional and technological forms of the urban water system.

Thus although the box 'picture' of the modern urban water systems is simplistic it helps to focus attention on the fact that typical modern urban water systems are characterised by large reservoirs, complex distribution networks, which lead to homes and places of work. After use the water heads back to the hydrological cycle via an equally complex sewerage network, mainly to ocean outfalls. It also helps to illustrate the rain which falls on the city, how the hard surfaces restrict infiltration, increasing stormwater, and how this is often contaminated along the way.

In an urban ecological model the priority is to attempt to 'internalise' the problems caused by increasing supply and discharge. But this requires a rethink of the internal 'working' of the urban water system. Thus consideration needs to shift towards the shape and focus of the future urban water sector in a way that acknowledges the 'total
water cycle of the city'. It provides an opening to evaluate the range of possible technologies to be employed, opportunities for resource recovery, and the scale best suited to their management, rather than simply focusing the debate on the suitability or otherwise of waterways as a sink for urban wastes.

From this perspective it becomes clearer that to address the economic, ecological and social issues faced by the urban water sector, the large centralised nature of conventional systems, in a technological and institutional sense, must be questioned (Clark 1990, Thomas and McLeod 1992, Niemczynowicz 1992; see also Chapter 2 ). One of the most significant realisations that has emerged as a consequence of beginning this challenging rethink is that approximately 85% of capital investment in urban water systems has been on "pipes and pumps" or distribution. The remaining 15% is attributed to water and waste water treatment (ESD Working Group Chairs 1992: 122). This ratio of investment is being questioned and the new perspectives suggest that distributed systems which reduce, re-use and recycle should be conceived. Some of the characteristics of this type of water system include:

- Minimising the amount of imported water through water efficiency programs.
- Optimising the use of rainwater and / or shifting the traditional stormwater conveyance systems with their significant pollution consequences to storage systems which focus on detention, retention, recharge and water quality control.
- Wastewater systems which produce useful by products and high quality effluent suitable for reuse.

Such a shift would also infer substantial institutional change. Application of these new perspectives to the "box" model of urban water systems suggests that the urban water system needs to be broken up as depicted in Figure 9.2. But cities are not boxes. In water or hydrological terms they are made up of catchments and sub catchments. In urban form terms cities include a variety of land uses with a corresponding variety of water management requirements. In social terms they are the place where most people
live and consequently high quality environments, particularly water environments, are increasingly being demanded by urban communities.

Shifting from centralised water management systems to more distributive water management technologies will require an unprecedented integration of urban land and water planning and consequently significant institutional change (Collett 1992, Gardiner 1993, Mouritz 1993). Gradually new planning processes and mechanisms are emerging which aid in achieving this integration. Urban Integrated Catchment Management and Water Sensitive Urban Design are two good examples of the processes and mechanisms being developed in the Australian context to aid in this integration. The following subsection provides a brief overview of these tools as examples of IUWM.

![Figure 9.2 The Box Model Of The City Broken Into Cells To Aid Internalising Of Urban Water Problems](image)
9.4 Urban Integrated Catchment Management

The concept of Integrated Catchment Management (ICM) has developed over a number of years, within the field of natural resource management, as an approach aimed at tackling the often complex or "messy" and interacting relationships of resource management and development, using river or groundwater catchments as a boundary for management. The catchment provides a physical entity within which ecosystem relationships can begin to be interpreted.

The application of ICM in Australia has predominantly focused on rural issues. However, increasing attention is being given to its application in optimising land and water interactions in both urban expansion and existing urban areas. Collett (1992) has suggested that the main objectives for ICM in the urban context should be:

- To improve the urban environment and the quality of life.
- To optimise energy and resource use in urban areas.
- To minimise soil erosion and sedimentation, especially during the construction phase of development, by application of appropriate controls.
- To minimise adverse downstream effects of urban areas by the use of appropriate runoff management methods.

These objectives are highly commendable. The first two appear to be higher order objectives, while the latter two are more narrow or technically focused. Achieving even the lower order objectives is likely to be a complex task as intensity of land use in urban areas and land and water interactions are possibly more complex than in rural areas. This is because of the range of jurisdictional boundaries, fragmentation of responsibility and potential range of land and water conflicts. This is likely to make the process of developing a 'catchment plan' more problematic. However, the potential for implementation of preventative or remedial action is likely to be simpler because of
the range of development controls available via land use control and other statutes and the inclination of urban people to accept these controls.

This is not to suggest that the introduction of the ICM concept into the urban context is not without its difficulties. The first step is understanding something about the characteristics of the ICM approach as a distinctly different socio-political process aimed at aiding decision making in the natural resource management and development interface.

The term Integrated Catchment Management can be interpreted in a variety of ways. Add the word Urban in front and it gets a geographical specificity but it is still open for interpretation. Mitchell (1990) and Hollick and Mitchell (1991) point out that ICM can be thought of in at least three main ways, as shown in Table 9.1. These interpretations appear to apply equally to rural and urban applications of these processes.

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>FOCUS OF ATTENTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Links between water quality and quantity and between surface and ground water</td>
</tr>
<tr>
<td>2</td>
<td>Links between water, land use, vegetation, wildlife and other resources</td>
</tr>
<tr>
<td>3</td>
<td>Links between water management, other natural resources and social and economic development or an Ecologically Sustainable Development perspective</td>
</tr>
</tbody>
</table>

*Table 9.1 Conceptual Levels Of Integrated Catchment Management*  

Within this hierarchy of views, the focus shifts increasingly from one of sound natural resource management to recognition of the interdependence of biophysical and socio-economic systems. At the third level, considerations of "balance" between environment and economic factors become increasingly the key element of concern. Similarly the approach becomes increasingly more "multi-objective" and integrative in its outlook and application. Mitchell (1991a) asserts that the third view provides an
operational vehicle for the implementation of Ecologically Sustainable Development initiatives.

Mitchell (1991a & b) and Hollick and Mitchell (1991) argue that for truly integrated approaches to become operational, certain attributes need to be made explicit (see Table 9.2). They assert that none of these attributes comprises an integrated approach on its own, but collectively they define an approach aimed at dealing with the conflict and uncertainty of natural resource management and development.

The ICM label is but one name given to an emerging group of processes or "tools for sustainability" being developed and tested under a broader heading of "ecosystem approaches" (Slocombe 1993). When adopted these approaches aim to be significantly different from traditional fragmented approaches to natural resource management and development. They attempt to provide networking structures to bridge the gaps between traditional administrative and institutional arrangements that have not been designed to deal with the complexity of ecosystem relationships or the so called "messy" problems of natural resource management and development (Carley and Christie 1992).

<table>
<thead>
<tr>
<th>APPROACH</th>
<th>ATTRIBUTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems Approach</td>
<td>Where attention is directed to both natural and human systems, their component parts, and the inter-relationships among those parts</td>
</tr>
<tr>
<td>Integrated Approach</td>
<td>Where attention is directed to the key issues and variables, rather than all issues and variables, and to the linkages</td>
</tr>
<tr>
<td>Stakeholder Approach</td>
<td>Where it is recognised that citizens and non-government groups should be able to participate in decisions about what ought to be, what can be and what will be for their area</td>
</tr>
<tr>
<td>Partnership Approach</td>
<td>Where it is recognised that state government, local government, non-government organisations and individuals each have a role</td>
</tr>
<tr>
<td>Balanced Approach</td>
<td>Where concerns about enhancing economic development, protecting the integrity of natural systems and satisfying social norms and values are attempted to be balanced</td>
</tr>
</tbody>
</table>

*Table 9.2 Attributes Of Integrated Or Ecosystem Approaches To Natural Resource Management And Development* (adapted from Mitchell 1991b and Hollick and Mitchell 1991).
The main characteristic of these approaches can primarily be attributed to the explicit recognition of the public's role in decision making and the acceptance of conflict and uncertainty as fundamental components of natural resource management. Martin (1991) has developed this point further and called for "communicative catchments" where technocrats, natural resource users and interested parties establish participative action learning processes which draw the parties together to resolve differences and instigate action and learning in a continuous cyclic and open process.

Collett (1992) concurs with these general descriptions and has suggested that where ICM has been applied it can be viewed to have fallen into three categories or models, titled Technological, Bureaucratic or Participative. These three approaches are summarised in Table 9.3. In Collett's view when UICM is applied in a "participative" way it has the best chance of directing communities towards sustainability.

Thus UICM has been proposed as an important planning mechanism which hopes to incorporate broad community values, skills and resources, with the more technical skills of agencies to firstly, deal with urban stormwater quality issues, and secondly, develop broad strategies to facilitate sustainable urban development. The ICM approach has been promoted in Australia as a philosophy, process and product (Hollick & Mitchell 1991). This approach is summarised as:

- **philosophy** - cooperation and collaboration with resultant shifts in organisational culture and participant attitudes.
- **process** - involvement of all the key agencies and including the public in a participatory process of problem identification and resolution.
- **product** - strategies which aim to link land and water management and incorporate environmental and economic considerations.
<table>
<thead>
<tr>
<th>Subject matter</th>
<th>Technological Model</th>
<th>Bureaucratic Model</th>
<th>Participative Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Appropriate aspects</td>
<td>Land use &amp;</td>
<td>Concerned with</td>
</tr>
<tr>
<td>Paradigm</td>
<td>of the water cycle</td>
<td>infrastructure</td>
<td>sustainability of</td>
</tr>
<tr>
<td></td>
<td>managed on a</td>
<td>creation</td>
<td>all uses of catchment</td>
</tr>
<tr>
<td></td>
<td>catchment basis</td>
<td></td>
<td>resources</td>
</tr>
<tr>
<td>Integration</td>
<td>Of a resource's use</td>
<td>Of several agency</td>
<td>Of community</td>
</tr>
<tr>
<td></td>
<td></td>
<td>programs</td>
<td>processes and</td>
</tr>
<tr>
<td>Responsibility</td>
<td>Single agency,</td>
<td>Several agencies;</td>
<td>Lying mainly with</td>
</tr>
<tr>
<td></td>
<td>responsibility clear</td>
<td>responsibilities</td>
<td>the community</td>
</tr>
<tr>
<td></td>
<td></td>
<td>diffuse</td>
<td></td>
</tr>
<tr>
<td>Linkages</td>
<td>Self contained and</td>
<td>Co-operative</td>
<td>Broad networking</td>
</tr>
<tr>
<td></td>
<td>inward looking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Style</td>
<td>Directive; must do,</td>
<td>Prescriptive;</td>
<td>Consultative:</td>
</tr>
<tr>
<td></td>
<td>top down</td>
<td>should do</td>
<td>bottom up</td>
</tr>
<tr>
<td>Performance</td>
<td>Easily benchmarked</td>
<td>More difficult to</td>
<td>Multi dimensional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>measure</td>
<td></td>
</tr>
<tr>
<td>Outcomes</td>
<td>With cross subsidies</td>
<td>Redistributive but</td>
<td>Choice maximising</td>
</tr>
<tr>
<td></td>
<td>&amp; externalities</td>
<td>inefficient</td>
<td>market based</td>
</tr>
<tr>
<td></td>
<td>embedded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community focus</td>
<td>Minimal, non- critical</td>
<td>Advisory</td>
<td>Community treated as</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>equals</td>
</tr>
<tr>
<td>Language</td>
<td>Obscure</td>
<td>Complex</td>
<td>Transparent</td>
</tr>
<tr>
<td>Description</td>
<td>Integrated (hydraulic)</td>
<td>Integrated (agency)</td>
<td>Total (community)</td>
</tr>
<tr>
<td></td>
<td>catchment management</td>
<td>catchment</td>
<td>catchment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>management</td>
<td>management</td>
</tr>
</tbody>
</table>

*Table 9.3 Models Of ICM*

(adapted from Collett, 1992)

While the various ways of discerning what is distinctly different about ICM approaches is valuable, establishing the strengths and weakness of the process is possibly more important. Learning from these types of activities is the only way to effectively implement UICM or as Benveniste (1989) suggests, "master the politics of planning". To help make these assessments Mitchell (1990) has provided a conceptual framework for analysis of ICM (see Table 9.4). This provides a tool to describe and learn from these processes (see Chapter 8 which provides a case study of an ICM).
<table>
<thead>
<tr>
<th>ASPECT</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context</td>
<td>The historical, cultural and institutional context into which any policy/process is introduced</td>
</tr>
<tr>
<td>Legitimation</td>
<td>The extent to which the policy and/or process is regarded as legitimate and credible depends upon the extent of legislative, political, administrative and/or financial support</td>
</tr>
<tr>
<td>Organisational Attitudes</td>
<td>Effective policy / process implementation is influenced by the cultures and attitudes of the organisations involved</td>
</tr>
<tr>
<td>Processes &amp; Mechanisms</td>
<td>The adequacy of processes and mechanisms used to make the policy / process operational and able to develop the desired 'product'</td>
</tr>
<tr>
<td>Functions</td>
<td>The extent to which critical functional responsibilities amongst agencies have been decided and their ongoing performance</td>
</tr>
<tr>
<td>Structures</td>
<td>Both institutional and process structure design must be compatible with function allocation</td>
</tr>
</tbody>
</table>

*Table 9.4 Elements of Mitchell's Conceptual Framework*
(adapted from Mitchell 1990)

### 9.5 Water Sensitive Urban Design

Water Sensitive Urban Design can be viewed as a tool or mechanism for performance based UICM and aims to complement the 'participative' community based process of catchment or watershed management. The term Water Sensitive Urban Design (WSUD) was coined in Western Australia during the process of a research project supported by the Western Australian Water Resources Council (WAWRC) which had the aim of devising and illustrating an approach to urban planning and design which incorporated water resource and related environmental management into the planning process at various scales and time horizons in the process (Water Sensitive Urban Design Research Group 1990). The term 'sensitive' was selected to capture in one phrase the elements of water management concern, water balance, water quality and water consumption along with related environmental and social issues.

The WSUD initiative has involved development of the Water Sensitive Urban Design Guidelines, a policy framework and schedule of Best Planning and Best Management Practices as a project for the Western Australian Department of Planning and Urban
Development, the Water Authority of Western Australia and the Environmental Protection Authority (Moran et al 1993).

WSUD is a "mechanism" for developing and implementing sustainable solutions at the interface between development, landscape modification and water cycle change. As such, WSUD represents a development control mechanism which provides the framework for implementation of structural and non-structural measures to control water balance, water quality and water consumption objectives. Table 9.5 illustrates the hierarchy of cost sensitive management options showing the new non-structural controls within the first tier of management options (note cost increase towards the top of the table). The WSUD Guidelines highlight the need to integrate water resource, land use and related environmental/social objectives in the planning process; from strategic to site specific development levels. A number of implementation options for each level of the planning process were identified (see Table 9.6). The objectives of WSUD adopted for the WA Guidelines are listed in Table 9.7.

<table>
<thead>
<tr>
<th>Level</th>
<th>Management Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 3</td>
<td>9 Retrofit existing developed site</td>
</tr>
<tr>
<td></td>
<td>8 Retrofit to existing open space</td>
</tr>
<tr>
<td></td>
<td>7 Retrofit to existing systems</td>
</tr>
<tr>
<td>Tier 2</td>
<td>6 Structural elements for redevelopment sites</td>
</tr>
<tr>
<td></td>
<td>5 associated structural improvements</td>
</tr>
<tr>
<td></td>
<td>4 Structural elements for new developments</td>
</tr>
<tr>
<td>Tier 1</td>
<td>3 New non-structural controls</td>
</tr>
<tr>
<td></td>
<td>2 Existing non-structural improvements</td>
</tr>
<tr>
<td></td>
<td>1 Evaluation of existing systems</td>
</tr>
</tbody>
</table>

*Table 9.5 Hierarchy of Cost Sensitive Management Options for Catchment Management*

(Note: There is increasing program requirements and costs towards the top of the table - Adapted from Hartigan and George 1992 )
<table>
<thead>
<tr>
<th>STRATEGIC / STRUCTURE PLANNING INCLUDING TOWN PLANNING SCHEME REVIEW</th>
<th>LOCAL STRUCTURE PLANNING/URBAN ZONINGS</th>
<th>RESIDENTIAL LAND SUBDIVISION</th>
<th>HOUSING DEVELOPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UTILISE GOVERNMENT POLICY &amp; REGULATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADOPT INTEGRATED WATER RESOURCE MANAGEMENT/ LAND USE PLANNING (DPD Policy D.C.6.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROTECT IMPORTANT WETLANDS, WATERCOURSES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WATER SUPPLY CATCHMENTS (Reserve in MRS and L.A. T.P. Scheme)</td>
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<tr>
<td>IDENTIFY AND PROTECT ARTERIAL STORMWATER MANAGEMENT SYSTEMS (WAWA Statutes)</td>
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<tr>
<td>PROTECT SENSITIVE AREAS FROM INCOMPATIBLE USES (Planning Control Area)</td>
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<tr>
<td>PLAN AREAS OVER MULTIPLE PROPERTY BOUNDARIES (MRS Improvement Plan)</td>
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<tr>
<td>PREPARE ENVIRONMENTAL PROTECTION POLICY</td>
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<tr>
<td><strong>UTILISE TOWN PLANNING SCHEME PROVISIONS</strong></td>
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<tr>
<td>REZONE AREAS TO BE DEVELOPED TO &quot;URBAN&quot; APPROPRIATE CONDITIONS RELATING TO</td>
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<tr>
<td>- Water Resource Management</td>
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<tr>
<td>- Performance standards</td>
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<tr>
<td>- Deemed to comply criteria (T.P. Scheme Amendment)</td>
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<tr>
<td>Opportunities to increase residential density</td>
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<tr>
<td>and revise development area in accordance with water resource management/development objectives for the area, achieved through the incorporation of appropriate BPP's &amp; BMP's at the strategic level.</td>
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<tr>
<td>TRANSFER DEVELOPMENT RIGHTS &amp; ARRANGE COST SHARING (L.A. / Owner Initiated guided Development Scheme)</td>
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<tr>
<td><strong>APPLY SUBDIVISION CONDITIONS</strong></td>
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<tr>
<td>RECONSIDER:</td>
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<tr>
<td>- Water Resource Management objectives/performance standards</td>
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<tr>
<td>- Application of strategic BPP's &amp; BMP's</td>
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<tr>
<td>- Application of local BMP's</td>
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<tr>
<td>- Health regulations</td>
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<td>- Sewerage policy</td>
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<tr>
<td>- LA By-laws</td>
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<tr>
<td>- Water self-supply opportunities/restrictions</td>
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<tr>
<td>FOR DEVELOPED AREA</td>
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<tr>
<td>- Road widths (reserves &amp; pavements)</td>
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<tr>
<td>- Public open space (passive &amp; active)</td>
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<tr>
<td>- Landscaping</td>
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<tr>
<td>- Drainage &amp; fill</td>
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<tr>
<td>- Water supply</td>
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<tr>
<td>- Sewerage</td>
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<tr>
<td>- Residential density (bonuses may be available if application of strategic &amp; local BPP's &amp; BMP's indicates &quot;spare capacity&quot; to meet objectives)</td>
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<tr>
<td>FOR UNDEVELOPED AREA</td>
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<tr>
<td>- Vegetation protection</td>
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<tr>
<td>- Clearing controls</td>
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<td></td>
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<tr>
<td>- Stocking limitations</td>
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<tr>
<td>- Fencing</td>
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<td></td>
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<tr>
<td>- Access</td>
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<tr>
<td>- Bushfire management</td>
<td></td>
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<tr>
<td>- Setbacks from watercourses/wetlands (reduction may be available if application of BPP's &amp; BMP's at strategic and local levels indicates &quot;spare capacity&quot; to meet objectives)</td>
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<tr>
<td>FOR TENURE/ MANAGEMENT OF UNDEVELOPED AREA</td>
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<tr>
<td>- Reservation &amp; acquisition</td>
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<tr>
<td>- Acquisition &amp; leaseback</td>
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<tr>
<td>- Council ownership &amp; management agreement (including regulated water self-supply &amp; rate levy)</td>
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</table>

*Table 9.6*

**PLANNING MEASURES TO IMPLEMENT WATER RESOURCE MANAGEMENT**

**SOURCE:** Moran 1993
Planning and management principle developed during the project are shown in Table 9.8. From these a series of best planning and best management practices were developed which recognise the ecological integrity of receiving environments, with emphasis on detention, retention and recharge and carefully located and designed discharge points. The design responses seek to shift from unmanaged private use of water to regulated and managed supply of well planned and water conserving open space areas. Best Planning Practices (BPPs) and groupings of Best Management Practices (BMPs) developed are listed in Table 9.9.

<table>
<thead>
<tr>
<th>WATER SENSITIVE URBAN DESIGN OBJECTIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Balance Objectives</td>
</tr>
<tr>
<td>• to maintain appropriate aquifer levels, recharge and stream flow characteristics in accordance with assigned beneficial uses</td>
</tr>
<tr>
<td>• to prevent flood damage in developed areas and</td>
</tr>
<tr>
<td>• to prevent excessive erosion of water ways, slopes and banks</td>
</tr>
<tr>
<td>Water Conservation Objectives</td>
</tr>
<tr>
<td>• to minimise the import and use of scheme water</td>
</tr>
<tr>
<td>• to promote the re-use of stormwater</td>
</tr>
<tr>
<td>• to promote the re-use and recycling of effluent</td>
</tr>
<tr>
<td>• to reduce irrigation requirements, and</td>
</tr>
<tr>
<td>• to promote regulated self supply</td>
</tr>
<tr>
<td>Water Quality Objectives</td>
</tr>
<tr>
<td>• to minimise water borne sediment loadings</td>
</tr>
<tr>
<td>• to protect existing riparian or fringing vegetation</td>
</tr>
<tr>
<td>• to minimise the export of pollutants to surface or groundwater</td>
</tr>
<tr>
<td>• to minimise the export and impact of pollution from sewerage</td>
</tr>
<tr>
<td>Environmental / Social Objectives</td>
</tr>
<tr>
<td>• to maintain water related environmental values</td>
</tr>
<tr>
<td>• to maintain water related recreational and cultural values</td>
</tr>
<tr>
<td>• any necessary, site specific water sensitive objective identified by the appropriate resource management authority</td>
</tr>
</tbody>
</table>

*Table 9.7 WSUD Objectives*

To integrate these principles into the urban development process, water resource management objectives need to be identified for specific geographic units. Two type of units are proposed:
- Water Resource Management Units (WRMUs) based upon catchments and within which general water resource management objectives apply, and for which catchment management strategies may be developed.

- Water Sensitive Planning Units (WSPUs) based upon land use and administrative planning entities within which more specific water resource management will be developed and applied, and for which local action plans may be applied.

This two tier system provides the "Planning Framework" for directing management and planning action and the selection of appropriate Best Planning Practices (BPPs) and Best Management Practices (BMPs) at the subdivision level. Figure 9.3 illustrates an archetypal arrangement.

<table>
<thead>
<tr>
<th>WATER SENSITIVE DESIGN PLANNING AND MANAGEMENT PRINCIPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It is much more efficient and cost effective to incorporate water resource issues early in the land use planning process than to address them later.</td>
</tr>
<tr>
<td>2. Water resource management should be addressed at the catchment or sub-catchment level.</td>
</tr>
<tr>
<td>3. Stormwater management is part of total water resource management.</td>
</tr>
<tr>
<td>4. Where possible the components of stormwater management should follow natural contours with the management systems incorporating as much as possible of the features and function of natural stormwater systems which is largely capital, energy and maintenance cost free.</td>
</tr>
<tr>
<td>5. Subject to meeting water resource management objectives in respect to assigned beneficial uses the post urban development conditions should approximate pre-urban conditions.</td>
</tr>
<tr>
<td>6. Local on-site storage and utilisation of runoff should be maximised.</td>
</tr>
<tr>
<td>7. Wherever possible storage areas should be an integral component of the urban landscape.</td>
</tr>
<tr>
<td>8. Stormwater management systems should emphasis the use of vegetation (particularly indigenous vegetation) to promote filtering, slowing of runoff to pre-development conditions.</td>
</tr>
</tbody>
</table>

*Table 9.8 Water Sensitive Design Planning And Management Principles*
BEST PLANNING PRACTICES & GROUPINGS OF BEST MANAGEMENT PRACTICES

- Best Planning Practices
- Stormwater Management System
- Residential Development Precinct
- Public Open Space Network Responsive to Drainage Function
- Road Layout
- Cluster Development
- Streetscape

Groupings of Best Management Practices
- Measures to promote infiltration and detention
- Measures to control scour, erosion and sedimentation
- Measures to control stormwater runoff pollution
- Measures to minimise pollution of sewage and encourage wastewater recycling
- Measures to promote water conservation

Table 9.9 Best Planning Practices & Groupings of Best Management Practices

Although WSUD provides a framework of objectives and a way of linking the application of BPPs and BMPs to the urban planning process, there is a need to develop an appreciation of the effect of these measures and how best to monitor their performance in meeting objectives. Essentially a hierarchy of goals, objectives and performance standards or criteria is needed. The emergence of community based Urban ICM projects presents the obvious process by which these community aspirations can be articulated.

Performance criteria should include a range of factors which help to demonstrate that the overall ecological integrity and human aspirations for the system are being met. Under the WSUD framework water balance, water quality and water conservation targets are proposed. Increasingly, however, it is being recognised that a range of other factors such as those listed in Table 9.10 need to be established to provide a more complete picture of the ecological integrity of the system. In terms of developing performance criteria for receiving environments, an appreciation of the temporal and spatial factors is also essential (ie some parts of an estuarine system may be more vulnerable than others at certain times of year).
It must be stressed that the establishment of these goals, objectives and performance measures needs to recognise the relative time frame for implementation (ie short- up to 5 years, medium - 10 to 20 years and long term - 20 to 100 years).

Although it is possible to establish meaningful goals, objectives and performance criteria, it needs to be recognised that the ability of Best Planning and Best Management practices to achieve long term goals and objectives in any particular context is uncertain. As yet no deterministic model exists that can predict exactly how an ecosystem will respond to urbanisation or how a BMP might compensate for these impacts. Even if such a model existed for a particular catchment it is not likely to be readily translatable to another water body without significant modifications (Anacostia Restoration Team 1991).

<table>
<thead>
<tr>
<th>ECOLOGICAL INTEGRITY FACTORS</th>
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<tbody>
<tr>
<td>• Hydrological change</td>
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<tr>
<td>• Channel form stability</td>
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<tr>
<td>• Substrate quality</td>
</tr>
<tr>
<td>• Water quality</td>
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<tr>
<td>• Stream community</td>
</tr>
<tr>
<td>• Riparian cover</td>
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<tr>
<td>• Stream reach</td>
</tr>
<tr>
<td>• Contiguous wetland</td>
</tr>
<tr>
<td>• Floodplain change</td>
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<tr>
<td>• Receiving water target</td>
</tr>
</tbody>
</table>

*Table 9.10 Ecological Integrity Factors*
(Source: Anacostia Restoration Team 1991.)

This fact, however, should not impede application. Planners, engineers and environmental scientists should rely on their qualitative and intuitive knowledge and understanding of these systems when developing BPP and BMP plans. Design of these systems must consider factors at the site, stream (or neighbourhood) and catchment scale, and endeavour to achieve the desired effect at the lowest possible social cost. In order to keep the uncertainties within acceptable limits, the second step must be to go through a rational or quantitative process, which translates into design standards, to meet short term performance criteria based on best available knowledge.
After implementation, ongoing monitoring and evaluation is required to determine the success of short, medium or long term goals and objectives relative to the quantitative design standards and assessment factors determined in the rational phase. Thus short term criteria can be either relaxed or tightened depending on their achievement of the medium and long term goals and objectives, and social costs. Figure 9.4 illustrates this iterative dynamic process.

A characteristic of this process is that design standards and performance criteria are dynamic and not static. It is an evolutionary process which incorporates feedback between the intuitive and rational approach until the long term goals are met. The role of the community in this iterative process is essential as it needs to be recognised that there are costs associated with meeting the performance criteria and consequently the community's long term goals. The community may modify its needs and wants when balancing the costs and benefits associated with obtaining the goals.

![Qualitative Intuitive Approach](image)

Figure 9.4 Dynamic Urban ICM Performance Model
(adapted from Hengeveld and Geldof 1993)

An important feature of this adaptive and flexible "performance" approach to Urban ICM is that by avoiding the static character of standards, the way is cleared to commence the implementation of BPPs and BMPs. It establishes a procedure to
manage conditions of uncertainty and provides the opportunity to develop tools to evaluate environmental performance and economic and social benefits. The methodology utilises the intuitive approach, but recognises the importance of accumulating systematic and detailed knowledge via the rational approach, but does not need to "know everything" before effective management can occur.

Consequently this holistic performance approach to catchment management seeks to put in place a flexible, adaptive, dynamic and evolutionary system that can adjust as further information becomes available, or the aspirations of the community change within a 'participative' model of Urban ICM.

9.6 Summary

The concept of IUWM represents a major professional attempt to "shift" the present design and decision making about urban water management towards sustainable outcomes. It represents a response to the growing recognition that there is a need to shift today's unsustainable water management practices into new forms, capable of integrating ecological and economic factors and recognising the needs of future generations.

Although there is a significant way to go before the concept of IUWM is embedded in praxis there are a range of initiatives within the Australian and International context which provide some confidence that a challenging new approach is emerging. This approach can be strengthened by using an urban ecological perspective which views the city as an ecosystem. This approach suggests that solving the internal water problems of the city by increasing the supply and discharge, simply aggravates the source and supply problems outside the city. An IUWM perspective to urban water management suggests that there is a need to strengthen a city's capacity to resist and to retain the flows without reducing the quality of urban life.
To help illustrate how these new perspectives are being applied two closely related Australian examples of UICM and WSUD have been described. This has illustrated that conceptual and practical development of these ideas is well advanced. The UICM represents a method of bringing the various stakeholders around the table to develop a framework for integration. Increasingly the focus of these processes has been towards institutionalising a philosophy of cooperation and developing participatory processes to link land and water planning and localise water management. Importantly these processes involve the community in making choices about the type of urban water systems they prefer thereby developing a sense of local ownership and action. This mechanism provides an essential link between professionals in urban water management and community aspirations.

In making choices and setting goals for catchment management it is increasingly recognised that short, medium and long term goals for achieving sustainability objectives are required. Thus the way forward appears to involve: a performance based approach to integrated urban water management that adopts an iterative process and balances the use of qualitative and intuitive knowledge against quantitative and rational information.

The concept of WSUD has been developed as a tool or mechanism to link and integrate the land use planning and water management process in urban areas. It provides a technical system for design and management of more sustainable urban water systems by presenting a framework of objectives and techniques to achieve the outcomes desired. Although the focus of WSUD has primarily been directed towards better stormwater management it represents a framework which extends to consideration of the role of urban design and management in water conservation and illustrates opportunities for reuse of wastewater. What is important about WSUD is that it presents an explicit framework for developing and approving design solutions which are multi objective. The development of these solutions is shown to require a far wider knowledge base forcing the need for transdisciplinary praxis.
CHAPTER 10

EVOLUTION OF WATER SENSITIVE URBAN DESIGN:
THE POLITICS OF EMERGING PROFESSIONAL PRAXIS

It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more difficult to manage than the creation of a new system. For the initiator has the enmity of all who would profit by the preservation of the old institution and merely lukewarm defenders in those who would gain by the new ones.

Machiavelli - "The Prince"

Ideas, like grapes, grow in clusters. People like to hang out together because they feel their ideas growing fuller and richer on the vine.

W. I. Thompson 1987

10.1 Introduction

In this chapter the attention turns from the characteristics of the emerging concept of Integrated Urban Water Management to the process of evolving the concept of Water Sensitive Urban Design in Perth, Western Australia, as an example of an attempt to integrate land and water planning in the urban development and renewal. The chapter illustrates the processes involved in introducing ecological principles into the institutional and regulatory setting. It explores some of the necessary ingredients required for that change to occur in the present milieux of professional praxis and the socio-political setting. This chapter draws from and updates a paper by Hedgcock and Mouritz (1993).

The chapter initially presents an introduction to the social, biophysical and institutional setting within which the concept of Water Sensitive Design (WSUD) has evolved. This is followed by an overview of the WSUD policy formulation process, providing an assessment of the factors that created the necessary conditions to achieve agency and public support for the concept.

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10.2 Understanding the "Nature of the Place"

The concept of WSUD evolved in Perth, a city of a little over 1 million people and the capital city of Western Australia. It is located in the south west of Western Australia. Perth is the most isolated city in the world, but it has developed a character and form from an array of influences; its physical setting, its early British colonial heritage, international planning theories and practice, plus local innovation and more recent cultural and economic influence from the USA and now Asia (Hedgcock and Yiftachel 1992).

The development of the city of Perth has been typically driven by the service needs of the boom and bust cycles of mineral and agricultural industries of the interior. The Swan Coastal Plain presented both development opportunities and problems. Its sand plain character presented few barriers to modification and urban development. The early settlers, and many that have followed, have seen little benefit in the natural regime, and substantive modifications to the natural systems have been the consequence of unrestrained urban development. An urban image based primarily on "European Ideals" of drained soils, solid ground, perennial lush lawns and a readily available water supply, has emerged as the cultural norm.

The approaches to the engineering of this new environmental reality has changed little over the years. Low lying land was either drained to the river and ocean outfalls or filled with the growing waste of the urban community. Streams and rivers were dammed on the adjacent escarpment and the water piped to reservoirs and storage tanks throughout the metropolitan region. The deep sandy soils provided what was believed to be ideal conditions for septic tank sewage disposal. As a consequence a reticulated system linked to primary treatment came late to the State and even today 30% of Perth's households still rely on septic tanks. Much of the indigenous flora was
quickly and easily removed to be replaced by verdant suburban landscapes supported by a cheap and plentiful water supply.

These traditions of suburban development saw water placed very low on the planning agenda. Any constraints it imposed on development were considered to be surmountable with suitably applied engineering largesse and indeed there was some early pride in the taming of this often unpredictable natural element (Le Page 1986). But these were crude solutions to a complex environment and have to a large extent set up the water problem for proceeding generations.

Perth's climate is Mediterranean with an average of eight months of near drought and heat combined with four months of wet and cold conditions. It sits on the western edge of the driest inhabited continent on Earth, surrounded by an arid interior. Perhaps partly due to this social isolation, the European inhabitants have begun, in recent times, to understand the "nature of the place" (Hough 1984). A large part of that understanding has been built up through the development of an appreciation of the interactions that occur between natural and human developed water systems and the interactions with land use.

A major focus of public and government concern has been the progressive loss of wetland environments. This loss, estimated at up to 80%, has come about primarily because of the low conservation value placed on these features by previous generations. Consequently these features were seen as ideal locations for transport corridors, mining of peat, horticulture, rubbish tips and filling for housing and industrial areas, and were modified to appear more like European water features. Increased recognition of the importance of wetlands has led to the development of extensive wetland mapping and evaluation systems (WAWA 1992). In a similar fashion the eutrophication of the Peel Harvey estuary south of Perth and the threat of the same problem developing in the Swan Canning estuary has taught us much about
catchment management and the need for precautionary approaches, particularly in respect to water quality management.

During the 1980's and in to the 90's an impressive list of land and water research studies and policy initiatives have been undertaken, aimed at understanding and protecting the future of the metropolitan region's water system. Collectively the numerous studies represent a growing understanding of the land and water interactions of the Swan Coastal Plain and identify some of the actions that have taken place to come to grips with the consequences of past practices. They all represent the growing shift towards recognising the value of inter agency cooperation or Integrated Catchment Management (ICM) approaches. In translating this ICM understanding into a framework for urban planning and design responses it has been useful to classify the water issues involved in terms of: water balance (WB), water quality (WQ), and water consumption (WC) (Hedgcock and Mouritz 1989) rather than the traditional more narrowly focused language of water quantity and quality. This framework has proved useful in developing an increased understanding of the relationship between urban form and character and the hydrological cycle.

For example between 40% and 60% of mains water is used outside of the home in Perth and there is a clear relationship between lot size and the extent of this water use (Sumner 1990). In the public domain a cultural priority towards active sports has meant that the park system has emerged which is dominated by expansive turf monoculture. These parks and reserves are heavy users of ground water and ironically in the driest state the provision of space for these activities is one of the highest in Australia. These characteristics of suburban development have been ingrained into the lifestyle and culture of Perth's residents and this argument is often used as a reason for the maintenance of the status quo. In this environment any change to the existing system faces considerable political constraints.
Yet these traditions are now facing a major challenge in meeting the complex demands of future populations. In the nineties and beyond it is forecast the metropolitan population will grow at the rate of 2% per annum (SPC 1987). To slake the thirst of this population the economic and environmental cost of unconstrained water supply development are becoming increasingly apparent.

This increased knowledge base and the growing political recognition of the declining condition of the State’s environment and natural resource base led to the development of a significant government policy shift towards 'integrated catchment management' (ICM) (WA Govt 1989). As MacRae and Brown (1992) point out, this approach called for greater community involvement and a whole-of-government approach to the 'coordination of planning, use and management of water, land and vegetation and other natural resources on a river or catchment basis'.

With population forecasts for the metropolitan region suggesting a doubling of the population within 20 to 30 years it was becoming apparent that the economic and environmental cost of unconstrained water supply development was becoming increasingly untenable (Postel 1992). In addition, an increasingly uncertain seasonal regime (a long term reduction in rainfall had been found in the previous 20 years), as well as the potential for climate change, meant that the need for a precautionary approach had become increasingly apparent.

Given this background, alternative approaches to water management within the Perth Metropolitan Region were becoming acceptable. The crux of these deliberations saw a move away from engineering led solutions to more ecologically responsive strategies designed to renegotiate the development response to the environmental conditions of the Swan Coastal Plain. Out of these considerations a new agenda emerged based not on a narrow range of unrealistic expectations but on a growing respect for the pre-existing natural environment (Seddon 1972).
Like all policy development that crosses institutional boundaries, delivery on the policy objectives is largely dependant upon the support of each of the policy and program stakeholders. Nowhere is this more evident than when developing policy which is focused towards the integration of 'land and water' planning and management in the urban environment. This is primarily due to the highly fragmented nature of agency responsibility for the various elements of the natural and developed water cycle. Acknowledging and dealing with the institutional setting, organisational cultures and participant attitudes therefore becomes an essential part of the policy development process (Mitchell 1990, 1991). A detailed account of these complex relationships is beyond the scope of this chapter, however, a very brief introduction to the main players is provided below. A more detailed account of institutional issues in relation to water and natural resource management can be found in Hollick (1988) and Hollick and Mitchell (1991).

Under the Australian constitution the management of water is the responsibility of the federation of states and territories which form Australia, so at the Commonwealth Government level there has been little direct influence over water management. However, during the 1980's and 1990's the Commonwealth has become increasingly more involved in initiation and coordination of national policy in the environmental and natural resource management area and more recently into urban policy issues. The main mechanism for policy implementation has been via funding of state agencies to achieve certain policy objectives.

The main government departments with an interest in water in the Western Australian bureaucracy are the Environmental Protection Authority (EPA), Water Authority of Western Australia (WAWA), Department of Planning and Urban Development (DPUD), Waterways Commission (WC), Department of Conservation and Land Management, Agriculture Department, and the two primary inter agency coordinating
structures, the Office of Catchment Management (OCM) and the Western Australian Water Resource Council (WAWRC). Local Authorities (LAs) which in most cases are the closest to the concerns of the community also have a very influential role in the planning, development and management of the urban water cycle, particularly stormwater.

10.3 Evolving the Concept

The environmental problems associated with the traditional planning and engineering approaches to water management in the urban area (as outlined above) received increasing attention towards the end of the 1980's. This was related to a number of factors including:

- The increasingly fragile and sensitive environments on which the 'front' of urban development was encroaching (Review Group 1987).
- The growing status of the Environmental Protection Agency and the Minister for the Environment given by the increasing importance of the 'green vote' in State elections (Singleton 1992).
- The establishment of a number of coordinating agencies within the public service that began to challenge the traditional sectoral approach to decision making eg Office of Catchment Management, Western Australian Water Resources Council (Synnott 1992).
- The opening up of the urban development approval process to public scrutiny in the course of environmental impact assessment.
- The growing interest of the Water Authority in areas outside of their traditional 'supply' brief, in particular demand management and water resource management.

In this changing climate of opinion the water cycle in all its various guises (e.g. wetland protection and drainage management) emerged as a significant determinant in the development assessment/approval process. However, the fragmented and complex nature of the range of agencies involved in determining water impacts often created a
gridlock of advice and counter advice that played into the developers' hands. To the
cry of 'red tape' they went over the heads of approval agencies to the Ministers and
ultimately Cabinet.

This situation came to a head when a large area of land over a valuable groundwater
resource and adjacent to the most pristine wetland system in the metropolitan region
was approved for suburban development. The shock of such a complete and
comprehensive defeat for water related interests forced a consideration of new
strategies and in particular the idea of moving away from the 'win all - lose all' polarity
that invariably surrounded the conflicts over development proposals. Out of this
context the idea of more middle ground strategies emerged, eg. ways of improving the
character and extent of development, as they affected the water environment, rather
than relying on the arguments of outright opposition to any development (Hollick
1988).

Out of this context emerged the concept of Water Sensitive Urban Design. The follow
discussion presents the key evolutionary steps in the process, while a point form
chronology of events in the process is provided in Table 10.1. The discussion covers
the period from late 1987 until early 1996.

10.3.1 Initial Research - Exploring the Concept

It was against the background of rapid urban growth and an emerging environmental
consciousness that an interest group was formed in late 1987 to investigate the
potential for water related concerns to be more sensitively considered and integrated
within the development process (Mouritz 1991).

The great majority of its members came from within the public service reflecting the
institutional concern over this issue. However, the group was convened in the Planning
School at Curtin University to reinforce what was seen as a core research brief for the
exercise. While this provided the project with an isolation and integrity away from the
mainstream of environmental politics, it also left the group with few resources and no formal avenue to effective decision making structures. This was addressed when the group was approached by the Western Australian Water Resources Council to operate under the umbrella of its programs.

The group then set about developing the concept of what was then being called Water Sensitive Urban Design (WSUD) through a research project funded collectively by urban land and water agencies. The objective of the project was to investigate the scope and potential of design initiatives to optimise water conservation, water balance and water quality values within the development process.

Although the emphasis was on design, it was recognised at the outset that design merely reflects a broader context of ideological and institutional parameters (Scarborough and Corbett 1992). As such, much of the work had to be focused on reform of these complex and conservative cultures.

The early work of the group concentrated on establishing a common philosophy concerning the value and significance of water in the development process. A Water Sensitive Design Policy was produced (Hedgcock and Mouritz 1989) that articulated in a general sense the relationship between wetland, water and the planning system asserting the role of water balance, water quality and water conservation as potential design criteria within the process of suburban design and development.

This had the effect of stimulating the state planning agency (DPUD 1988) to respond to this initiative in preparing their own policy document based on similar tenets. Although the policy had little direct impact on later development decisions it could be seen as an early article of faith in the wider project.
<table>
<thead>
<tr>
<th>Timing</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid to late 1980's</td>
<td>Throughout this period substantive public debate about wetland, groundwater and river conditions in the face of increasing urban expansion.</td>
</tr>
<tr>
<td>Late 1987</td>
<td>WSUD interest group formed</td>
</tr>
</tbody>
</table>
| During 1988  | Common philosophy of group debated  
Interest group becomes an official research committee of Western Australian Water Resources Council (WAWRC)  
Draft Water Sensitive Design Policy produced and circulated between stakeholder agencies via (WAWRC)                                      |
| During 1989  | Department of Planning and Urban Development responds to Draft Policy with an official policy called 'Planning Considerations in the Metropolitan Region for Sources of Public Water Supply and Sensitive Water Resource Areas. Policy No. DC63.  
Initial research project funded jointly by stakeholder agencies, DPUD, WAWA, EPA.                                                                 |
| During 1990  | Release of research report "Water Sensitive Residential Design; An Investigation into its Purpose and Potential in the Perth Metropolitan Region" by WAWRC.  
Public review and comment, general agreement with the recommendations at inter agency level and agreement by the DPUD to be responsible for the development of the Guidelines.  
Public acknowledgment of the need for WSUD in METROPLAN, the guiding planning document for the future of Perth. |

*Table 10.1 A Chronology of WSUD's Evolution*
<table>
<thead>
<tr>
<th>Timing</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>During 1991</td>
<td>Second phase of research commences, with funding from the Urban Water Research Association of Australia. The focus is on theoretical underpinning, practical case studies and policy implications.</td>
</tr>
<tr>
<td>September 1991</td>
<td>The concept is promoted widely within urban development circles when the Australian Institute of Urban Studies (WA) runs a seminar on Water Sensitive Urban Design.</td>
</tr>
<tr>
<td>November 1991</td>
<td>Murray Darling River System suffers major eutrophication symptoms, brings media attention onto the whole issue of Urban and Rural Water Quality.</td>
</tr>
<tr>
<td>December 1991</td>
<td>Consultants commissioned to prepare guidelines</td>
</tr>
<tr>
<td>During 1992</td>
<td>The consultancy process involved a number of steps culminating in the preparation of three working papers which focused on:</td>
</tr>
<tr>
<td></td>
<td>• Developments in stormwater management and water conservation in other countries, around Australia and related local studies to provide an insight into &quot;state of the art&quot; practices and experiences.</td>
</tr>
<tr>
<td></td>
<td>• Examination of metropolitan land use and water resource planning and management practices to establish how best to incorporate the guidelines into the development approval process.</td>
</tr>
<tr>
<td></td>
<td>• Preparation of a preliminary planning framework, recommendations and compilation of the Best Planning Practice and Best Management Practice.</td>
</tr>
<tr>
<td>Late 1992</td>
<td>Water Authority release extensive map and resource inventory of Wetlands of the Swan Coastal Plain.</td>
</tr>
<tr>
<td></td>
<td>National significance of supporting research project presented in a number of national forums.</td>
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<tr>
<td></td>
<td>Consultants invited to present Better Cities workshop on Designing suburbs to save and better water.</td>
</tr>
<tr>
<td>Summer 1992/93</td>
<td>Swan River starts to show real signs of eutrophication and the media take up the issue.</td>
</tr>
<tr>
<td></td>
<td>The development of the Swan Canning Environmental Protection Policy gains momentum.</td>
</tr>
<tr>
<td>During 1993</td>
<td>Political climate changes with the election of a conservative government. Provides new dimension to policy development process.</td>
</tr>
<tr>
<td>April - December 1993</td>
<td>Draft Guidelines Released for comment generally.</td>
</tr>
<tr>
<td></td>
<td>Procrastination on policy implementation. Process falls into leadership void within government.</td>
</tr>
</tbody>
</table>

*Table 10.1 A Chronology of WSUD's Evolution (continued)*
<table>
<thead>
<tr>
<th>Time Period</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early 1994</td>
<td>Hydrology Panel of Institution of Engineers decides to hold a Seminar on Water Sensitive Design.</td>
</tr>
<tr>
<td>April to September</td>
<td>Study applying WSUD principles is undertaken for the Dept of Planning and Water Authority for South East corridor of Perth.</td>
</tr>
<tr>
<td>1994</td>
<td>Minister for Planning opens Institution of Engineers Seminar on WSUD. Announces in principle support, but not a policy on WSUD.</td>
</tr>
<tr>
<td>September 1994</td>
<td>Seminar includes speakers from interstate and overseas who promote importance of document.</td>
</tr>
<tr>
<td></td>
<td>Guidelines released as &quot;consultants' report&quot; not a policy document.</td>
</tr>
<tr>
<td>October 1994 - June</td>
<td>WSUD project undertaken by team for City of Canning. From Drains to Living Streams and Handbook on Catchment Management published.</td>
</tr>
<tr>
<td>1995</td>
<td>Parliamentary committee on groundwater management endorses the need for implementation of WSUD policy.</td>
</tr>
<tr>
<td>June 1995</td>
<td>Network structure to support community involvement in catchment management proposed, WSUD illustrated as potential tool.</td>
</tr>
<tr>
<td>August 1995</td>
<td>Project to translate Guidelines into a design manual commences.</td>
</tr>
</tbody>
</table>

Table 10.1 A Chronology of WSUD's Evolution (continued)

One of the reasons that the impact of the policy was limited was the lack of applicable information and research on operationalising the concept of WSUD. This then became the central task of the research group. In summary this involved:

- Case study analysis of suburban developments that had successfully responded (from a design point of view) to particular characteristics of its hydrological environment.
- The identification of a development site close to Perth and exhibiting all the design challenges of a complex hydrological environment.
- The preparation of two hypothetical designs for the site; one using conventional approaches to design and the other adopting what were then being called water sensitive design criteria.
- The assessment of the performance of the two designs from the point of view of costs, environmental outcomes and marketability.

The result of this exercise was to prove that the concept of water sensitive design could be usefully applied within the process of suburban development. However, it is
one thing to prove the advantages of a hypothetical design, it is quite another to establish an appropriate framework for ensuring that such design initiatives become an integral component of the wider development process.

Three crucial areas of activity were seen as central to the further adoptance of the idea and these formed the basis of the research report’s recommendations:

- The need for agreement on a common set of water objectives across the range of government agencies involved in water based decision making (eg WAWA, EPA, WC, LA’s etc).
- A coordinating policy mechanism to implement these objectives.
- The availability of guidelines outlining a suite of planning and design ideas to apply in situations where policy dictated a water sensitive design response (WSUDRG 1990).

10.3.2 The Guidelines

These recommendations were first publicly acknowledged with METROPLAN, the new strategic policy document for the future of Perth’s physical form (WA Govt 1990). After some delays a second round of research, with the emphasis firmly on these aspects of implementation, was established. Now that the problem had been located in the institutional domain of DPUD, this agency took over the organisational roles and responsibilities. The next phase of the project was run as a consultancy exercise with the original members of the interest group taking up strategic roles on the consultancy team or the project’s steering committee.

Accepting the fact that WSUD was now considered a proven concept and an appropriate structure for reforming the development process, the consultant’s brief concentrated on the production of guidelines for achieving WSUD and the establishment of a policy and administrative framework within which these might be successfully implemented.
The study process involved a number of steps culminating in the preparation of three working papers which focused on:

- Examination of relevant developments in the area of stormwater management and water conservation in other countries, around Australia and related local studies to provide an insight into "state of the art" practices and experiences.
- Examination of metropolitan land use and water resource planning and management practices to establish how best to incorporate the guidelines into the development approval process.
- Preparation of preliminary planning framework recommendations and compilation of the Best Planning Practice and Best Management Practice.

The investigations undertaken for the production of the WSUD policy and guidelines reaffirmed the need for a planning framework that could:

- Set water sensitive objectives as part of a multi-objective framework.
- Relate suitable planning and management practices to achieving these objectives.
- Provide a method of assessing the suitability of planning and management practices.
- Identify the various levels of implementation (strategic, regional/local, site and building) and integrating appropriate design responses across each level.

This was achieved by establishing water resource management and planning objectives for catchment based units. The initial effort was on the establishment of the units and the objectives within the areas under the most pressure for urban expansion. The longer term aim is to apply this approach to all developed and undeveloped catchments on the Swan Coastal Plain (Moran et al 1993).

This framework of objective setting provides the basis within which, at the development stage what has been termed Best Planning Practices and Best Management Practices, can be selected and applied. The guidelines present some 80 of
these practices which encourage an integrated approach towards water management in
residential design, seeking not only to meet water sensitive design objectives but also to
minimise costs and reduce future maintenance burdens. For the first time, water
objectives related to the urban environment from a wide range of agencies have been
coalesced into a single document that will drive the process and character of urban
development if adopted by the political process.

10.3.3 Parallel Research

While the guidelines were prepared as a consultancy project undertaken largely by
practising urban development professionals, the whole process was also enhanced
with resources dedicated to what can best be described as a parallel research project.
That research forms the basis of this thesis and provided the opportunity to seek out
the theoretical underpinning of the concept and to establish the case studies (see
Chapters 11, 12 &13) that can contribute to the policy development process.

Importantly the research funding provided the opportunity for the process to be linked
to the academic domain. This allowed a degree of freedom not normally found in
consultancy projects. It provided the opportunity to locate the concept within a broad
sustainability context. It also allowed some freedom to voice concerns and provided
opportunities to assist in the promotion of the concept through organisation of
seminars. This all aided the process through what Benveniste (1989) refers to as
creating the conditions for the multiplier effect.

In addition because the research funding was provided from a national body, the
concepts and findings were presented at a number of local, national and international
forums helping to bring the ideas to a wider cross section of those involved in the
development community and to receive advice and encouragement from this wider
group. As a result a national network of people working in the general area of
innovation in the water industry was formed and a limited international network
established.
10.3.4 Institutionalising the Concept

While it must still be said that the process of developing the guidelines and the associated research has yielded little in terms of on the ground results, the concept has started to be institutionalised within the very agencies from which the early members of the interest group came. This is no small feat in itself. Throughout the process there has been considerable scepticism and reluctance to integrate the output from the process into the regulatory environment of the development approval process. The scepticism came from many quarters including: professionals involved in the development community, senior government officials and conservative politicians who perceived the Guidelines as a restriction to development instead of a framework for evaluating and optimising the interface between development and environmental conflict.

With support at the policy level of the bureaucracies and within political circles relatively low, institutionalisation of the concept has been slow and fragmented. The process has been driven more by chance than design as no formal implementation structure was established to drive the implementation process. A number of factors have come together to move the concept towards part of the emerging practice, including:

- Promotion of the concept by the Hydrology Panel of the local branch of the Institution of Engineers who hosted a seminar on the topic.
- Commissioning of a study to apply the concept to a major urban expansion area as a joint venture between the planning and water management agencies.
- Subsequent more detailed studies for local authorities where the concept has been applied at a policy and design level for both green fields and redeveloping areas.

While these processes have been very helpful in gradually moving the concept into the institutional forum, there have been many blockages and reluctance on the part of vested interests. For example as part of the implementation process it was
recommended that a formalised program of research and demonstration be undertaken that would allow the guidelines to be developed into a more formal design manual. Funding was sought and obtained as a partnership between the team that had developed the concept and the agencies involved. But significant delays in release of the funds occurred because of what can only be described as a reluctance by some of the individuals within some agencies to drive or even be a willing partner in the reform process.

10.4 Assessment of Process

The process of reforming and overhauling long standing planning and engineering traditions and practices has never been more urgent. Growing environmental awareness and political consciousness demand new ideas and approaches and yet so often when these do emerge they are stymied by bureaucratic inertia. As such, the successful progress of new practices into the institutional domain deserves reflection (Johnson 1983). It is from this experience that the agenda for much needed future change can be explored and charted.

WSUD is a suitable case in point. Not only did the concept require the adoption of new design approaches in that most conservative of all Australian traditions, suburbia, it was also required to operate in the tangled web of inter-departmental rivalry. A number of factors combined to maintain the momentum of reform in this area which are worth isolating. They include: public support, research and organisational framework, ownership, cultivating professional support, progressive local government support and teamwork.

10.4.1 Public Support

There is no doubt that a sympathetic political environment created the climate for instituting reform in this area and the growing priority given to environmental concerns by the public has kept the issue alive over the last five years. Water is a very live issue in Perth. In a city that experiences long hot and dry summers, with temperatures
periodically rising to over 40 degrees C, the value of water is increasingly well understood. Domestic water charging and the environmental deterioration of valued wetland environments have kept awareness high and this has been reinforced by publicity and advertising campaigns by the Water Authority.

While the value of water has generally been well understood, the actual understanding of the water environment has undoubtedly increased more recently. Nowhere is this more apparent than in the relationship between land use and water management. Polluted waterways are all too common in Western Australia. A ground water system feeding surface water features, stagnation and heat combine to form ideal conditions for eutrophication. The loss of clear water to green ooze touches a raw psychological nerve in Western Australians. They feel their vulnerability in the face of a harsh environmental reality. In the face of such vulnerability there has been widespread public interest in cause and effect relationships of eutrophication and gaining an understanding of the water cycle in general. To this end the Western Australian Water Resource Council has provided valuable resource information to the public and educationalists.

Throughout the WSUD exercise, publicity for the exercise was generated through presenting papers at a number of public and professional forums. Initially the emphasis of these presentations was to graphically describe the water problem facing Perth both currently and in the future and to outline in a simple and uncomplicated manner the role of WSUD in addressing these problems. It was a message of hope and optimism that glossed over the institutional hurdles of implementing reform. As various elements of the project produced useful supporting information these concepts and information were presented. Gradually the term WSUD became part of the lexicon and appeared in a variety of documents and forums.
Importantly the WSUD project also tied in very well with a much larger public debate of the time relating to future water supply issues, in particular a proposal to construct a 1500 km pipeline from the Kimberley region to supply Perth’s water needs in the 21st century (Synnott 1992). It provided a useful counterpoint in these deliberations by presenting a framework of improved urban water management as a way of overcoming some elements of future supply problems. However, the concept had not developed or become institutionalised enough to provide a counterpoint to initiation of a major $1 Billion public works program to provide centralised sewerage (using traditional techniques) to the 25% of households in Perth with septic tanks. If the concept of WSUD or IUWM had been more fully developed an opportunity to instigate significant innovation could have occurred.

10.4.2 Research and Organisational Framework

The original WSUD interest / research group was initially established as a small number of concerned and committed individuals that shared a common philosophy and not much else; senior and middle ranking public servants, a local government officer, a lecturer and a student. Yet looking back it represented a strong and complementary team.

This first phase of the research, with its academic base, provided the opportunity to locate the central philosophical / theoretical / conceptual basis of the work within the emerging literature on environmental design and urban ecology (McHarg 1969, Hough 1984). Thus the research was able to draw on a wealth of experience and knowledge housed within the academic domain. This was complemented by the professional support of the research group and the committed assistance of the urban development professionals engaged to develop the early hypothetical designs. In this way the research was academically and practically based and the public servants provided the vital link to the policy forums and the wider professional community.
This structure provided the framework for rapidly moving ideas into action, that elusive link between talking about things and doing them. The research task concentrated on justifying and assessing emergent ideas. International, national and local case studies were used in a two way process, to substantiate feasibility and to network the role and purpose of the group. Local planning and engineering consultants were used in the model design exercise to give credibility to the outcomes and to spread the word in the local professional community.

This form of reaching out gave the project a momentum and wider interest that to a great extent saved the exercise in its darkest hours. When recommendations were stalled in agenda queues, when committees were stalling on further financing, it was this broad base of support and interest that instilled some urgency into committee consideration.

The second phase, with its emphasis on implementation, benefited greatly from the complementary nature of the disciplinary membership of the team. Initially an important part of the research process was a division of responsibilities within disciplinary areas: town planning, engineering, landscape architecture, etc. However, what emerged as the project progressed, was a series of team meetings to discuss and debate progress. In these sessions much of the creative element of the research emerged as the boundaries between disciplinary focus began to dissolve. On reflection, it can be argued that the WSUD policy and guidelines are a product of a transdisciplinary learning process. Each disciplinary member was challenged with the need to view the problems and issues from the others' perspective and cross the boundaries between disciplines to formulate integrated solutions (Dorcey 1991).

However, this would have been ineffective were it not for the commitment of the Steering Committee members, particularly those in the public service who had been with the project since its inception. Given their seniority it was these members that
opened the doors of financial and policy support. In a period when everybody was
talking about the value of inter-agency contact and collaboration the project was a
useful model for all concerned. From the outset this structure has allowed the project
to bridge the gap between the conceptual and practical, while recognising the political
and institutional context it was working within. A major short fall in the process was
that there was no continuity between the process of developing the concept, and
implementation or the ongoing research phase. Although many of the same players
were involved there was no structure or mechanism to drive the reform process. This
meant the reform agenda was driven in a fragmented way partly within and also from
outside the institutional structures.

10.4.3 Ownership
One major concern that emerged from the organisational structure was the problem of
who owned the project. While the initial independence of the group was useful in
establishing its integrity and trans-disciplinary nature this proved a problem when it
came to initiating policy direction. To solve a problem generally requires someone to
own that problem. Perhaps not surprisingly government departments are slow to own
a new approach unless it is something that they have developed themselves.

Transferring the problem from the academic to the public domain was a serious issue
that the project faced. In retrospect it was resolved by clearly targeting a suitable
department (Urban Planning), securing a high level of political support and reassuring
the department that there was significant kudos to be had in running with the project.
This is not to say that progress towards achieving optimal policy outcomes was not
hampered by the institutional framework and the established practices of agencies.
Increasingly the Steering Committee and the consultants felt that they were attempting
to reform the entire planning system in order to implement what were initially
considered to be minor amendments to the character of urban development.
Progressively it was realised that the inherent fragmentation of the agencies involved in urban water management needed to be overcome. A mechanism was needed to coordinate the various policy positions and then link them to the planning system so as to provide a means to implement the policy objectives. After the development of the guidelines it was recommended that a long term coordinating group to monitor, update and revise the WSUD policy and guidelines was needed. This process of establishing a permanent organisational framework however never emerged so the steps towards restructuring institutional arrangements to accommodate the imperatives of WSUD initiatives have not yet been realised.

10.4.4 Cultivating Professional Support

In addition to the environmental concern in the public arena the support of the professional community both within and without the public service was critical to the credibility of the concept. To gain support the project could not be painted as extreme or radical. Instead it was described in the language and context of other establishment initiatives of the government. In particular the government's stated and published commitment to environmental protection, sustainable development, waterways and catchment management all were seen to dovetail with the central tenets of the project. Support from the agencies and individuals involved in these areas was established as they realised it could provide a useful plank in their own agendas.

It was necessary to gain support from both sides of the professional community - those involved in controlling development (mainly through the activities of government agencies) and those acting as agents of the development industry (initiating and designing development proposals). The two cultures are quite different even given a common professional affiliation and it is quite common for there to be conflict between the two sectors in their interaction. This interaction can be a complex set of proactive and reactive responses from both sets of players and with both constantly trying to seize the initiative (see for example Kennedy 1988, Mac Kenzie and Wajcman 1985). Both groups needed to be cultivated to ensure WSUD was adopted. Natural linkages
to government were already present so particular effort had to be made to cultivate support from the development industry.

In order to ensure support was achieved from professionals in the development industry, the following steps were taken:

- A representative of the development industry was included in the research group. Like the other professionals this person was a senior representative of the industry.

- Constant interaction was sought with the development industry and the professionals that serve it. On a number of occasions ideas were canvassed with key individuals and direction sought so they were brought along with the project.

- The project was presented not as a new set of regulations but as a new and emerging opportunity for the development industry involving challenging new concepts and relationships with other consultants. The group was keenly aware that effective WSUD needed to transform the traditional relations within the consultancy community. The idea of surveyors, planners, engineers and landscapers working in isolation in a demarcated, linear project process was analysed as part of the problem of traditional approaches to suburban development. So what had to be sold was a new working environment of professional teams brainstorming creative solutions to complex transdisciplinary problems. While this is the ideal the constraints of existing praxis has meant that this is rarely achieved.

- Given the new demands that WSUD will place on the professions servicing the development industry, there was no doubt that there was also an element of commercial advantage. Those who became conversant with the new initiative were well placed to gain competitive and commercial advantage. This perspective was not lost on the many consultants that freely contributed to the wider exercise.
In the latter stages of the 1980s the development industry became painfully aware of the impact of environmental consciousness on their operations. Environmental impact statements, environmental audits, strategic drainage plans were just some of the requirements that were placed on industry in the cause of winning development approval. However, even once this was forthcoming, they still faced the spectre of more public opposition that could still sink a project on political grounds. This atmosphere of analysis and uncertainty was having a major impact on commercial decisions surrounding projects and many developers were becoming exasperated with the new agenda of environmental awareness. WSUD was seen as a middle ground, as a way of integrating that awareness and concern back into the development process rather than trying to jump (or avoid) environmental hurdles in the latter stages of the approval process. This context helped sell the message of WSUD and in particular it was seen as one way of making an aspect of the new environmental rules more explicit.

As the awareness grew about WSUD, the development industry professionals began to want to understand the concept and its implications. This demand was achieved by dissemination of information and knowledge through seminars supported and organised by the various professional institutes.

10.4.5 Progressive Local Government Support

It would be wrong to present WSUD as an unqualified success. Although its progress thus far has been impressive and its future implementation looks to be on sound foundations there are still problems surrounding the concept that have not been fully resolved. At the heart of this has been the less than wholesale support of local government.

Although local government is the poor partner of government in Australia (Painter 1989) it is nevertheless of critical importance in managing the outcome of major development decisions. Because of this dependent relationship it assumes an
important advisory role in development decisions that central agencies have come to respect.

WSUD initiatives are seen as a management problem at the local level. Traditional approaches to stormwater disposal, urban drainage and open space design were seen as simple, foolproof, robust and manageable. WSUD seems risky, untried and contentious to an authority that operates at the cutting edge of public concerns. While verge infiltration and dual use open space (drainage and recreation) might mean localised recharge and pollution attenuation to the proponents of WSUD, local authorities see mainly public complaints, enforcement problems and liability.

Throughout the project it was always acknowledged that it is the city engineer who has dictated the style of local water management. They can have a dominant role in shaping the character of the urban form, often with little regard for the wider catchment consequences. While the project has consistently attempted to pull local government representatives into its organisation, the fragmented and diverse nature of this level of government has meant that the influence and impact of the ideas have at best been limited.

While this is true in the main, as the momentum of the concept developed the more progressive Local Government authorities have sought out advice on policy and practical application. Thus the sphere of government closest to the development process has begun to realise the potential to use the concept as part of its development control framework, in many cases more progressively than State Government.

10.4.6 Teamwork

While all of the factors presented above have been essential to the development and introduction of the WSUD concept, teamwork has been the central factor. Teamwork involved both the team that developed the concept and the network with which it interfaced. By the team it is meant the professionals who worked on developing and
communicating the concept. The network can be thought of as the wider group of supporters who helped reinforce and direct the concept into the institutional and professional setting.

For the team of professionals involved in developing the concept, the whole process became more than just another project. At an intellectual level it was felt by all that the process was breaking new ground and a powerful team spirit developed. The focus of the group was always on the problem, hence complementary professional skills came together to develop meaningful solutions.

It also became clear that challenging the status quo and institutionalising the concept required more than just the team. To challenge the complacency of existing practice takes a network of supporters. Given that the team was essentially outside government in order to be free to develop the idea, it required some political skill to have government begin to take it on. In this respect the network of supporters from within the government were powerful allies, helping to identify funding and projects.

The network that established beyond the local institutional setting was also very important. This wider network included people working in a similar field around Australia and internationally. Importantly this helped to locate the WSUD initiative within a wider context of experience. This provided a flow of information and experience that helped to place the emerging practice of WSUD close to the front of international practice, but not so far out in front that it was seen to be extreme.

10.5 Summary

The concept of IUWM is still largely peripheral to main stream practice in urban development and management. As such the analysis provided of the evolution of WSUD provides an interpretation of the difficulties of confronting existing professional praxis. The development of WSUD has been noteworthy in translating
social concerns about environmental issues of urban water management into the policy arena and ultimately contributing to a longer term process of institutional reform in the highly fragmented institutional setting of water management in Perth, Western Australia. This was no small agenda and it relied on a combination of good luck, good judgement and the commitment and support of a wide range of players. Such a confluence is difficult to plan for and indeed it is often only in retrospect that some of the critical stages and relationships emerge.

From this perspective it is clear that the initial phase of the process was very successful in scoping the nature of the problem and formulating a pathway through the institutional maze of urban water management to begin the reform process. An important part of the success of this process can be attributed to the fact that from the early research to implementation, the focus has been equally directed to policy development, practical design solutions and appreciation of the institutional context. Importantly the focus was never constrained by a single agency perspective and required the knowledge and skill of a transdisciplinary team. Thus the WSUD initiative filled a space between a range of programs and actions of the various agencies responsible for urban land and water planning at a time when innovation was needed. Although the concept is far from fully institutionalised it has now achieved a currency of its own and become part of the lexicon of the local urban development community. Thus even if there has been limited practical expression of the concept an understanding is emerging more broadly of the purpose of the concepts and of the opportunities its application presents.

The main weakness in the process and the reason why the concept has not become fully endorsed at a policy level is due to the fact that the issues involved fall between the cracks of the institutional setting. This reality has combined with a lack of leadership on the part of the senior bureaucrats to formulate an implementation program or structure to guide its introduction into the urban development arena.
Although this has been the case, the conflicts and pressure between urban development and management of the water environment continue. As answers are sought to resolve these conflicts the framework and techniques of WSUD have been used as a means to resolve the mismatch. Thus although no formal policy has been achieved the concept has become practice because there is a need. Some of the case studies outlined later will illustrate this point.

The emergence of WSUD with its emphasis on the integration of land use planning with stormwater, water supply, wastewater collection, treatment and disposal, provides a new way of thinking about and linking these components in the urban water cycle. It provides an example of how IUWM approaches represent both a new philosophy and a technique which is helping to codify the emerging values of sustainability into professional praxis.
CHAPTER 11

CASE STUDY 1 - PALMYRA

...planning (should be) thought of as a management task - a facilitating task that deals with emergent changes."

G. Benveniste 1989 1

11.1 Introduction

11.1.1 Background

This chapter describes research related to water system design at the Palmyra Woolstores Redevelopment Site in Perth Western Australia. The primary objective of this chapter is to illustrate how the concept of sustainable development and Integrated Urban Water Management (IUWM) can be applied to urban water systems. This particular case study examines and contrasts three different approaches to the establishment of water systems for an inner urban redevelopment site. In this context the chapter is both exploratory and demonstrative of possible options and innovations. The designs proposed should not be seen as the last word on the sustainability of urban water systems, present or future. It is but one contribution to a process of evaluation of IUWM options.

11.1.2 Case Study Site Selection

The Palmyra site was selected as a case study for a number of reasons. Initially it was selected because it was one of the projects selected for funding under the Federal Government's Better Cities program. The site was also initially included as part of another Federally funded project to demonstrate innovative wastewater treatment technologies. Unfortunately this element of the project was discontinued for a variety of reasons. In terms of case study selection it was also felt that this location presented a relatively simple site where some of the concepts developed might easily be applied.

11.1.3 Research Process

The research process included the following elements:

- Evaluation of the applicability of the WSUD planning framework of Water Resource Management Units in relation to the Palmyra site.
- Interaction with the developer, consultants and local authority representatives involved in the actual development proposal.
- Site visits.
- Integrated design meetings involving all or specific members of the design team.
- Evaluation.

This research approach provided the WSUD team with the opportunity to undertake a design exercise using the concepts and approach developed as part of the WSUD Guidelines. The hypothetical nature of the project allowed the team to explore the ideas further without the normal development constraints, allowing the team to propose possible urban design and water service options, all of which are technically feasible but have yet to be implemented as a package.

11.1.4 Structure of Case Study

This chapter has a further five sections. Section 11.2 outlines the outcome of the application of the Water Sensitive Design planning framework to the Palmyra area. The three urban design concepts and their related water management features are introduced in Section 11.3, while Section 11.4 provides the evaluation of the design options. In Section 11.5 a case study summary is provided. Appendices provide technical information and cost justifications.

11.2 The Water Sensitive Design Approach

11.2.1 Introduction

This section provides an outline of how the Water Sensitive Design planning framework and objective setting process has been applied to Palmyra. As indicated
above much of the approach has been developed as part of the WSUD Guidelines project. The WSUD approach is used here as a framework for the development of the "Towards Sustainable" design.

11.2.2 Planning Framework

This section outlines developmental steps in applying the WSUD "process", which with refinement could be used by the urban development community for any type of urban development proposal. The Water Sensitive Urban Design Guidelines project has pointed to the need to integrate water and land use planning from the strategic level to the design level in the planning process, so as to integrate water resource and related environmental/social objectives.

As pointed out in Chapter 9, Section 9.2.4, to achieve this, water resource management objectives need to be identified for specific geographic units. Two types of units are proposed:

- Water Resource Management Units (WRMU's) within which general water resource management objectives apply, and
- Water Sensitive Planning Units (WSPU's) within which more specific water resource management objectives will be developed and applied.

The two-tier system provides the "Planning Framework" for directing management and planning action and the selection of appropriate Best Planning Practices (BPP's) and Best Management Practices (BMP's) at the subdivision level. The two levels are suggested to distinguish between those areas where easily identifiable objectives can be identified (i.e. WRMU) and those where competing, possibly conflicting planning and water resource objectives need to be resolved and clarified through the establishment of specific objectives and if warranted, the setting of performance standards for the unit or part thereof (i.e. WSPU). WSPU's may be made up of several WRMU's or be part of a WRMU (i.e. for a wetland).
At the time of undertaking the research no WRMU had been defined for Palmyra, therefore this project provided some insights into the process of defining these units. WRMU information had only been developed for the major urban expansion areas around Perth. As the Palmyra site is outside of the present information base, the discussion below illustrates how the establishment of water and related environmental objectives can still be undertaken and incorporated into the site design process using the WSUD Guidelines approach.

11.2.3 Defining Water Resource Management Units

In the draft WSUD Guidelines it is indicated that a WRMU would be defined primarily on the basis of Water Authority of Western Australia (WAWA) drainage catchments. In existing developed areas these are generally related to main drain catchments or in new areas, to natural catchment boundaries. However, further refinement may be necessary as WAWA main drains are normally only applied to areas where drainage catchment boundaries cross two or more local authority boundaries. This means that for all those areas where the local authority is responsible for drainage units, further WRMU’s will need to be prescribed within shire boundaries on the basis of local drainage catchments.

This process seems straightforward, however, it makes little sense to establish specific units across a large proportion of the established areas of Perth, particularly in areas where:

- there is little or no significant impact occurring on receiving environments and,
- the water table is well below the surface and drainage is handled primarily via a steep sided infiltration basin which allows infiltration through deep sands to groundwater.

For these areas it may be more appropriate to establish one or two broad units and sets of objectives which reflect the broad goals of WSUD. Palmyra appears to be such an area (see justification below).
11.2.4 Water Resource and Related Environmental and Social Objectives

The concept of establishing water resource management and planning units was developed to establish a way of prescribing water resource and water related environmental and social objectives within definable areas so that they can be integrated into urban planning and management processes. The initial focus of this approach is to ensure that in new development, water issues are adequately evaluated and if necessary, management practices implemented as urban development occurs. However, the establishment of the units and objectives also has the potential to guide improvements in water management issues in established areas. For example it is increasingly recognised that water quality treatment is likely to be necessary in areas where drainage has historically been directed to wetlands and/or rivers. In addition, the establishment of units provides the opportunity to set specific objectives related to groundwater management, for example where excessive groundwater use is taking place.

The WSUD Guidelines identified the typical water and related environmental objectives. These were presented in Table 9.7.

The prioritization of these objectives for any unit and for any particular development is a major issue to be tested in the early stages of the WSUD guidelines evaluation. This is because traditionally the focus of stormwater management at the local authority level has been flood protection. By contrast the WSUD approach requires a broader array of objectives to be incorporated into the design and evaluation of urban developments. A key element of the ranking of objectives will be site specific conditions. The Palmyra case study proposals present some insight into these issues.
11.2.5 Defining Units and Objectives for Palmyra

11.2.5.1 Checklist

To help establish the criteria for establishing units and objectives in the case study areas the check list shown in Table 11.1 was developed. It aims to provide a guide to the data sets required to clarify units and objectives. It is derived in part from WAWA drainage reports. The check list is used simply to act as a "first pass" guide to issues within the case study. It can be used and adapted to any site.

<table>
<thead>
<tr>
<th>Water Sensitive Urban Design Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Location</td>
</tr>
<tr>
<td>2. Local Authority</td>
</tr>
<tr>
<td>3. Land Use</td>
</tr>
<tr>
<td>Existing</td>
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<tr>
<td>Proposed</td>
</tr>
<tr>
<td>4. Drainage District</td>
</tr>
<tr>
<td>Prescribed WAWA</td>
</tr>
<tr>
<td>Yes / No</td>
</tr>
<tr>
<td>Local Authority</td>
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<tr>
<td>Yes / No</td>
</tr>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Extent</td>
</tr>
<tr>
<td>5. Soil type(s)</td>
</tr>
<tr>
<td>% of catchment</td>
</tr>
<tr>
<td>Infiltration characteristics</td>
</tr>
<tr>
<td>6. Groundwater</td>
</tr>
<tr>
<td>Flow System Name</td>
</tr>
<tr>
<td>Comments (ie direction of flow, general info)</td>
</tr>
<tr>
<td>Depth across site</td>
</tr>
<tr>
<td>&lt;1m .......Ha</td>
</tr>
<tr>
<td>1- 5 m.......Ha</td>
</tr>
<tr>
<td>&gt;5 m...........Ha</td>
</tr>
<tr>
<td>Water resource protection status - Yes / No - - (Priority 1, 2, 3)</td>
</tr>
<tr>
<td>Status of self supply (i.e. Is there competition for water resource from public and private use? Have extraction limits been set? Should they be?)</td>
</tr>
<tr>
<td>7. Proximity to wetlands</td>
</tr>
<tr>
<td>Is the wetland the receiving environment for the catchment Yes /No</td>
</tr>
<tr>
<td>Wetland Name</td>
</tr>
<tr>
<td>Wetland classification (Bulletin 374, Draft Lakes EPP)</td>
</tr>
<tr>
<td>8. Sewered / Unsewered</td>
</tr>
</tbody>
</table>

*Table 11.1 Water Sensitive Urban Design Check List*
11.2.5.2 Application of the Checklist to the Palmyra Case Study Site

At the Palmyra site the checklist provided the assessment of the site shown below.

1. **Location:** Old Woolstores Site Leach Highway - Palmyra - see map

2. **Local Authority:** Melville

3. **Land Use:** Existing: Presently vacant (abandoned) site, was a large woolstores warehouse

   Proposed: Residential development

4. **Drainage District:**

   - Prescribed WAWA: No
   - Local Authority: Yes

   **Name:** No defined WRMU - Part of Metro south infiltration area.

   **Extent:** The site occurs on a catchment divide, surface flows of runoff will be to the west and east. Stormwater in the area is generally managed by piped systems to sumps. There is no major receiving body. The cross fall from the highest point on the site and the lowest points is approximately 6 metres to the west and 12 metres to the east. At present the site is benched in a series of steps that previously accommodated the wool sheds. At that time the site was probably 80% impervious, with roof runoff directed to and contained in swales at the intersection of the benches. For any new development, the local authority require stormwater to 100 year events contained on site. The risk from bigger rainfall events to be contained within regional stormwater systems (to be checked by Council engineer).

5. **Soil type(s):** unsure of % of catchment. Infiltration characteristics

   The site is within the Spearwood Dune System, Karrakatta soil type, Environmental Geology Series S7 soil - sands derived from Tamala Limestone.

6. **Groundwater**

   **Flow System Name:** Western extremities of Jandakot system

   **Comments:** Flow westerly to north westerly towards ocean but gradient very shallow.
Depth across site  
<1m - 0.0 Ha 
1-5 m - 0.0 Ha 
>5 m - 8.8 Ha 

(Depth to water table ranges from approximately 28 to 40 m)

**Water resource protection status** - No - (Priority 1, 2, 3)

Status of self supply (i.e. Is there competition for water resource from public and private use? Have extraction limits been set? Should they be?) Depth to water table restricts use by private users, some shire and institutional use in the area.

7. **Proximity to wetlands**

Is the wetland the receiving environment for the catchment?

No wetland in receiving environment

**Wetland Name**  
N/A

**Wetland classification (Bulletin 374, Draft Lakes EPP)** - N/A

8. **Sewered / Unsewered** - No sewerage is presently connected to the Palmyra site, however the majority of the adjacent area is sewered.

11.2.5.3 **Discussion**

The Palmyra site occurs on the drainage divide of localised catchment systems within the Spearwood Dune system, in an area where no significant water resource or related environmental issues dictate special conditions. It is suggested that this site fits within a general Water Resource Management Unit which encompasses a broader area of similar characteristics where the primary drainage mechanism is conveyance systems directing runoff to infiltration basins.

As no issues of special concern have been identified for this site the general objectives listed above have been adopted. Table 11.2 provides an indication of the applicability of these objectives to this site. On the basis of this assessment a selection of Best Planning Practices and Best Management Practices from the WSUD Guidelines have been incorporated into the design process.
11.3 The Designs

11.3.1 Introduction

This section provides a brief site analysis and discussion on the three designs used in this comparison: "Conventional", "Proposed" and "Towards Sustainable". Each of the options is presented in graphical form and the budget estimates for the designs are summarised in the evaluation section.

11.3.2 The Site and History of the Development Proposal

The Palmyra Woolstores site is an 8.8 Ha redevelopment site. It is located in a middle suburb of Perth, within the local authority area of the City of Melville. Palmyra is approximately 4 km east of Fremantle and 10 km south-west of the CBD of Perth. It is located on one of Perth's arterial highways - Leach Highway and thus had good access to transport and other economic and social infrastructure associated with a developed residential area (See Figure 11.1). The site had been identified within government circles as a preferred location for the demonstration of urban consolidation or infill housing in the "Green Street" mode.

The land was purchased from the Fremantle Cemetery Board by Homeswest (Western Australia's public housing authority) in an arrangement organised by the Government's Asset Management Task Force. Homeswest are the developer of the site and have the intention of developing the majority of the site for sale to the general public with the retention of a small proportion for public housing.
<table>
<thead>
<tr>
<th>WSUD Objectives</th>
<th>Applicability to Palmyra site</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Balance Objectives</strong></td>
<td></td>
</tr>
<tr>
<td>• Maintain appropriate aquifer levels,</td>
<td>Low - Small size of project in relation to modifications from surrounding area, however,</td>
</tr>
<tr>
<td>recharge and stream flow characteristics in accordance with assigned beneficial</td>
<td>retention, detention and recharge should always be optimised</td>
</tr>
<tr>
<td>uses (environmental values)</td>
<td><strong>High</strong> - Comply with accepted engineering standards</td>
</tr>
<tr>
<td>• Prevent flood damage in developed areas</td>
<td><strong>Moderate - low</strong></td>
</tr>
<tr>
<td>• Prevent excessive erosion of water ways, slopes and banks</td>
<td></td>
</tr>
<tr>
<td><strong>Water Conservation Objectives</strong></td>
<td></td>
</tr>
<tr>
<td>• Minimise the import and use of scheme water</td>
<td><strong>High</strong> - apply all available water efficiency strategies, including inhouse and self supply</td>
</tr>
<tr>
<td></td>
<td>options.</td>
</tr>
<tr>
<td>• Promote the re-use of stormwater</td>
<td><strong>High</strong> - incorporate water harvesting techniques wherever practicable</td>
</tr>
<tr>
<td>• Promote the re-use and recycling of effluent</td>
<td>**Moderate - potential for community scale treatment and reuse exists but government sewerage</td>
</tr>
<tr>
<td></td>
<td>policy likely to restrict application in normal circumstances</td>
</tr>
<tr>
<td>• Reduce irrigation requirements</td>
<td><strong>High</strong> - small lot sizes and hydrozoning and low water use garden design principles to be</td>
</tr>
<tr>
<td></td>
<td>used</td>
</tr>
<tr>
<td>• Promote regulated self supply</td>
<td>**Moderate - potential for self supply for ex-house and public areas</td>
</tr>
<tr>
<td><strong>Water Quality Objectives</strong></td>
<td></td>
</tr>
<tr>
<td>• Minimise water borne sediment loadings</td>
<td><strong>Low to moderate</strong> - site conditions not highly susceptible to erosion</td>
</tr>
<tr>
<td>• Protect existing riparian or fringing vegetation</td>
<td><strong>Not applicable</strong></td>
</tr>
<tr>
<td>• Minimise the export of pollutants to surface or groundwater</td>
<td><strong>Low</strong> - due to depth to groundwater and attenuation capacity of soil</td>
</tr>
<tr>
<td>• Minimise the export and impact of pollution from sewerage</td>
<td><strong>Moderate - potential of localised treatment to be examined</strong></td>
</tr>
<tr>
<td><strong>Environmental / Social Objectives</strong></td>
<td></td>
</tr>
<tr>
<td>• Maintain water related environmental values</td>
<td><strong>Not applicable</strong> at a site scale but regional scale environmental, social values may be</td>
</tr>
<tr>
<td>• Maintain water related recreational and cultural values</td>
<td>influenced, for example localised wastewater management may help to offset need for ocean</td>
</tr>
<tr>
<td></td>
<td>outfalls.</td>
</tr>
<tr>
<td>• Any necessary, site specific water sensitive</td>
<td><strong>Not applicable</strong></td>
</tr>
<tr>
<td>objective identified by the appropriate resource management authority</td>
<td></td>
</tr>
</tbody>
</table>

*Table 11.2 Applicability of WSUD Objectives To Palmyra*
The potential for redevelopment of the site created considerable interest and tensions within the local community. A community design workshop was held in September 1991 which provided input into the development planning. This process along with the normal negotiations between the City of Melville and the developer has provided considerable input into the planning for the site. One of the most unusual characteristics of the development conditions imposed on this site was the requirement to allocate 30% of the site to Public Open Space (POS), the justification for this being that the Palmyra area is generally deficient in POS allocation, primarily as a consequence of historical development and redevelopment patterns.

Other significant design constraints included:

- A desire to maintain North-South access through the site.
- Road and vehicular access restrictions onto Leach Highway.
- Maximum 120 dwelling units - made up of single dwelling and grouped housing sites (this equates to housing density of R20 under the WA zoning systems).
- Preparation of design guidelines to ensure the dwellings developed on the site are compatible with the "typical" Palmyra housing stock.
- A desire to maintain the existing grid road pattern into the new development.

The community workshop and further interaction between the developer's consultants and the community representatives produced a plan which was ultimately endorsed by Melville Council. That design and interaction with the developer and the consultants engaged on the development has provided the basis for developing comparative designs and costings. As of March 1996 the site has been partly developed after several modifications to the design.
11.3.3 Site Analysis

A site analysis plan is presented in Figure 11.2. The main points to note are:

- The site has a long east-west alignment (775 metres) and thin north-south alignment (110 metres).
- The site straddles a crest of a dunal ridge with the high point two thirds the way along its length.
- The fall across the site is approximately 12 metres to the west and 16 metres to the east in a series of terraces formed to accommodate the previous use of the site as a wool stores building.
- From the high point, panoramic views are available eastwards to the Darling scarp, while to the west there are glimpses of loading derricks at Fremantle Harbour.
- The east-facing third of the site is exposed to hot easterly winds in summer and the west-facing two-thirds are exposed to cold westerly winds in winter and cooling south westerlies in summer - the latter being at times very strong.
- The west-facing two-thirds is fully exposed to summer afternoon sun.
- Traffic on Leach Highway generates very loud noise, which peaks at the Carrington Street intersection and at the hillcrest on Leach Highway approximately midway along the long axis of the development.
- Soil over the site is coarse grained sands of the Spearwood dune associations and highly disturbed by previous activity, little or no top soil remains and soils are infertile and highly porous.
- The site is bordered by older style housing along McGregor Road to the North. Fremantle Cemetery is located to the south of the site across Leach Highway and is characterised by hedge-like planting along the highway and a combination of large Lemon Scented Gums and Norfolk Island Pines. To the east is the "Golden Egg" farms' distribution centre and to the west across Carrington street is a service station and housing.
11.3.4 Description of Design

The three designs - "Conventional", "Proposed" and "Towards Sustainable" are illustrated in Figures 11.3, 11.4, & 11.5 respectively. Throughout the design descriptions reference is made to when Best Planning Practices (BPPs) and Best Management Practices (BMPs) from the Water Sensitive Design Guidelines have been applied. Table 11.3 provides a summary of the main water systems characteristics of each of the designs.

A number of "planning considerations" were held as constraints on all three designs. These constraints were drawn from the public and local government and other agencies' policies for the site which were discussed in Section 11.4.2. The most significant constraints were:

- Approximately 30% POS.
- Maximum dwelling yield of 120 units split approximately 50:50 between single residences and grouped housing.
- Maintenance of existing grid road pattern.

11.3.4.1 Design 1 & 2- "Conventional" and "Proposed"

*The built environment*

Designs one and two vary only in respect to drainage requirements. The "Conventional" design utilises open space in the north-west and south-east corners of the site for drainage purposes. Otherwise in each case the designs comprise two loop roads extending from the existing street system. The major orientation of the roads is east to west along the maximum slope of the site. These roads serve a mix of single and grouped housing sites.
SUSTAINABLE URBAN WATER SYSTEMS: PALMYRA WOOLSTORES SITE CASE STUDY LOCATION DIAGRAM

Figure 11.2 Site Analysis
Public open space is concentrated in the central (higher portion) of the site, with grouped housing fronting onto the POS on three sides. In addition all grouped and single residential blocks back onto Leach Highway. Group housing is also proposed in the south west corner of the site in the vicinity of the busy Leach Highway / Carrington Street intersection.

The road on the northern boundary of the site, McGregor Rd is narrowed in these designs and traffic calming measures introduced.

*The water system*

In water system terms, the "conventional" design consists of the following features:

- Water supply - scheme water in standard fashion.
- Water efficiency measures - no interior or outside water conservation.
- Bore water for Public Open Space (POS) (and possibly some home owners).
- Sewerage - conventional gravity reticulation linked into sewerage mains.
- Stormwater - large steep sided infiltration basins and piped "conveyance" system.

The "Proposed" design varies from the "Conventional" design primarily in terms of application of low water use landscaping principles on the public open space and incorporation of localised infiltration systems for stormwater.

That is, the "Proposed" design no longer relies on the use of piped drainage for minor flows but rather collects the stormwater from the kerbing by conventional gully grates/side entry pits, which are also designed as spill control separators, and thus directs this pre-treated stormwater into infiltration bores.

The purpose of the spill control separator is to improve stormwater quality by physical separation of hydrocarbons, debris and sedimentation of coarse particulates. The purpose of the infiltration bore is similar to infiltration trenches, that is, to
infiltrate the pre-treated stormwater into the soil profile thus maximising the potential for recharging groundwater.

The use of these techniques is effective only if associated with regular cleaning, otherwise the turbulence of the stormwater entering the chamber between events can entrain floating oil and resuspend sediment in the outgoing stream and lead to its premature clogging.

The economic benefits of this system are essentially the elimination of piping, access holes and the construction of retention/ infiltration basins, resulting in reduced capital costs and additional land available for purposes other than drainage.

These localised infiltration bores have been designed for minor events only: all major rainfall events are directed to the POS via a swale system at the north-west and north-east corners of the site. Other elements of the water system are essentially the same.

In terms of landscape elements both option 1 & 2 have a range of landscape treatments typically applied to suburban estates, that is:

• Planting to all external road verges but not to internal roadways (except where these are contiguous with POS)
• Planting to all designated POS
• Pedestrian paths / dual use paths to all relevant road verges and POS
• A dedicated bore and irrigated system to all planted areas & irrigation of the Leach Highway planting to cease after a two year establishment period.

For the "Conventional" Design it is assumed that choice of plant species would not take irrigation water requirements into account (for example, a random mixture of high and low water demand plants) and "focal" areas would be heavily fertilised and irrigated to maintain a lush appearance.
For the "Proposed" Design the overall landscape layout varies only in so far as grassed gently sloped infiltration basins are substituted for fenced, unplanted steep sided infiltration basins employed in the "Conventional" design. This results in a slight (2000 m²) increase in planted area. However, as with the rest of the landscaped area, it is intended that the planting would be designed and managed in accordance with Best Management Practices for water conservation:

- Xeric planting (where appropriate).
- Hydrozoning.
- Water harvesting.
- Soil improvement.
- Turf and irrigation management.

This results in a reduction in irrigation water requirements over the "conventional design" even with the extra planted area.

11.3.4.2 Design 3 - "Towards Sustainable"

The built environment

The main feature introduced into the "Towards Sustainable" design is the emphasis on integrating water sensitivity into the design as a higher priority than normally undertaken in the urban design process. This has been achieved by using the WSUD Guidelines and selecting Best Planning Practices and Best Management Practices to meet the water sensitivity objectives for the site. To achieve these objectives a rather different design was developed (see Figure 11.5).
One of the main features of this design in contrast to the other designs is that the tiered character of the site is maintained. This reduces site works while simultaneously assisting the site's compliance with WSUD objectives. In this design roads are re-oriented to cross the site (north-south) rather than longitudinally to reduce road and drainage gradients. This is consistent with Best Planning Practices.

The roads have been staggered from existing street patterns to allow the development to match the existing tiering of the site and to avoid four way intersections on McGregor Road. However, to maintain legibility and access, 10 metre wide landscaped pathways are provided as visual and pedestrian extensions to the existing street pattern, linking the older part of Palmyra with Leach Highway and the cemetery beyond.

Though the total quantity of POS is maintained at approximately 30%, it is dispersed on to each tier of the site. This allows for local retention of stormwater and local effluent re-treatment systems to be incorporated into the site. Thus within the site a series of sub-catchments have been formed to facilitate wastewater management. Figures 11.6 & 11.7 illustrate the stormwater management systems and the sewerage system is illustrated in Figure 11.8.

Where possible stormwater generated from hardstand has been reduced. This is especially evident along the 'laneways' which are essentially porous pavements, which incorporate two significant design details. Firstly, rather than directing the percolating water vertically, through the subgrade, the percolate is directed horizontally into the landscaping. Secondly the central portion of the 'laneway' is brick paved to assist pedestrians, the disabled and cyclists, who find the rough texture of the porous pavement annoying. The texture of the porous pavement does provide tactile contrast to normal road surfaces, encouraging a speed reduction, thus also providing a traffic safety function (see Figure 11.7).
A longitudinal path (5 metres wide) running east to west along the development links each area of POS and also serves as a stormwater route during major storm events. Stormwater flow would be contained in a vegetated swale alongside the path and would only flow under extreme conditions to the POS. The pathway also serves as a service route with all services in a common trench below the brick paved surface which would allow access for maintenance.

Public open space areas are generally located on the northern side of the site to maximise solar access to surrounding development. In particular it allows development on the southern side to be oriented away from Leach Highway and the negative effects of the prevailing south westerly winds.

Two lines of units are envisaged - both oriented north but with the southernmost line consisting of two storeys to allow viewing over the POS and to provide wind and noise protection to the next line of units.

To avoid rear fences along Leach Highway, access to the southernmost line of units is from a nine metre wide driveway parallel to and abutting Leach Highway and connects to the north-south roads. This assists with legibility of the design and together with linking pathways, sets development further back from Leach Highway. The additional space required is offset by the southernmost 10 metres of the 30 metre wide McGregor Road reserve which has to be acquired.

Figure 11.8 illustrates the clustering of development around each area of POS. Each area is landscaped to complement its function, utilising water conservation BMPs (i.e. hydrozoning, soil improvement, turf and irrigation management and xeriscape principles).
The major public open space areas occupy the least desirable areas for development (eastern end - adjacent industry, western end abutting busy Carrington Road/Leach Highway intersection). The western-most POS will be designed to buffer the site from the busy intersection.

The central public open space is at the highest point of the site at the intersection of the two pathway systems and provides a natural focal point. It is to be designed primarily as a children's playground and is surrounded by group housing for protection from the climatic extremes and for facilitation of surveillance.

 Provision is made in this POS for a lookout tower housing a service reservoir for local dual use water supply. The longitudinal path provides the route for the dual use supply (and all water services) which will be used for private garden watering, POS irrigation (when recycled effluent supplies are deficient) and road verges.

The lot yield from the “Towards Sustainable” option has been made comparable with that of options 1 and 2 consistent with the design constraints adopted for all designs, but could have been increased to be more consistent with the goal of economic efficiency, i.e. more people could have been able to enjoy the same or indeed improved landscape / POS features.

**The water system**

In water systems terms this design consists of the following features:

- Dual water supply - scheme water is supplied in a standard fashion plus development of a community supply system for residential outdoor use.

- Water efficiency measures -
  
a) The assumption that there would be provision in the contract of sale and / or building codes to enforce the use of best available water efficiency in the interior of the dwelling units.
b) Outside water conservation is encouraged through preparation of housing development guidelines which outline low water use gardening strategies.
c) All homes are on a community based irrigation system which is managed to optimise water efficiency.

- Public open space is designed on low water use garden principles with reticulation from recycled effluent and supplemented by bore water through a state of the art irrigation system which is part of the development’s water supply system.
- The streetscape / front verges are developed in such a way that reinforces the water sensitive design theme.
- Sewerage - The design uses a number of community scale anaerobic decomposition Ecomax systems and tertiary polishing by dividing the site into a number of sub catchments and locating the treatment system in the Public Open Space. Effluent reuse is achieved through the watering of these spaces.
- Stormwater - The design has incorporated an integrated stormwater management approach involving BMPs used in the "Proposed" design by including swales and porous pavement. This allows for the stormwater runoff generated from impervious surfaces to be either infiltrated into the soil profile or harvested for use by vegetation.

Collectively these characteristics of the water system represent an integrated package of design features which make this design option substantially different from the other designs examined here or in normal urban development projects undertaken in Australia.
<table>
<thead>
<tr>
<th>CONVENTIONAL</th>
<th>PROPOSED</th>
<th>TOWARDS SUSTAINABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water supply - Scheme water in standard fashion</td>
<td>Water supply - Scheme water in standard</td>
<td>Water supply - Scheme water supplemented by</td>
</tr>
<tr>
<td>and groundwater bores for POS</td>
<td>fashion and groundwater bores for POS</td>
<td>community groundwater scheme as a secondary</td>
</tr>
<tr>
<td>Water conservation</td>
<td>Water conservation</td>
<td>supply for all outdoor use in households and</td>
</tr>
<tr>
<td>No interior / outside water conservation devices</td>
<td></td>
<td>for POS</td>
</tr>
<tr>
<td>POS design dominated by high water use plants</td>
<td>POS design partially water sensitive</td>
<td></td>
</tr>
<tr>
<td>Sewerage - standard reticulation system</td>
<td>Sewerage - standard reticulation system</td>
<td>POS designed using all water sensitive</td>
</tr>
<tr>
<td>Stormwater - Large sumps and piped system</td>
<td>Stormwater - Limited application of WSUD - BMPs</td>
<td>design techniques</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sewerage - not connected to mains - Community</td>
</tr>
<tr>
<td></td>
<td></td>
<td>scale Ecomax system with wastewater recovery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for use in the POS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stormwater - Application of a full range of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WSUD - BMPs</td>
</tr>
</tbody>
</table>

**Table 11.3 Comparison And Summary Of Water Elements Of The Three Designs**

(Note: POS = Public Open Space)

### 11.4. Evaluation

An evaluation of a design exercise such as this needs to consider a broad range of factors to determine how well the designs demonstrate an integration of economic, environmental and social factors, and thereby provide a shift towards sustainable outcomes. Ideally an evaluation technique such as least cost planning would be applied as a methodology for assessment of the broad economic factors involved. Unfortunately such frameworks have not been developed for this type of assessment and if they were applied they are still limited in their ability to evaluate many social and environmental issues.
Figure 11.5 Towards Sustainable Design
Figure 11.6 Stormwater Management
Figure 11.8 Sewerage Management Systems
Figure 11.9 Typical View of Development
Therefore this evaluation section attempts to highlight, comment upon and where possible quantify the benefits and costs of the design options under consideration. The underlying tenet is that optimal decision making aimed at achieving sustainable solutions should aim to provide what has been referred to as "win - win - win - win" solutions, where every exchange process provides a win to the parties involved in the exchange, plus wins to the community and a win to the environment (Meier 1994b).

The evaluation below provides an assessment of the financial factors which need to be considered, including consideration of capital and operating costs. Considerations on a qualitative basis are provided of the wider issues of urban and resource efficiency.

The environmental factors considered are focused towards the ability of the design to meet the Water Sensitive Design objectives but do not consider wider environmental issues. Consideration is also given to the planning process, community consultation and institutional factors related to the designs, particularly the ability of the design to satisfy the requirements of approval agencies.

In general terms the aim of the evaluation section is to consider the value of the Water Sensitive Design Guidelines as a tool to facilitate more sustainable solutions at the interface between urban development and the human developed water cycle.

11.4.1 Financial Factors

11.4.1.1 Capital costs

A comparison has been made of the capital cost for the three options considered in this study. The overall capital costs and development statistics are summarised in Table 11.4. The technical background and justifications for these cost estimates are outlined in Appendix 1. A summary of the comparison between the design options is provided in Appendix 2.
The costs data presented in Table 11.4 are project estimates only and should be used as a guide for comparison between the designs. The estimates for the "Conventional" and "Proposed" designs are based on cost estimates prepared by the consultants working on the real project. The estimates for the "Towards Sustainable" design have been prepared by the research team for this project.

A comparison of the costs of the three design options shows the following:

- The capital cost for the "Towards Sustainable" design is 3% higher than the "Conventional" design and 10% higher than the "Proposed".
- The "Towards Sustainable" design provides capital savings in some areas but has higher costs in terms of roads, sewerage and irrigation.
- The "Towards Sustainable" design has savings in costs in the areas of earth works (due to the retention of the terraced site) and stormwater infrastructure (due to application of the most effective BMP).
- All designs have comparable cost in the area of retaining walls.
- The landscaping costs, exclusive of irrigation, are slightly higher for the "Towards Sustainable" design due to a slightly larger area and better site preparation.
- In the "Towards Sustainable" design the Community Self Supply System includes irrigation of all dwellings, which is not part of the other two designs.
- The "Towards Sustainable" design incurs increased capital cost in terms of roads (due to added road length) and sewerage (due to the localised treatment facility)
- Water supply headworks costs for the "Towards Sustainable" design assume a reduction by 20% due to the potential efficiency gains and overall reduction in peak demand achieved by the use of the community bore system. A reduction by 10% in the cost of reticulation due to pipe size reductions is also assumed due to lower overall and peak demand. If these headworks charges are not provided the water infrastructure costs would be constant across the designs. This would mean that the capital cost for the "Towards Sustainable" design
would be 6% higher than the "Conventional" design and 12.5% higher than the "Proposed".

- The capital cost for the community self supply and reuse system in the "Towards Sustainable" design includes the establishment of the reticulation within each of the dwelling units, which is not the case in the other two design options. Thus each dwelling unit in the "Towards Sustainable" design has added value which would be recouped in the land prices.

Comments on assumptions and findings

This capital cost assessment of the development options illustrates that the "Towards Sustainable" design has slightly higher capital costs than the other design options. This has occurred primarily because of the relatively conservative cost estimate used for the localised wastewater treatment unit. The marginally higher capital cost needs to be weighted against some of the other factors considered below.

The costings also assumed that incentives would be offered by the water utility to encourage such a proposal on the grounds of the potential efficiency savings offered by the design. At present no incentive structure of this kind exists, but if it did it could be used effectively as a tool for facilitating structural efficiency at the design phase of developments.

These estimates clearly illustrate that the "Towards Sustainable" option is competitive in overall capital cost terms. It is likely that such systems could be attractive to developers if appropriate incentives were provided or if the costs could be adequately incorporated into broader project costs and/or transferred to the consumer on the understanding that other ongoing costs are reduced (see below).

11.4.1.2 Operating Costs - Water Related

This section presents an evaluation of the water and wastewater related operating costs associated with the alternative designs. The comparison is based on calculation
of the water consumption and wastewater generation operating costs for the "Conventional" and "Proposed" designs (which have essentially the same system) and the "Towards Sustainable" design at the household level. Table 11.5 summaries this comparison. This is followed by an outline of the assumptions made in developing this comparison.

Cost estimate for water supply incurred by the Water Authority

For the water related operating costs comparison the following assumptions have been made:

- For the "Conventional/Proposed" the average water consumption per single household is 290 kl/annum, of which 170 kl is inside use and 120 kl is outside use. For the grouped housing consumption is 230 kl/annum with in-house use 150 kl and ex-house use 80 kl (These figures are based on average WAWA consumption statistics - see Section 11.4.2 and Table 11.7 below).

- For the "Towards Sustainable" design a 40% reduction of inhouse consumption has been assumed on the basis of installing all available water efficient fittings and appliances\(^2\). Thus internal water use for single households is 102 kl/annum and 90 kl/annum for grouped houses. Ex-house consumption is provided by a regulated self supply system and a 10% reduction in use is assumed because of use of water efficient garden design and irrigation. This equates to 108 kl/annum for single housing and 72 kl/annum for grouped housing (see Table 11.7).

- The Water Authority uses an estimate for current average cost of supply and distribution of water in the Perth area of 60c/kl (made up of 40c/kl for existing sources and 20c/kl for distribution; new capital and asset replacement costs would be additional), however if full environmental costs (see for example Warner 1993, Diver and Mouritz 1994) were included this figure would be at least 80c/kl. Thus a figure of 80c/kl has been used in calculations.

\(^2\) This assumption is based on work undertaken by the Water Efficient Appliances and Plumbing Group of the AWRC's Water Technology Committee.
<table>
<thead>
<tr>
<th>Item</th>
<th>Conventional</th>
<th>Proposed</th>
<th>Towards Sustainable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design features</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total area</strong></td>
<td>8.8150 Ha</td>
<td>8.8150 Ha</td>
<td>8.8150 Ha</td>
</tr>
<tr>
<td>Area Public Open Space</td>
<td>2.2285 Ha (25%)</td>
<td>2.5103 Ha (26.5%)</td>
<td>2.6472 Ha (27.6% including PAWs)</td>
</tr>
<tr>
<td>Area of Roads</td>
<td>1.1520 Ha</td>
<td>1.1520 Ha</td>
<td>1.2280 Ha</td>
</tr>
<tr>
<td>Drainage / Public Access Way</td>
<td>0.3698 Ha</td>
<td>0.0860 Ha</td>
<td>0.1120 Ha</td>
</tr>
<tr>
<td>Lot yield - Single</td>
<td>63</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td>- Grouped</td>
<td>54</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td><strong>Development capital costs to be met by the developer</strong></td>
<td>$110,000</td>
<td>$110,000</td>
<td>$40,000</td>
</tr>
<tr>
<td>Earthworks:</td>
<td>$204,000</td>
<td>$204,000</td>
<td>$284,000</td>
</tr>
<tr>
<td>Roads &amp; Paths:</td>
<td>$237,520</td>
<td>$215,920</td>
<td>$240,000</td>
</tr>
<tr>
<td>Walls:</td>
<td>$255,000</td>
<td>$124,000</td>
<td>$80,000</td>
</tr>
<tr>
<td>Stormwater:</td>
<td>$157,716</td>
<td>$157,716</td>
<td>-</td>
</tr>
<tr>
<td>Sewerage:</td>
<td>$143,000</td>
<td>$143,000</td>
<td>$450,000&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Headworks charge</td>
<td>$228,033</td>
<td>$228,033</td>
<td>$182,426&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Reticulation</td>
<td>$384,000</td>
<td>$384,000</td>
<td>$345,600&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Irrigation</td>
<td>$140,000</td>
<td>$147,000</td>
<td>$280,000&lt;sup&gt;6&lt;/sup&gt;</td>
</tr>
<tr>
<td>Landscape (for POS &amp; verges)</td>
<td>$355,500</td>
<td>$339,500</td>
<td>$358,550</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>$2,194,769</td>
<td>$2,053,169</td>
<td>$2,260,576</td>
</tr>
</tbody>
</table>

*Table 11.4 Development Statistics And Capital Cost*

<sup>3</sup> Complete reticulation, localised wastewater and reuse system, thus no sewerage headworks charge is appropriate.

<sup>4</sup> A reduction by 20% due to efficiency gains and overall reduction in peak demand achieved by the use of the community bore system.

<sup>5</sup> A reduction by 10% in cost reticulation due to pipe size reductions is assumed.

<sup>6</sup> This irrigation cost includes provision of irrigation to public open space and households as part of the community water supply system within the Towards Sustainable design.
<table>
<thead>
<tr>
<th></th>
<th>&quot;Conventional/Proposed&quot;</th>
<th></th>
<th>&quot;Towards Sustainable&quot;</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single</td>
<td>Grouped</td>
<td>Single</td>
<td>Grouped</td>
</tr>
<tr>
<td><strong>Cost Estimates To Water Authority:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scheme Water</td>
<td>$232.00</td>
<td>$184.00</td>
<td>$81.60</td>
<td>$72.00</td>
</tr>
<tr>
<td>Reticulated Sewerage</td>
<td>$261.63</td>
<td>$230.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cost Estimates For Local Water Management System:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community Bore</td>
<td></td>
<td></td>
<td>$55.08</td>
<td>$36.72</td>
</tr>
<tr>
<td>Local sewerage treatment</td>
<td></td>
<td></td>
<td>$225.98</td>
<td>$198.89</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$493.63</td>
<td>$414.85</td>
<td>$362.66</td>
<td>$307.61</td>
</tr>
<tr>
<td>Rate estimate charged to householder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scheme Water</td>
<td>$203.43</td>
<td>$175.82</td>
<td>$148.58</td>
<td>$146.30</td>
</tr>
<tr>
<td>Self supply</td>
<td></td>
<td></td>
<td>$71.60</td>
<td>$47.73</td>
</tr>
<tr>
<td>Sewerage</td>
<td>$450</td>
<td>$400</td>
<td>$293.77</td>
<td>$258.55</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$653.43</td>
<td>$575.82</td>
<td>$513.95</td>
<td>$452.58</td>
</tr>
</tbody>
</table>

*Table 11.5 Annual Water Related Operating Costs & Rates Estimate*

- On this basis, single dwellings in the "Conventional/Proposed" design would "cost" $232.00 for water supply and in the "Towards Sustainable" design would "cost" $81.60. Grouped houses in the "Conventional/Proposed" design would "cost" $184.00 and in the "Towards Sustainable" design would "cost" $72.00.

- An additional cost for self supply in the "Towards Sustainable" has been estimated as 51 cents/kl on the basis of operating and replacement costs (see Appendix 1 for justification). This means that an annual levy for the single households of $55.08 and $36.72 for the grouped houses would apply.

*Water rate estimate to the householder*

A similar comparison can be made on the basis of water rates and charges to the householder:

- Using the 1993/94 charges - i.e. the first 75 kl are incorporated into the service charge of $118.45; the next 75 kl to 150 kl are charged at 19 cents per kl; the
<table>
<thead>
<tr>
<th></th>
<th>&quot;Conventional/Proposed&quot;</th>
<th></th>
<th>&quot;Towards Sustainable&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single</td>
<td>Grouped</td>
<td>Single</td>
</tr>
<tr>
<td>Scheme Water</td>
<td>$232.00</td>
<td>$184.00</td>
<td>$81.60</td>
</tr>
<tr>
<td>Reticulated Sewerage</td>
<td>$261.63</td>
<td>$230.85</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$493.63</td>
<td>$414.85</td>
<td>$362.66</td>
</tr>
</tbody>
</table>

|                      | **Community Bore** | **Local sewerage treatment** |          |          |
|                      | $55.08 | $36.72 | $225.98 | $198.89 |
| **Total**            | $493.63 | $414.85 | $362.66 | $307.61 |

|                      | **Rate estimate charged to householder** |          |          |
| Scheme Water         | $203.43 | $175.82 | $148.58 | $146.30 |
| Self supply          |          | $71.60 | $47.73 |          |
| Sewerage             | $450    | $400 | $293.77 | $258.55 |
| **Total**            | $653.43 | $575.82 | $513.95 | $452.58 |

Table 11.5 Annual Water Related Operating Costs & Rates Estimate

- On this basis, single dwellings in the "Conventional/Proposed" design would "cost" $232.00 for water supply and in the "Towards Sustainable" design would "cost" $81.60. Grouped houses in the "Conventional/Proposed" design would "cost" $184.00 and in the "Towards Sustainable" design would "cost" $72.00.
- An additional cost for self supply in the "Towards Sustainable" has been estimated as 51 cents/kl on the basis of operating and replacement costs (see Appendix 1 for justification). This means that an annual levy for the single households of $55.08 and $36.72 for the grouped houses would apply.

Water rate estimate to the householder

A similar comparison can be made on the basis of water rates and charges to the householder:
- Using the 1993/94 charges - i.e. the first 75 kl are incorporated into the service charge of $118.45; the next 75 kl to 150 kl are charged at 19 cents per kl; the
next 151 to 350 kl are 53.7 cents per kl etc. - the "Conventional / Proposed" single house would have an annual water bill of $203.43 and the grouped houses would have an annual water bill of $175.82. (It must be noted that rates and charges are planned to increase and the "free" water allowance is to be replaced with a complete user pays system).

- For the "Towards Sustainable" design, the single house would have an annual water rate of $123.58 and the grouped houses would have an annual water rate of $121.30.

- Community bore water charges would be based on the estimated maintenance cost of 51 cents /kl, plus 30% for profit, giving the secondary supply a cost of $71.60 and $47.73 per year respectively for single and grouped housing.

Cost estimate for sewerage incurred by the Water Authority

In relation to sewerage costs and charges for the "Conventional / Proposed" design the following assumptions have been made:

- For an average house approximately 90% of internal consumption is discharged as wastewater, therefore approximately 153 kl of wastewater is produced per annum in single houses and 135 kl per annum for the grouped houses under the "Conventional / Proposed" design.

- The WAWA has an estimated cost of $1.71 per kl for collection and treatment of wastewater (Stokes & Stone 1993, p35). Thus, a cost of $261.63 can be estimated for each single household and $230.85 can be estimated for each grouped housing site in the "Conventional / Proposed" design.

Sewerage rate estimate to the household

In relation to sewerage rates for the "Conventional / Proposed" design the following assumptions have been made:

- An estimate of normal rating systems for sewerage which are based on property valuation, the charge in this area would be approximately $450.00 per annum for single residences and $400.00 for the grouped houses.
Costs and rate estimate for localised wastewater treatment and reuse system

For the "Towards Sustainable" design’s localised sewerage and effluent reuse system, it is assumed that a rate would need to be set on the basis of annual operating costs and longer term replacement costs for the five localised wastewater systems. The following assumptions have been applied:

- Annual maintenance of the proposed wastewater system has been calculated to include an annual pump out of the anaerobic tanks. This has been costed at $75/hour for one day of the year ($500) which is based on commercial quotations of the rate of hire of one truck and two personnel. In addition, the pump out has associated liquid waste disposal costs of $30/kl ($4,500 assuming tanks are at capacity). These costs were converted to Net Present Costs (NPC) using a discount rate of 6, 10, 15 & 20%, an inflation rate of 5%, and a time frame of 20 years.

- In addition, an accumulated fund for part replacement and other operating expenses has been factored in. This was set at a conservative 50% of the capital cost of the system (i.e. $150,000) and put into NPC value at the same rates previously mentioned.

- The rates for this wastewater system also include the replacement of the red mud leach drain after twenty years at a cost of $50,000 (as quoted by supplier). As with other costs, this was put into NPC terms.

- These figures were then combined to arrive at the gross cost to be borne by the proposed management body. This was then divided among the housing configurations in accordance with their expected contribution to the wastewater load (57% for single housing and 43% for grouped).

- A profit margin of 30% was added to the gross cost to the management body at the time of calculation. This cost is then transferred to the household resulting
in wastewater charges which provide an adequate incentive for a water service management company to take on the role of operator.\footnote{A complete analysis over various discount rates and time frames was conducted and the results are presented in Appendix II. The chosen parameters are in line with economic modelling techniques commonly applied.}

- Applying a discount rate of 10% provides a cost to the manager estimated at $225.98 for single residential and for grouped housing at $198.89. Costs to householders are estimated at $293.77 for single residential and for grouped housing at $258.55. (Note that normal utility discount rates are usually 6% and that it is not until this rate exceeds 15%, which would be excessive, that the costs and rates exceed the cost of the traditional wastewater systems, see Appendix 1 - Table 6.1).

\textbf{Stormwater}

An additional factor not evaluated in great detail is the maintenance costs for the stormwater system. Normal drainage management costs in areas like Palmyra which are not part of a Water Authority main drain area are incorporated into local authority rates and are therefore difficult to calculate. However, if an incentive based stormwater rate system used the area of impervious surface as a basis of setting a stormwater management fee (as is applied in a number of States in the USA and in some countries in Europe), then a fee of approximately $3.00 per month per household would be applicable. As there is no practical basis for making comparison between the design alternatives this component of the evaluation has been inconclusive.

\textit{Comments on operating cost evaluation}

The assumptions and estimates presented in this evaluation are as complete as possible. They reveal an indication of the potential that this type of integrated water managements systems might offer, both to water utility managers and consumers. There are of course a wide range of other factors which require further investigation and consideration, particularly the issue of how this form of development should be evaluated against the marginal cost of additional water supply and sewerage infrastructure.
For example, if the marginal cost of additional infrastructure is considered, as this is a new service, it could be argued that the use of efficiency measures within the "Towards Sustainable" design, especially the community bore and wastewater reuse system, would provide substantial savings to the marginal cost of additional water and wastewater treatment infrastructure. This is potentially significant because the marginal costs of new sources of water has been estimated as in the order of 15 to 25 cents/kl (and possibly more), depending on source options. But this cost does not consider the full environmental cost or the so-called avoided costs of being more efficient.  

In addition to the marginal cost savings outlined above, the community bore system in the "Towards Sustainable" design would reduce the peak demand capacity on the water distribution system. This is achieved by negating the peak demand created by summer outside watering. This element of the marginal distribution costs of supply is a large component of the overall distribution costs, thus savings are substantial if this type of design feature is adopted.

In terms of placing additional pressure on a sewerage system, similar arguments could be developed. But often the counter argument is presented that the infrastructure is already available and is possibly not at capacity. Thus in terms of wider infrastructure efficiency, these systems such as those proposed in the "Towards Sustainable" design are often considered to present little overall benefit. However, if such systems were encouraged a substantial reduction in loading to the system would be achieved, offsetting the capital cost of further expansions to the system.

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8 Marginal cost estimates provided by Water Authority staff.
11.4.2 Urban Efficiency Factors

In urban sustainability terms there is also a need for urban developments to demonstrate more intensive use of urban space, to increase infrastructure efficiency and structurally assist in the reduced consumption of materials and energy (Roseland 1992).

Of the three designs the "Towards Sustainable" design presents the best qualitative demonstration of how to incorporate these factors into the design. With respect to the land use intensity, all the designs could have had increased densities, however, the "Towards Sustainable" design provides a land use configuration more amenable to accommodation of greater dwelling density and thus population, whilst maintaining amenity.

Infrastructure efficiency and resource efficiency are also enhanced, especially in the field of water use in the "Towards Sustainable" design. This is achieved through the incorporation of efficient technologies into the design. Some consideration of enhancing solar penetration is also incorporated in the "Towards Sustainable" design, once again enhancing the resource efficiency aspect of this design option.

A significant energy saving is also potentially achieved in the "Towards Sustainable" design. This is due to the use of the Ecomax wastewater treatment technology. This technology utilises no energy in its treatment process as compared to the mains sewerage which has a significant energy cost associated with collection, pumping and treatment of wastewater. In fact a number of commentators have pointed out that water utilities are the largest non industrial energy users in most cities and thus the water sector is being targeted as an area where energy efficiency strategies are likely to have significant benefit (see Diver and Mouritz 1994). However, the potential energy savings suggested by this design need to be evaluated against the potential energy use
proposed by the wastewater reuse system and the need to transport septage sludge off site.

What this brief consideration of the "urban efficiency" factor suggests, is that a wider set of factors, not normally considered in a water infrastructure design and decision making, is required. The development of a least cost planning approach for evaluation of these factors has the potential to provide a framework within which resource efficiency and infrastructure optimisation could be more adequately assessed (Fisher and Kinrade 1993).

11.4.3 Water Sensitive Objectives

Some of the most important factors which need to be considered in relation to assessing the overall performance of the various design options are how well they meet the objectives of Water Sensitive Urban Design. These objectives were provided in Table 7.7. In Table 11.6 an indication of the level of achievement for each of the designs in relation to Water Sensitive Urban Design objectives is provided.

Unlike the water balance and water quality aspects of the design evaluation some quantification of the water consumption characteristics is possible. An estimate of water consumption and an overall estimate of inputs and outputs to the site has been undertaken.

Table 11.7 provides an estimate of water consumption based on average household water consumption figures and for open space annual watering requirements. A conservative reduction of 10% less water use has been applied where water conservation best practices have been applied to outside use. Assumptions used in calculating water consumption are:

- For the "Conventional" and "Proposed" design total consumption for single and grouped housing is based on lot size and water consumption statistics as presented in "Water Topic" information sheet # 15 WAWA 1993.
• Percentage of inhouse and outside water use is based on Domestic Water Use Study (Metropolitan Water Authority 1995) - (i.e. 58% inhouse use & 42% outside use).

• "Towards Sustainable" inhouse assumes a 40% reduction in use through application of water efficiency technologies and appliances.

• "Towards Sustainable" outside use assumes a (conservative) 10% reduction in water use through use of efficient irrigation technology and assumes that similar types of gardens with similar watering requirements would occur in both options.

• Note also that the "Towards Sustainable" outside water source is from locally abstracted groundwater with only very minor use from mains water supply.

Table 11.8 provides an estimate of the total water use for the whole development, including all inside and outside water use, plus public open space water use. The assumptions within Table 11.8 include the following:

• Household consumption data taken from Table 11.7.

• Public open space consumption based on typical watering rates and the conservative estimate that a 10% reduction of water consumption will be achieved in the "Towards Sustainable" design using efficient watering technologies.

• Effluent volume of 4,500 kl /annum from Ecomax systems is recoverable during summer months, with the remainder of water being lost to evapotranspiration and infiltration.

Figure 11.10 provides a comparison between the estimated annual water budget for the "Conventional" and "Towards Sustainable" designs. This illustrates the main characteristics of the two extreme designs in terms of the inputs and outputs of water from the whole site. Rainfall and evapotranspiration across the site is assumed to be constant.
<table>
<thead>
<tr>
<th>WSUD Objectives</th>
<th>Design 1</th>
<th>Design 2</th>
<th>Design 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Balance Objectives</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• maintain appropriate aquifer levels, recharge and stream flow characteristics in accordance with assigned beneficial uses</td>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>• prevent flood damage in developed areas</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>• prevent excessive erosion of waterways, slopes and banks</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td><strong>Water Conservation Objectives</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• minimise the import and use of scheme water</td>
<td>*</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td>• promote the re-use of stormwater</td>
<td>*</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td>• promote the re-use and recycling of effluent</td>
<td>*</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td>• reduce irrigation requirements</td>
<td>*</td>
<td>**</td>
<td>***</td>
</tr>
<tr>
<td>• promote regulated self supply</td>
<td>*</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td><strong>Water Quality Objectives</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• minimise water borne sediment loadings</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>• protect existing riparian or fringing vegetation</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>• minimise the export of pollutants to surface or groundwater</td>
<td>*</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td>• minimise the export and impact of pollution from sewerage</td>
<td>*</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td><strong>Environmental / Social Objectives</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• maintain water related environmental values</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>• maintain water related recreational and cultural values</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>• any necessary, site specific water sensitive objective identified by the appropriate resource management authority</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

*Table 11.6 Achievement of WSUD Objectives*

Achievement - Low = *, Medium = **, High = ***
<table>
<thead>
<tr>
<th>Water Use Area</th>
<th>Single Dwellings</th>
<th>Grouped Dwellings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional / Proposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside use</td>
<td>170</td>
<td>150</td>
</tr>
<tr>
<td>Outside use</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td>Total household</td>
<td>290</td>
<td>230</td>
</tr>
<tr>
<td>Total for all Dwellings</td>
<td>63 dwelling units @ 290 = 18,270 kl/annum</td>
<td>54 dwelling units @ 230 = 12,420 kl/annum</td>
</tr>
<tr>
<td>Towards Sustainable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside use</td>
<td>102</td>
<td>90</td>
</tr>
<tr>
<td>Outside use</td>
<td>108</td>
<td>72</td>
</tr>
<tr>
<td>Total household</td>
<td>210</td>
<td>162</td>
</tr>
<tr>
<td>Total for all Dwellings</td>
<td>63 dwelling units @ 210 = 13,230 kl/annum</td>
<td>54 dwelling units @ 162 = 8,748 kl/annum</td>
</tr>
</tbody>
</table>

*Table 11.7 Household Water Use Estimates (Kl/Annun) For Conventional And Towards Sustainable Designs*
<table>
<thead>
<tr>
<th>Water Use Area</th>
<th>Single Dwellings</th>
<th>Grouped Dwellings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional / Proposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside use</td>
<td>170</td>
<td>150</td>
</tr>
<tr>
<td>Outside use</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td>Total household</td>
<td>290</td>
<td>230</td>
</tr>
</tbody>
</table>

| Total for all Dwellings| 63 dwelling units @ 290 = 18,270 kl/annum | 54 dwelling units @ 230 = 12,420 kl/annum |
|                        | 30,690 kl/annum                                      |

| Towards Sustainable    |                  |                   |
| Inside use             | 102              | 90                |
| Outside use            | 108              | 72                |
| Total household        | 210              | 162               |

| Total for all Dwellings| 63 dwelling units @ 210 = 13,230 kl/annum | 54 dwelling units @ 162 = 8,748 kl/annum |
|                        | 21,878 kl/annum                                      |

*Table 11.7 Household Water Use Estimates (KL/Annun) For Conventional And Towards Sustainable Designs*
**Figure 11.10 Water Budget Comparison**
<table>
<thead>
<tr>
<th>Water Use Area</th>
<th>&quot;Conventional&quot; / &quot;Proposed&quot;</th>
<th>Towards Sustainable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household - inside</td>
<td>18,270</td>
<td>12,420</td>
</tr>
<tr>
<td>Household - outside</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- scheme</td>
<td>13,230</td>
<td>-</td>
</tr>
<tr>
<td>- community bore</td>
<td>-</td>
<td>8,748</td>
</tr>
<tr>
<td>Public Open Space</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Bore water)</td>
<td>21,202</td>
<td>19,275</td>
</tr>
<tr>
<td>Road &amp; lane verge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- bore water</td>
<td>9,652</td>
<td>4,275</td>
</tr>
<tr>
<td>- effluent reuse</td>
<td>-</td>
<td>4,500</td>
</tr>
<tr>
<td>TOTAL</td>
<td>62,354</td>
<td>49,218</td>
</tr>
</tbody>
</table>

Table 11.8 Total Development Water Use Estimates
All Uses (kL annum)

In respect to the water balance factors for the design options the main differences are:

- There is an almost two-thirds reduction in imported water in the "Towards Sustainable" design.

- There is a substantial reduction in wastewater discharge (80% reduction) in the "Towards Sustainable" design; the only material left is septage sludge from the anaerobic digestion which would ideally be recycled or composted.

- Increased local extraction of groundwater (approx 15% more) occurs in the "Towards Sustainable" design to provide POS and household outside watering needs, which in the "Conventional" design is provided by scheme water supply.

- Irrigation water in the "Towards Sustainable" design is supplemented by effluent reuse of approximately 50% of available effluent, (half of this is assumed to be lost to evapotranspiration) the remaining 50% of effluent produced during winter months is infiltrated.

- Infiltration of all rainfall is assumed to be achieved in both designs, however, the "Towards Sustainable" design distributes run-off to public open space.

- Total water consumption is substantially lower (21%) in the "Towards Sustainable" design.
11.4.4 Planning Process and Community Consultation

Arriving at acceptable design solutions for any new development, whether in a largely built up area, such as in the case of this site, or in a more typical urban expansion area, requires an appropriate and carefully designed planning process. Increasingly it is also being recognised that sound community consultation processes are required (Sarkissian and Perlcut 1994). Careful attention to planning process issues become even more important for those developments that attempt to introduce innovative design solutions. The following discussion provides some brief comments on these issues, in the context of the experience gained from the planning process that occurred at Palmyra.

A brief summary of the key events or issues associated with the planning of this development provides some insights into the importance of the issue. In this description only the events which significantly influenced the application of the Water Sensitive Design solutions are noted. However, it must be noted that the development of this site has been a relatively complex and problematic process, which commenced in 1991 with site works and land development occurring during the first half of 1994. Thus approximately a two and a half year time period is involved. The summary is based on records taken during the research process and from personal communication with participants in the process (Hedgcock pers. com.).

Some of the key events included:

- The site became available as part of the Assets Management Task force investigations in 1990.

- The site was included for consideration in the Better Cities program in 1991.
• The Department of Planning and Urban Development and Homeswest held a community planning and design workshop in October 1991. The most significant desires expressed by the community included:
  - The community called for a substantial allocation of public open space (30% rather than the normal 10% was agreed to as the wider Palmyra area had an under allocation of open space).
  - The built form should be as far as possible contextual and there was resistance to higher density or grouped housing.
  - Maintenance of pedestrian access way referred to as McKemmie Walk was considered essential.
  - A set of design guidelines should be produced which establish preferred housing types and other design details.
  - There was no explicit discussion of the need for Water Sensitive Design during the community workshop, although there is some reference to it.

• 4) Following this phase, a preliminary design was prepared and negotiations started with authorities about specific development details. At this stage (i.e. well into the project's public phase) the idea was floated that the design should include Water Sensitive Design principles. Meetings were held between the Melville City Council, the developer, the consultants engaged on the real project and the research team.

• An agreement was reached in late 1992 between the parties that the research team could use the project as a case study site, to compare alternative design options on a research or hypothetical basis, but on the understanding that if any useful concepts were developed these may be incorporated in the design. The research team started to prepare alternative design concepts and some of the concepts were attempted to be incorporated into the real proposals for the site. However, essentially what happened was that Water Sensitive Design concepts were
"grafted" onto an existing design. Two design teams working on the one site is not ideal as they come from different assumptions and approaches.

- Around the same time an idea was floated that this site should be considered for demonstration of innovative wastewater technology under a special grant from the Commonwealth Government. A number of discussions were held between the Water Authority and Melville City Council. The result of these discussion was that the site was not considered a suitable site for demonstration and the funds associated with this grant were reallocated to other projects. Only limited discussions were held with the research team and as the research process had commenced on a hypothetical level it was decided to continue the investigations as a feasibility study.

- Ultimately a design and a set of design guidelines were produced and the process of approving the design was commenced formally through the City of Melville and the Department of Planning and Urban Development.

- Independently, the research-focused design team completed the alternative design options and preliminary costings. These were presented to the developers (Homeswest) in draft form, who welcomed the ideas but suggested they would be better applied to another site as the planning process for this site was too advanced.

- However, before the development process commenced, there was a State Government election and the local member became the Minister for Housing. Lobbying of the new Minister by some members of the local community increased until Homeswest was asked to develop a totally new design for the site. This occurred under the direction of a new project manager, with a new set of designers.
• The final design includes one building which incorporates a grey water reuse trial and the stormwater system includes flush curb roads, swale and local recharge bores. All of these are potential Water Sensitive solutions, however, the design detail at the site level, in respect to the stormwater system, has promoted some negative comment. Unfortunately the design that was finally implemented appears to have grafted some useful WSUD Best Management Practices onto a design rather than fully incorporating the concept into the design process. Ongoing review of the development will be required to establish performance and perceptions of the design solutions offered.

This discussion of the planning process at Palmyra has identified a number of key issues:

• There is a great deal of difficulty in achieving innovative design solutions when there is limited, if any, commitment from any of the major stakeholders in the process. Before any formal demonstration or full scale trial of the concepts presented here is attempted, it is recommended that various stakeholders, (be they developer, the regulatory agencies or the community) need to support and dedicate the resources to a trial. Overcoming that most conservative of Australian traditions, suburbia, is no easy task.

• The establishment of a well designed community planning process is essential, as these processes establish the community's criteria upon which design professional base and further develop the design. But the designer still has the flexibility in the production of the design to meet a wide set of established planning and design controls. However, if sections of the community become disenfranchised by the process and become politically active, the whole process can be derailed or fail completely.

• There is considerable difficulty in introducing innovative concepts, such as local wastewater reuse or even integrated stormwater management late in the planning
and design process. What is likely to be produced is a fragmented or poor quality design solution which may not meet the objectives being aimed for.

- There are likely to be trade-offs between community desires, environmental principles and existing urban development practices. Innovative design solutions aim to achieve a compromise. However, really creative solutions will not emerge unless attention is paid to developing a planning process where the various stakeholders have the opportunity to table and work through issues in an open and creative process.

The types of problems identified here are by no means isolated to this development or at this attempt to achieve a Water Sensitive Urban Design example. The emerging design processes often referred to as “inquiry by design” or “planning charettes” may offer new ways of developing urban design, and in this case water management solutions, less constrained by the conservatism of traditional urban development processes. But innovations are not likely to occur unless there is a well supported programme of demonstration to promote the concept. In addition appropriate incentives and education must be available for those involved in the urban design and development industry before such practices become mainstream.

11.4.5 Institutional Issues

Before a design such as that proposed in this report could be implemented a number of institutional issues need to be resolved. In many ways these issues are the hardest to resolve, but increasingly it is being recognised that institutional changes are required, as well as technical change, if the water sector is to make the shift towards more sustainable outcomes (Industry Commission 1992, Johnston & Rix 1993). The following discussion provides some initial comments on these issues in the context of the experience gained from the Palmyra process.

One of the most important "institutional" challenges of the "Towards Sustainable" design is the need to establish a community scale management structure to oversee,
maintain and improve the water management system devised for the site. This would involve management of the stormwater, the irrigation system for outside water use, plus the wastewater treatment and reuse system. To manage these facilities a management structure and a rating mechanism would be required. Such a management structure could be established through the local authority or as a separate entity. There are a variety of options available (see for example Morehouse 1989). A brief review of options available within existing institutional arrangements is provided below.

In the case of the local authority it could provide a specific rating system for this development and manage the site as a special area. It is more likely, however, that a specific management body for this development would be viewed as more desirable, as this type of function is not considered a contemporary role of local government.

One mechanism that could be used is a "body corporate" provided for under the Strata Titles Act. The "body corporate" structure could form the legally constituted body made up of residents or their representatives to manage communally owned property. These structures are commonly used in unit developments to manage parking areas, grounds, elevators, stairwells etc. In the "Towards Sustainable" design it could be used to provide the management mechanism to oversee all the water sensitive features such as: maintenance of open space, wastewater and reuse system and provide maintenance on the stormwater system.

An additional technique that is likely to be needed to facilitate the design would be the use of covenants on the land titles and/or on the building approvals. These could be used to ensure that all of the proposed design features, such as the irrigation system for each house and water efficient appliances would be mandatory. The covenants would ensure a design standard was maintained. This form of mechanism has been used increasingly in a range of developments to ensure that design guidelines in a wide
range of matters are adopted. There is of course the problem of managing the system installed into the future.

The need for a management structure should be seen as a community building process, which starkly contrasts with the other designs which maintain the present institutional arrangements: i.e. water services are managed for the community, who need not get involved in any real sense. The management and maintenance of the development in this form also provides employment opportunities at a local level. These aspects of the "Towards Sustainable" are community building processes in themselves. They also link into other aspects of sustainable city thinking relating to the use of more local management in open space, solid waste, transport and even small scale urban agriculture (see Newman 1993b).

It should also be noted that the establishment of what is essentially a "build own and operate" water system represents a small scale version of privatised infrastructure provision which is becoming increasingly evaluated and used by the water industry on a much larger scale (e.g. Manzi, 1992). As such the most important factor related to implementation of such proposals is the need for an adequate regulatory framework.

Some of the social and institutional barriers to the water management system of the "Towards Sustainable" design include:

- The Government Sewerage Policy would need to be wavered as Palmyra has the main sewerage system in the area. However, if the proposal was in a non sewered area the community scale localised system would be more readily accepted.
- As the design reduces the cost of both water supply and particularly sewerage headworks, reforms in terms of headworks charges would also need to be developed to make the proposal attractive to developers.
To facilitate this form of development other forms of incentives may also need to be developed, for example density bonuses may be applicable if water savings are achievable.

The stormwater system proposed varies considerably from that normally approved by local government and would probably experience some resistance because of the need for ongoing management and would probably require a commitment to upgrading if problems occurred.

One of the main features of the design which is inconsistent with the local community’s aspirations for the site is the proposal to split up the public open space. The community workshop and input into the real design process had argued for establishment of one central area of POS. However, this design provided a far greater amenity throughout the site. It is suggested that the community would accept this option if the total rationale had been provided as part of the consultation process. Thus a key element in any demonstration of such a design would be a community design process with the local residents and potential clients/owners of the development.

In terms of transferability of the design to other locations this design benefited by having a very generous 30% POS, which as well as providing amenity provided the opportunity for locating the proposed wastewater system. Therefore the transfer of this design to other sites would require some rethinking, however, it is still argued that the overall concept could be applied widely, possibly with other forms of localised wastewater technologies.

Clearly the most controversial issue in this design proposal is the proposed local wastewater treatment system. But as Wright (1994) has suggested wastewater reuse is constrained by:

- A myriad of legislation, common law principles and policies.
- An approval process that is complex and involves numerous pieces of legislation and multiple decision makers.
• An exaggeration of the potential legal liabilities associated with the environmental and public health risks of such schemes.

It would seem that across Australia there is a need to develop a clear framework for wastewater reuse schemes such as that developed by the New South Wales Recycled Water Coordination Committee (1993).

Typically the development of new institutional arrangements such as those outlined are viewed with scepticism. However, it is becoming increasingly recognised that institutional and social change, particularly building the capacity of the community to manage its own affairs, will be just as necessary as technological change to achieve sustainability.

11.4.6 Aesthetic and Market Considerations
A number of qualitative points can be made about the aesthetic value of each design option. In this case it can be argued that although all the designs assume a high quality landscape, the "Towards Sustainable" design is likely to provide more potential to achieve "greening the city" objectives as the planting would reflect the Mediterranean climate of Perth due to the application of water sensitive principles including use of xeriscape techniques.

Some of the marketing or aesthetic benefits that can be substantiated in the "Towards Sustainable" design that are not achieved to the same degree in the other design options include:
• Better noise attenuation along Leach Highway due to incorporation of both a wall and bund.
• Increased permeability/circulation for both vehicles and pedestrians.
• Reduced overall energy consumption related to sewage treatment and dispersal.
• Better Solar and Weather orientation.
• More equitable distribution of Public Open Space.
The developers of the Palmyra site, Homestwest, were asked to provide feedback on the design at a presentation of the design and costings. From a marketing perspective they suggested the "Towards Sustainable" design appeared to have many innovations and attractive features which could provide a potential market edge. However, they suggested that the local wastewater reuse concept was "too hard" for the normal urban development industry to take on. They suggested that unless there was "institutional" support for such schemes, the development industry would be reluctant to invest resources in a concept that may be a liability in the future. But they did suggest the design has enough overall appeal to warrant further investigation. They suggested if efficient approval arrangements and adequate resources were provided to ensure management and monitoring of the system, a Water Sensitive Urban Design demonstration project could be incorporated into another site, in an unsewered area or newly developing area.

11.5 Summary

In summary, the innovative, "Towards Sustainable" design has been shown to be cost competitive and potentially more environmentally benign than the other development options considered. The capital cost estimate for the "Towards Sustainable" design is within 10% of the "proposed" development costs. However, the water related operating cost of this design is approximately 11% lower, while cost reductions of up to 25% are likely to flow onto residents of this form of development. In addition water consumption for the "Towards Sustainable" design is estimated to be 28% less than for the "conventional or proposed" designs. Qualitative improvements in terms of water balance and water quality are also suggested to be achievable with the "Towards Sustainable" design.

These results are achieved through the application of the Water Sensitive Design Urban Guidelines. Specifically, the water system within the "Towards Sustainable" design includes the application of:
• Water Efficiency - Measures include the use of best available water efficient technologies in the interior of the dwelling. Outside, water conservation is encouraged through deployment of xeriscape practices and a community based irrigation system which uses the most efficient irrigation technology and is managed to optimise water efficiency both in household gardens and in the public open space.

• Localised Sewerage Treatment And Recycling - The design uses a community scale anaerobic decomposition system and tertiary polishing by dividing the site into a number of sub catchments and locating the treatment system below the Public Open Space. Effluent reuse is then achieved through the use of treated effluent for the watering of these spaces.

• Integrated Stormwater Management - The design has incorporated a stormwater management approach involving innovative Best Management Practices which allows for the stormwater run-off generated from impervious surfaces to be either infiltrated into the soil profile or harvested for use by vegetation.

• Dual Water Supply - Scheme water is supplied in a standard fashion, but in addition a community supply system utilising local groundwater for residential outdoor and public open space use is incorporated into the design.

Collectively the water system and urban design solution represent an integrated package of design features which make this design option substantially different from the normal urban development projects undertaken in Australia. The specific design features of the project will not (and should not be) directly transferable, but what is transferable is the conceptual basis of integrated water management systems as presented in the Water Sensitive Design Guidelines.
The Water Sensitive Urban Design Guidelines provide the framework for developing innovative urban water systems, which are potentially more economically efficient and more environmentally benign than traditional approaches. In addition it is argued that the urban design solutions which emerge by applying this approach have the potential to be highly attractive and sought after developments.

While the investigations indicated that this type of solution is cost competitive, a comprehensive least cost planning framework needs to be developed to allow a more comprehensive analysis to be undertaken. But even if such techniques are developed there are always a number of social and environmental factors that cannot be quantified.

Although the hypothetical nature of the project limited the degree of social analysis undertaken, it was possible to review the planning process that occurred at this site. This analysis highlighted that, because of the complex and often conservative nature of the urban development process, broad stakeholder support would be required before attempting to fully implement this type of concept, even as a demonstration project. To gain this support, attention needs to be given to designing and adequately resourcing a planning and consultation process aimed at introducing the types of innovations envisaged by this study.

Implementation of the more innovative elements of the design, such as small scale wastewater treatment and the recycling system, plus the community scale second class water system, will require social acceptance and institutional changes that are quite challenging. The question of social acceptance is one that requires further examination, however, there is growing evidence that the community is willing to become involved in these types of reforms. The institutional implications are probably more difficult to resolve as they involve the need for new agreements to be formulated between the
various agencies responsible for regulating and administering policy in these areas, including Planning Departments, Water Authorities, Health Departments and Local Government, to name just a few of the key stakeholders.

A key institutional issue is that this form of design response calls for the establishment of a more localised management structure, which could potentially involve private water service companies. This should be seen as consistent with the growing move to private sector involvement in water and wastewater service delivery, but with one substantial difference - the smaller, more localised approach. While the emerging practice of private investment in the water industry has to date been focused on large scale investment, the type of design solution arrived at in this study would potentially facilitate smaller and medium size water service companies to form. This is similar to what has been happening in the renewable energy technology and energy efficiency fields - small scale private firms are providing the innovative edge to introduce the sustainable technologies.

Whilst the case study has only examined the feasibility of the design in a hypothetical sense there has been enough positive feedback on the design concept for the next phase of the research to be full demonstration. If suitable arrangements can be devised to provide adequate management of the water system and a suitable site can be located, the concept of integrated water management systems could proceed to full demonstration. This would allow for the further validation of the concepts.

Such demonstrations would also help to test a broader question: whether these types of integrated solutions could assist an increasingly commercialised or corporatised water sector provide more flexible responses to the provision of water services, that are customer focused, as well as meet wider social, environmental and economic objectives of sustainability.
While many questions on the institutional aspects raised by the research remain unresolved, the case study demonstrates the potential value of the Water Sensitive Urban Design Guidelines as a planning process which has the potential to facilitate integration between urban planning and design and management of the human developed water cycle. The over riding assertion is that the more widespread use of these guidelines will lead to more Ecologically Sustainable Development in the urban context.
CHAPTER 12

CASE STUDY 2 - BAYSWATER

The (stormwater) disposal objective is obvious in the catchment with its focus on capacity and volume. Similarly with the storage component of the existing system, capacity and large scale management dominates. For on-site stormwater management to work at its most effective, features should be numerous, small and purpose designed rather than few, large and of a standard design base.

H. B. Quayle 1994

12.1 Introduction

12.1.1 Background

This chapter explores the application of WSUD as a tool for Urban ICM and aims to show how it is possible to integrate community aspirations about water environments, with the land use planning system. It does this by focusing on a case study of the Bayswater Main Drain, one of the major drainage channels discharging into the Swan River in Perth, Western Australia.

This drain was an attractive creek providing environmental relief and recreational value to a developing urban area. However, for many years the overriding objective has been the need to drain the area to facilitate urban development. In the last few years there has been increasing recognition that this "drain" is a significant contributor of pollution loads to the Swan River. In addition there was a growing belief amongst some members of the local community that the waterway itself should be seen as a valuable asset to the community rather than a convenient "drain" for the area's wastes.

This concern ultimately led to the establishment of the Bayswater Integrated Catchment Management Committee (BICM), the first Urban Integrated Catchment Management process established in Perth, Western Australia. That committee

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undertook a multi-stakeholder, "participative" planning process, over a period of some three years. It ultimately developed a catchment plan for the area entitled "Re-creating the Catchment".

In particular the chapter adds a social dimension to the WSUD approach by linking them to the participative Urban Integrated Catchment Management process undertaken in the catchment by the multi-stakeholder Bayswater Integrated Catchment Management committee. That committee established a broad goal and set of recommendations for "Recreating the Catchment" (Bayswater Integrated Catchment Management Steering Committee 1993). In this chapter, their work has been used as a base to evaluate the potential role of Water Sensitive Urban Design in a fully urbanised catchment which is undergoing various forms of redevelopment or pressure for redevelopment.

12.1.2 Case Study Selection

The selection of the Bayswater Main Drain and Bayswater Integrated Catchment Management process as the case study was simplified by the fact that this process was the first group to initiate a systematic revaluation of the process and function of urban drainage in Perth, Western Australia. The evolution of the BICM process coincided with the development of the Water Sensitive Design concepts and guidelines. As such, it became obvious that exploring the potential application of these Guidelines in the context of a fully urbanised catchment undergoing redevelopment pressure could provide valuable lessons. Thus the opportunity to interact with the first Urban Integrated Catchment Management (UICM) process in Perth was the primary reason for selection of this case study.

This case study research has developed and evolved over a period of three years. Research has included "participant observation" of the reform process being undertaken by the BICM committee. As such it provided an opportunity for a form of "participative action research" to be undertaken (Patton 1990). Part of the research
effort has gone into examining the socio-political elements of that process, thus a brief
treatment of that issue is reported here.

The research undertaken for this report uses the excellent work of that process as a
basis with which to examine the potential for applying the principles of Water
Sensitive Urban Design, to what is essentially a fully urbanised catchment, which is
undergoing incremental redevelopment. The chapter provides descriptive information
about the catchment, plus a background to the catchment planning process undertaken
by BICM, before illustrating through a number of examples the potential of applying
the WSUD as a tool for Urban Integrated Catchment Management. The chapter is
based on a work of the WSUD team reported by Mouritz et al (1995) and
acknowledgement is made of the contributions of the other participants in the study.

12.1.3 Structure of Chapter
This chapter has a further seven sections following this Introduction. Section 12.2
outlines the physical characteristics of Bayswater Main Drain, while Section 12.3
outlines the progress of the Urban Integrated Catchment Management process under
way in the catchment. In Section 12.4 a framework for applying WSUD is developed.
This is subsequently applied at a series of levels; at the planning unit level in Section
12.5 and at the subdivision level in three hypothetical subdivision redevelopment
examples in Section 12.6. A summary of the case study is provided in Section 12.7.

12.2 The Bayswater Main Drain Catchment

12.2.1 Context
The Bayswater Catchment is the largest urban drainage catchment in the Perth
metropolitan area, with an area of some 27 km². It discharges into the Swan River just
up stream of the Garratt Road Bridge (see Figure 12.1). The catchment includes all or
part of the suburbs of Bassendean, Bayswater, Bedford, Dianella, Eden Hill,
Embleton, Mirrabooka, Morley, Nollamara and Noranda. As such the catchment is
predominantly residential (2336 ha), but with some commercial centres (69 ha), primarily the Morley and Bayswater centres, and a major industrial area (295 ha).

The catchment traverses three local government areas: City of Bayswater (66% of catchment), City of Stirling (27% of catchment) and Town of Bassendean (7% of catchment). The approximate population of the area is 75 000 or about 7% of the population of Perth.

In the early part of the century, prior to expansive urban growth, the catchment consisted of swamps, lakes and naturally flowing creeks with clear water and an abundance of native flora and fauna in and around the waterways. Urban development began in the lower catchment, in the area of Bayswater itself, with development generally progressing on a northwards front away from the Swan River.

To service this development a system of drains has evolved comprising 15 kms of open drain and 27 km of piped drain (see Figure 12.2). The main drain in the lower part of the catchment was formerly a natural creek, which was subsequently formalised into a drain as urban development progressed. Its primary purpose was to reduce groundwater levels to allow unsewered residential development, through the use of septic tanks. The drain also serves as a stormwater system, collecting runoff from roads and car parks, and in major storm events, roof and garden runoff, as well as water which infiltrates the ground.

The result has been that an interesting landscape feature supporting a diverse array of flora and fauna has now been relegated to a drain adjoining backyards, in a way that typifies a city turning its back on the water environment. What was once an identifiable local feature has been pushed into the background to make way for urban development. The objective of the BICM Steering Committee was to initiate a process
to re-establish the integrity of this system and to restore and develop it as an asset within the urban environment.

12.2.1 Physiography

In physiographic terms the catchment is typical of this part of Perth. The topography is flat to undulating, consisting of the ridges and flats of the Swan Coastal Plain Dunal system. The western parts of the upper catchment include the eastern extension of the Spearwood dune system, consisting of shallow grey humus rich upper layer above yellow sands over Tamla limestone. The eastern upper and middle catchment to lower catchment consists of the Bassendean Dune System, consisting of deep grey to white silica sands. Parts of the middle and lower catchment consist of the Guildford formation of sand over clay. Much of the lower lying portions of the catchment were originally wetlands, either permanent or seasonally inundated, with pockets of peaty clay and sandy peat (see Figure 12.2).

All of these soil types are highly permeable, allowing rapid infiltration of rainfall into the shallow unconfined aquifer which is the southern extension of the Gnaangara Mound. Extensive areas of the dunal part of the catchment are underlain by semi permeable and impermeable layers of "coffee rock" sandstone which diverts infiltration and groundwater flow.

In general terms, the soils of the catchment have low nutrient retention characteristics, potentially allowing nutrient transport through the soil to the groundwater of the catchment and subsequently into the drain.

The vertical fall along the 8.5 kilometre length of the catchment is approximately 70 metres. The cross fall of groundwater from the upper northern parts of the catchment, south to the Swan River is approximately 10 metres (see Figure 12.3).
The vegetation complexes of the catchment originally consisted of low to moderate woodlands of coastal plain Jarrah - Marri to Banksia woodlands and heath. Around the swampy areas extensive Melaleuca or paperbark woodlands and shrub lands would have existed.

12.2.3 Catchment Development and Land Use

The urbanisation of the catchment commenced in the 1920s and has spread northward as metropolitan Perth has grown. The most rapid phase of development occurred during late 1940s to the 1970s. Development and redevelopment has continued within the catchment through to the present day. Figure 12.4 shows the development of the catchment at three different time frames of approximately 20 year intervals.

In the early years of development of the low lying parts of the catchment, swamps and seasonal wetlands were used as market gardens, some of the earliest being run by people of Chinese extraction. The draining of these areas for vegetable production and peat mining provided the justification for the earliest formalisation of the original drainage system (Freind 1992). Although few records are available on the original nature of the drainage system, it is known from interviews with previous and long time residents and from WAWA records that the lower part of the drain was a natural creek (Freind 1992).

As the catchment became developed, the formalised drainage system, linking permanent and seasonally inundated low lying parts of the catchment, was developed and expanded to cope with the drainage needs of urbanisation. One of the important justifications for the drainage programme was the need to lower the watertable to make it possible to use septic tanks in these developing suburbs. Some 60% of the catchment is presently serviced by septic tank wastewater systems. The remainder is connected to deep sewerage (see Figure 12.5). A plan has recently been announced to establish sewerage via the so-called Infill Sewerage Programme.
Approximately 86% of the catchment consists of residential dwellings, primarily of single housing units. Some pockets of higher density areas occur. The industrial area of the catchment is approximately 11% of the total area and a wide range of industry types occur. This includes CSBP’s fertiliser manufacturing complex, medium and light manufacturing to small service industries. The commercial developments in the catchment represent some 2.5% of the catchment area and are predominantly retail outlets, ranging from regional shopping complexes such as at Morley to neighbourhood shopping centres.

Since most of the catchment has been developed during the last 40 years, the character is similar to much of urban Australia developed during this period. Single zoned landuse; variable quality housing stock, including a high proportion of State housing of generally low aesthetic quality; car dominated; monocultural residential areas and in the commercial areas, limited attention to quality developments.

As with inner to middle urban areas elsewhere, redevelopment of the urban fabric is ongoing. One of the most noticeable changes in the structure of the area in recent years has occurred as a consequence of modifications in the road system in the area, primarily the Tonkin Highway and the subsequent strengthening of the role of Collier Road as the main link road between the major activity nodes - the Morley Shopping Centre and the Bayswater Industrial Area. The Morley Regional Centre, which is centrally located within the catchment, has undergone a major redevelopment programme. This is in line with Metroplan, Perth’s metropolitan regions’ guiding policy document (Department of Planning and Urban Development 1990), which identified Morley as a "Strategic Regional Centre". This provided the impetus for further detailed planning to guide the redevelopment of the centre and resulted in the Morley Regional Centre Structure Plan which provides the framework for the redevelopment of the centre over a 20 to 30 year time frame (DPUD 1992a).
Metroplan pointed out the potential for increased urban density or urban consolidation at least within part of the catchment. The Department of Planning and Urban Development has also more recently developed a draft Perth Metropolitan Region Residential Density Policy (DPUD 1992b). This document points to the potential of the area for increased density as well as providing a framework for encouraging consolidation in strategic locations, for example near transport services and regional centres.

In response to the growing recognition of the need for urban consolidation, local authorities have begun to review residential density. In Bayswater this process commenced in 1991 with the commissioning of a consultancy study which provided the City of Bayswater with recommendations on density (BSD 1991). These form the basis for modifications to the town planning scheme, allowing for fairly conservative increases in density. Similar moderate increases in density are proposed within the other local authority areas within the catchment.

As increased density is only permitted in sewered areas, only the 40% of the City of Bayswater that is sewered could be considered at this time although the recently approved Infill Sewer Programme will increase this potential significantly. A dual residential code was recommended by the Consultants in which the higher code could be attained provided certain conditions were complied with, including the connection to sewer. In order to prepare a housing density strategy and design guidelines the Consultants divided the municipality into eleven (11) precincts (see Figure 12.5). The base code of R17.5 which permits one dwelling per 500 square metres was adopted for many of the precincts. As 85% of all lots under the Bayswater municipality are below 1000 square metres, only 15% of all lots have potential for infill. Of these 9% are sewered.
In view of the above and the fact that Bayswater has already experienced its major population growth, the Consultants concluded that any additional growth expected to result from changing household composition or increased residential densities would be minimal, particularly if Bayswater were to overcome its marked deficiency in Public Open Space (BSD 1991: 12). Overall housing and population projections for suburbs which comprise the bulk of the catchment are indicated in Table 12.1.

Notwithstanding these considerations, records provided by the Water Authority of Western Australia on redevelopments within the catchment over a 12 month period indicate that 18 redevelopment applications have been approved. These developments include a number of lot amalgamations for unit developments, the largest being 17 lots amalgamated to produce a 24 unit development, to a number of dual occupancy developments. This illustrates the typical pattern of incremental changes occurring in the catchment even though a number of constraints exist. Thus if drainage restoration or other elements of catchment management are to be pursued, the optimum time for this to be implemented is by guiding the redevelopment processes occurring in the catchment.

<table>
<thead>
<tr>
<th>Suburb</th>
<th>Existing Dwellings</th>
<th>Existing Population</th>
<th>Additional Dwellings</th>
<th>Additional Population</th>
<th>Total Estimated Dwellings</th>
<th>Total Estimated Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashfield</td>
<td>425</td>
<td>1095</td>
<td>27</td>
<td>70</td>
<td>452</td>
<td>1165</td>
</tr>
<tr>
<td>Bassendean</td>
<td>3398</td>
<td>8705</td>
<td>18</td>
<td>46</td>
<td>3416</td>
<td>8755</td>
</tr>
<tr>
<td>Bayswater</td>
<td>4601</td>
<td>11343</td>
<td>-</td>
<td>-</td>
<td>4601</td>
<td>11343</td>
</tr>
<tr>
<td>Dianella</td>
<td>7226</td>
<td>18965</td>
<td>522</td>
<td>1370</td>
<td>7749</td>
<td>20335</td>
</tr>
<tr>
<td>Morley</td>
<td>6451</td>
<td>18188</td>
<td>54</td>
<td>152</td>
<td>6505</td>
<td>18340</td>
</tr>
<tr>
<td>Noranda</td>
<td>2824</td>
<td>8676</td>
<td>90</td>
<td>277</td>
<td>2914</td>
<td>8953</td>
</tr>
<tr>
<td>Totals</td>
<td>24925</td>
<td>66976</td>
<td>711</td>
<td>1915</td>
<td>25636</td>
<td>68891</td>
</tr>
</tbody>
</table>

*Table 12.1 Housing And Population Projections*  
(Source: DPUD 1993 - Appendix 2 Table A25. p.65)
12.2.4 The Drainage System

The drainage system to service the Bayswater Catchment now consists of more than 15 km of open drain, more than 27 km of piped drain, numerous dry and wet detention basins, plus in some locations pump stations to lift the water so that it will continue to flow along the drain without the need for deep pipes. These features are summarised in Table 12.2.

Essentially the drainage system has been developed and redeveloped incrementally in response to the water table reduction and flood protection needs of urbanisation of the catchment. As with most drainage systems developed during this period in Australia, and around the world for that matter, little if any thought was given to social, recreational or environmental values (Hough 1984, O'Loughlin et al 1992). As a consequence the potential of the drainage systems as a feature within the urban landscape has been lost, and the water leaving the catchment has the potential to negatively impact on the water quality of the receiving environments.

In drainage design terms the drain is a classical conveyance design efficiently discharging an all year round base flow and storm peaks to the Swan River. The base flow is made up of groundwater discharging from the southern flanks of the Gnangara Mound. In water quality terms, little long term data on the drain's conditions was available until the BICM process started. It is now known that the drainage waters contain pesticides, metals and nutrients in excess of desirable levels (Klemm & Deeley 1991). The extent of septic tanks in the area has been linked to nutrient pollution of the groundwater system and the thus the drain, however, research has indicated that this issue is primarily a problem only in areas of very shallow groundwater (Gerritse et al 1990).

Management of the drain is shared by the Water Authority, which is responsible for the so called main drain sections of the system, and by the Local Authorities who are
responsible for the stormwater systems which ultimately run into the drain. Water quality monitoring is undertaken by the Swan River Trust. Figure 12.2 illustrates the main sub catchments of the Bayswater Main Drain Catchment.

### 12.3. The BICM Process

#### 12.3.1 Introduction

The Bayswater Integrated Catchment Management (BICM) process is the first significant inter agency, local government and community attempt at addressing the "catchment issues", primarily drainage and water quality issues within urban Perth. The Urban Integrated Catchment Management (UICM) concept has been presented in some detail in Chapter p, Section 9.2.3. In this section the BICM process, features and outcomes are described.

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open drains</td>
<td>These are the most obvious parts of the drain. They often pass through reserves between back fences. Mostly the banks are too steep for safe public access. Total length of open drains in the catchment is 15 190 metres.</td>
</tr>
<tr>
<td>Piped drains</td>
<td>Usually all that can be seen of these is at the inlet and outlet points at compensating basins and open drains. Total length of piped drains is 27 465 metres.</td>
</tr>
<tr>
<td>Wet detention basins</td>
<td>A &quot;wet compensating basin&quot; is one which is in contact with the water table, at least some of the time. These can be ornamental lakes in parks (maintained by the local authority to the water’s edge), or they may be fenced-off holes in the ground (solely maintained by WAWA). They could well be described as stormwater buckets, with a hole to let the water drain away slowly. They are designed to prevent local flooding by holding stormwater when the drainage pipes are too full to cope.</td>
</tr>
<tr>
<td>Dry detention basins</td>
<td>Designed so that most stormwater passes through pipes under the basin. Water rises into the basin only when the pipes overflow following heavy storms. They are more common high up in the catchment, where the water table is not high, hence they would be unlikely to hold water for many days in a year. Often they are managed as grassed parkland, with drain inlet/outlets at the perimeter.</td>
</tr>
<tr>
<td>Pumping stations</td>
<td>These have been installed at some compensating basins to lift the water, so that it will continue to flow along the drainage system. Thus the need for very deep pipes is avoided.</td>
</tr>
</tbody>
</table>

*Table 12.2 Common Stormwater Management Responses*

(Source: BICM 1993)
12.3.2 Analysing the Bayswater ICM process

The analysis provided below of the BICM process which uses this Mitchell's framework (see Section 9.4, Table 9.4) and adds the category of "Products", as it is essential to gain an impression of the outcome of the process as well as its internal workings. Collett's model (see Section 9.4, Table 9.3) is also used as a way of assessing the process.

The assessment is based on: participant observation of the researcher in the process, which included attendance at meetings and workshops; review of minutes of meetings; a questionnaire issued to BICM participants (see BICM 1993 Appendix 9); and a review of BICM undertaken by Hudson-Mabbs (1992); a review of the BICM Catchment Strategy, "Recreating The Catchment" (BICM 1993). The focus of this review is directed towards the assessment of the process and products, seeking insights and includes suggestions from those involved. The points raised are intended to aid others involved in such processes, therefore aiding in the wider application of UICM.

12.3.3 Context

As already pointed out, the BICM process was the first urban integrated catchment management process undertaken in Perth. It commenced at a time when an ICM policy and programme had been gradually gaining momentum in rural Western Australian for a period of two or three years. Thus at least there was a general level of awareness between agencies about the concept of ICM, even if its practice was fragmented (Hollick and Mitchell 1991).

The BiCM process was initiated as a result of a combination of community pressure and public sector recognition of the need to begin to address the water quality condition of Bayswater Main Drain, with particular emphasis on mitigating its potential impact on the Swan River.
The public and political recognition of the problem of water quality of the drain was brought to a head in the early 1990s at public meetings which began to look for solutions to the problems being observed by local residents. The idea of a catchment group was raised during this period and after learning of the successes of a similar catchment management process for the Throsby Creek in Newcastle, the BICM process was facilitated, initially by the Swan River Trust and then by the Office of Catchment Management, a semi autonomous government unit established to promote and facilitate catchment management.

Establishment of the process required gaining agreement between three local government authorities and several state government agencies to initiate and resource the process. Although the three neighbouring local authorities had worked together in the past, they had never attempted to sit down with state agencies and community groups to focus on an issue as complex as catchment management. The issues in the catchment are typical of the fragmented and complex land, water and societal interaction of urban areas.

From the outset it was acknowledged that the BICM process was to be a testing ground for UICM. As such the process was entered into in good faith, even if with some reservation by all concerned. The principal aim was establishment of cooperative arrangements between stakeholders to overcome urban environmental degradation and (hopefully) to provide a basis for establishing an environmental context for the ongoing development of the catchment.

12.3.4. Legitimation

From the outset there was positive political support for the process, particularly from the local member of Parliament, who became the chairperson for the initial phase of the process. This was significant because the chair held a neutral position, separate from any potential organisational agenda of the stakeholders. Having a local
politician involved also provided a degree of legitimation to the process, as well as providing access to wider audiences, including political and decision making processes.

Throughout the process there has been relatively good administrative support from state and local government stakeholders. However, the extent of local government contributions across the three councils involved was highly variable. In the early parts of the process the project was not seen as a high priority in the work programs of either state agencies or local authorities, but most agency and local government representatives viewed the project with interest, because it represented a new approach.

Financial support for the process has been limited, with minor allocations from each of the local authorities during the preparation of the Catchment plan. As the process progressed the various institutional stakeholders progressively became more interested as the project gained publicity and gained credibility through its actions and progress. Ultimately substantial resources were allocated from within agencies to assisting the preparation of the catchment plan. For example map production and other data assessment was provided by the Water Authority as part of their contribution to the process.

As the process progressed, applications to various funding sources provided additional resources. For example $300 000 of Federal Government funding was made available through the Water Authority to test nutrient stripping techniques in detention basins. Other sources such as the National Landcare Program provided resources for community education and ultimately for a part time coordinator, who has been employed to assist in the implementation phase of the process.
Now that the process has gained credibility through the publication of its plan, resources in the order of $100,000, for expenditure over the next 12 to 18 months, has been obtained from state and federal grants to aid in implementation. The process has thus legitimised itself and has established its own credibility.

12.3.5 Organisational Attitudes

Organisational attitudes towards the process have varied through the course of the process. In the early phase of the process the organisations involved appeared to accept the value of the project, however, there were sometimes substantial reservations about its potential to achieve desired outcomes.

During the course of the process there was an apparent attitudinal shift in many of the participants, who represented the various agencies involved. Initially there was considerable hesitancy about the participatory nature of the process, which gradually moved towards a view which acknowledged the value of building community support and involvement.

One of the difficulties which needed to be overcome during the process was the style of language used in the written material produced by the process. With such a cross section of community representatives and technical people a less technocratic form of documentation was required. Initially this caused some problems, but eventually it was realised that what was being developed was a community based report which needed to be highly accessible to all concerned.

Although the process has not been all "smooth sailing", considerable cooperation and interaction that had not previously existed between the stakeholders developed. Some degree of friction is bound to be part of these processes as they are about attempting to redirect some of the resources and priorities of the stakeholders involved. This inevitably causes some tension. For example, initially the process was given a
relatively low priority within the work programmes of many of the organisations involved. Thus progress was often slow.

At an organisational level the main impediment was identified as this resource issue. For these processes to work efficiently resources need to be planned and allocated within budget and work schedules of organisations and participants. This has gradually changed as the activities and flow on requirements of the process and recommendation have been accepted.

Most new processes begin this way and institutions have their own priorities and find resources hard to shift until the legitimisation process passes some threshold. This occurred some months into the project as process objectives became better appreciated within stakeholder groups.

12.3.6 Process & Mechanisms

Due to the "newness" of the approach the BICM process was always recognised as a learning experience (by mistakes). However, the lack of comparative examples was acknowledged as a problem. The process was modified from the approach used in the Throsby Creek, UICM project in Newcastle, New South Wales. The problem of distance limited free exchange of information and ideas with that project. The main difference in the BICM process was the encouragement of far greater community involvement directly in the process.

The BICM process involved the stakeholders forming a Steering Committee with representatives from the three local authorities and relevant State authorities such as the Swan River Trust, the Water Authority, and Environmental Protection Authority, together with members of the community. The chairperson of the committee is the local member of Parliament. The Steering Committee's role was to identify the issues and prepare a plan of action. The community representation came particularly from Bayswater Greenworks, a group which had been actively involved in both lobbying
about the issue and undertaking restoration projects associated with the Swan River and the Drain. Other community representatives included teachers from the local schools, interested individuals and representatives from other local groups.

Five task groups were initially formed to collate information and develop action plans and recommendations. After about eight months the task groups' number was reduced to three, titled, "Water Quality", "Wetlands and Drainage" and "Community Awareness". Representation on the Task Groups also included State and local authority representatives and community representatives.

The various Task Groups prepared reports which were tabled at Steering Committee meetings and ultimately drawn into a strategy report. From initiation of the process to preparation of the Catchment strategy more than three years elapsed.

Although it was never explicitly acknowledged, the BICM process adopted an "action research" type approach, which is a cyclic process of learning, reflection and action to develop solutions to the problems of the drain. Because of the newness of the process little attention was given to these types of process issues. It is likely that recognition of the cyclic action learning approach and improved "process" training could greatly assist participants in this and other UICM projects in understanding the process and their role.

During the process there was considerable concern about the ability of the "process" to adequately communicate its message and purpose to the wider community. Increased attention was focused towards short term goals and activities that will provide the opportunity for public activity (i.e. clean up days and community awareness days). This was partially due to the uncertainty as to how successful the process would be and partly a "missionary zeal" by those involved who became more and more convinced of its importance.
Another mechanism used to enhance the objectives of the process included substantial networking with schools and other community groups. Competitions were run with school children who came up with a logo for the committee's correspondence. Community awareness was seen as an essential part of the process, to establish lines of communication, developing media information and promoting the process at public gatherings, such as local fairs.

Another important part of the process was the release of the Catchment Strategy as a draft for comment. A promotion and review process was undertaken and the final document, with revised recommendations, was published. The recommendations identify key structural and non structural initiatives aimed at fulfilling the broad vision from the community processes. The final document provides the basis for an implementation committee and a part time catchment coordinator to begin the process of working towards the "vision". The final document signalled the end of a process. Its success in reaching that stage was adequate testimony to the UICM process having "arrived" and being legitimised.

12.3.7 Functions

As the BICM was the first UICM process there was no clear demarcation or definition of responsibilities apart from the fact that the various agency representatives came to the process based on their organisations' responsibilities in relation to the drain or pollution management. By contrast community group members came to the process with personal and local interests in mind. Within the process itself there has been an ongoing redefinition of functions of the various participants. As the process progressed there was considerable co-operation developed between participants that aided in the gathering and sharing of information.

Outside the BICM process itself, a tension has emerged with respect to management and responsibility for managing urban stormwater, particularly the issue of quality.
WAWA's management focus is on water quantity, while the Swan River Trust is focused more towards water quality. There is also pressure for local authorities to be given more responsibility which they are reluctant to take on. While this tension is evident "below the surface" no formal discussion process has been entered into. Similar problems are evident in other Australian cities.

Greater recognition of these issues and the overlapping interests have been a by product of the process. A particular area for discussion in the future will be revenue distribution for management and monitoring of drainage throughout the metropolitan area.

Essentially there is a significant policy void which "participative" catchment management processes are attempting to fill with little or no resources. The lack of a clear policy which resolves the institutional fragmentation of these issues remains the greatest impediment to urban stormwater management becoming more ecologically sustainable.

12.3.8 Structures

The structure within the process has included the establishment of a multi-stakeholder Steering Committee and Task Groups which were modified as seen fit during the process. This adaptability proved important as it allowed for reallocation of the resources and to help focus the efforts of the Task Groups. The process benefitted from the relatively well developed committee skills of the members and administrative support from local authority staff.

Some problems were identified with the reporting of information back into agencies and local governments. This, in part, may have been due to the newness of the process as well as the relatively low priority this activity had in the context of other organisational commitments. As the process progressed informal networks were established which have added to communication and action. However, providing a
structure to ensure there is communication between the key players is essential for the long term success of UICM processes.

As the process gained credibility these problems began to subside. However, if these sort of processes are to be more widespread then the formal status of these activities and the need for these activities to be more closely built into agency programs must be recognised. Staff and resources need to be allocated to these types of processes. This is not likely to be achieved until corporate commitment is given to UICM processes and this support is reflected in budgets and work programs of agencies, i.e. a clear structure is provided.

Suitable structures will only change if the issue of urban drainage management is perceived by both the public and the government as a real issue. Recent media attention has raised the health of the Swan River to a highly topical issue but the structures have not yet emerged to provide a clear UICM programme.

12.3.8 Products

The main product of the process has been preparation of a catchment plan which focussed attention on the various land and water interactions within the catchment and presented recommendations to guide the redevelopment of the catchment. That strategy is based around a "vision" for the catchment which was first articulated at a community workshop in March 1991. That "vision" was recorded in the report as:

"they (the community) wanted for the drain to become a benign contributor to the Swan River and (for the drain to) be returned to a more natural state by landscaping, tree planting and re-establishment of wetlands. They (the community) looked forward to the day when gilgies would return to an attractive creek that was once called the Bayswater Main Drain. They foresaw a creek which would be a recreational resource rather than an eyesore and would be associated with an environmental study centre." (BICM 1993: 14)
Essentially, the BICM committee's vision is to "Re-create the Catchment" in a manner where the water environment is considered as an important community asset. In a bid to meet this broad goal, the catchment strategy included some 70 recommendations clustered under the following objectives:

- Historical development of the drain;
- Conservation values;
- Improving water quality; improving public access;
- Guiding redevelopment in the catchment;
- Encouraging community involvement;
- Obtaining sufficient resources to implement the strategy.

The other less tangible "products" of the BICM process have been (and will continue to be) the increased community and political recognition of the problems of urban drainage and their potential resolution through UICM. This increased awareness provides the political context within which implementation of the strategy will commence. However, the redevelopment of an urban drain, which a community has all but ignored, into a functional, cultural and ecological component of the urban landscape will require a substantive commitment over the long term. A good start has been made, the question of whether it is a sustainable process still hangs in the balance.

12.3.10 BICM and Models of UICM

The general characteristics of the BICM process can also be viewed in terms of the models of ICM presented by Collett (1992). This is illustrated in Table 12.3 which highlights in bold italics the aspects of the BICM process which are consistent with the elements of the three models.
<table>
<thead>
<tr>
<th>Subject matter</th>
<th>Technological Model</th>
<th>Bureaucratic Model</th>
<th>Participative Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paradigm</td>
<td>Technological</td>
<td>Bureaucratic</td>
<td>Environmental</td>
</tr>
<tr>
<td>Integration</td>
<td>Of a resource's use</td>
<td>Of several agency programs</td>
<td>Of community processes and values</td>
</tr>
<tr>
<td>Responsibility</td>
<td>Single agency, responsibility clear</td>
<td>Several agencies; responsibilities diffuse</td>
<td>Lying mainly with the community</td>
</tr>
<tr>
<td>Linkages</td>
<td>Self contained and inward looking</td>
<td>Co-operative</td>
<td>Broad networking</td>
</tr>
<tr>
<td>Style</td>
<td>Directive; must do, top down</td>
<td>Prescriptive; should do</td>
<td>Consultative: bottom up</td>
</tr>
<tr>
<td>Performance</td>
<td>Easily benchmarked</td>
<td>More difficult to measure</td>
<td>Multi dimensional</td>
</tr>
<tr>
<td>Outcomes</td>
<td>With cross subsidies &amp; externalities embedded</td>
<td>Redistributive but inefficient</td>
<td>Choice maximising market based</td>
</tr>
<tr>
<td>Community focus</td>
<td>Minimal, non-critical</td>
<td>Advisory</td>
<td>Community treated as equals</td>
</tr>
<tr>
<td>Language</td>
<td>Obscure</td>
<td>Complex</td>
<td>Transparent</td>
</tr>
<tr>
<td>Description</td>
<td>Integrated (hydraulic) catchment management</td>
<td>Integrated (agency) catchment management</td>
<td>Total catchment management</td>
</tr>
</tbody>
</table>

Table 12.3 BICM & Models of ICM
(Showing those aspects of the models that have been consistent with the BICM process in bold and italics).

This assessment illustrates that while some elements of the "participative" model as suggested by Collett (1992) are easy to incorporate, barriers exist to their complete application. This may of course be a product of deficiency in the model, but what is clear is that the participative process has been successful in legitimising the need for
more integrated decision making within the Bayswater Catchment and the value of these processes for wider application.

An important point to be made from this assessment is that although the process has been significantly "participative", the group has been relatively narrowly focussed towards the issues of the drain. It has not attempted to deal with the sustainability of all the natural resource issues of the catchment. To do so would have almost definitely limited its ability to focus on a strategy for the drain and would not have achieved much at all. Possibly as the process moves into the implementation phase, and if a more substantive structure is implemented, then the wider issues of the catchment may be considered.

12.3.11 Summary

UICM is a form of participative planning which aims to provide a new form of decision making in relation to urban drainage and potentially broader catchment issues. As a planning process UICM is essentially a networking structure designed to draw in and focus the various stakeholders in a way that seeks balanced solutions to the often "messy" and complex problems of natural resource management and development (Carley and Christie 1992).

The BICM process is the first example of this form of process in Perth, Western Australia and one of an emerging trend around the world. It adopted a holistic and participative planning approach. The process established collaboration between three local government authorities and several state government agencies, plus community groups. It provided the testing ground for developing co-operative arrangements between these stakeholders with the aim of improving the condition of the urban water environment and has provided a basis for developing an environmental context for the ongoing development of the catchment.
Although the process was seen originally as somewhat marginal to the core activities of the institutional stakeholders, increasingly resources were allocated to the various tasks involved in preparing the catchment strategy once the process gained some credibility. In the process there was an apparent positive change in organisational attitudes of government departments and local authorities towards the issues involved and the process itself. The inherent value in the process took over from the initial reticence and uncertainty of the players.

Although the process was fairly well understood by those involved there is value in recognising and describing the various phases of these processes. Formal recognition of the cyclic action learning approach and some training in the process could greatly assist participants in this and other UICM projects in understanding the process and their role.

Attention is now turning towards implementation of both short and long term actions and policies. One of the major challenges remaining is how to successfully use the land use planning process and the redevelopments occurring in the catchment to achieve the outcomes desired. Another associated issue is the need to develop funding mechanisms to support rehabilitation activity.

A major test for the implementation phase of the process will be maintaining and increasing local political support for the concepts presented in the plan. Long term implementation will, however, be impeded until the recommendations of the strategy become fully incorporated into local authority and agency policy, programs and budgets. These sorts of issues are being pursued by an implementation committee. In addition long term funding mechanisms need to be established, such as a development / restoration fund, which would tax ongoing development within the catchment to fund environmental improvement.
The following sections of this chapter use the understanding of the catchment and the drain, along with the "vision" developed by the BICM process as a basis to examine how Water Sensitive Urban Design could be used as a tool for UICM in the Bayswater Catchment.

12.4 A Framework For Linking UICM & WSUD

12.4.1 Introduction

While the BICM process has provided a catchment management strategy, to date no clear framework has been established with which to link that strategy into broader policy processes related to land and water integration or the protection of the Swan and Canning Estuary. Consideration of this issue is important as agencies and local authorities attempt to develop mechanisms to achieve better integration of land and water planning and protection of urban waterways. Thus as these policies develop and the BICM process moves from strategy to implementation, recognition needs to be made of:

- **Total Catchment Goals**: such as the objectives and standards of the Swan-Canning Environmental Protection Policy, representing the overarching statutory policy requirements.

- **Community Goals**: such as the BICM vision and objectives, representing the product of community and inter agency process.

- **Urban land and water integration goals**: such as the objectives of Water Sensitive Urban Design guidelines and policy framework, representing the generic environmental planning framework aimed at integrating land and water planning.

Such a framework is depicted in Figure 12.6.
12.4.2 Catchment Goals for the Swan & Canning Rivers

Objectives and performance standards for the Bayswater Catchment Management Strategy will need to be consistent with those for the receiving body, the Swan-Canning River System for which an Environmental Protection Policy (EPP) is currently being prepared. This EPP will aim to provide a framework for management of all catchments and sub catchments of the Perth metropolitan region. It is therefore feasible to set performance criteria for each WRMU in terms of its desired contribution to the improvement of the quality of the Swan - Canning System.

The EPP may also provide a set of criteria for:

- Water quality for various sections or reaches of the river
- Levels of heavy metals and other contaminants
- Total phosphorous
- Continued existence of a specified number and diversity of water bird species
- Retention of peripheral & fringing vegetation
- Maintenance of minimum floodway capacity.

Water quality standards are expected to be generally in accord with the "Western Australian Water Quality Guidelines for Fresh and Marine Waters" (Masini et al 1992). These guidelines set standards based upon the "Beneficial Use" or the "Environmental Value" designated for management purposes.

Five Environmental Values are nominated:

- Ecosystem protection
- Recreation and aesthetics
- Raw water for drinking water supply
- Agricultural water
- Industrial water.
TOTAL CATCHMENT SCALE:-
Set goals, objectives and target for Environmental Protection Policy. Establish administration framework. Designate subcatchment WSMU's.

SUBCATCHMENT/WRMU SCALE:-
Develop Catchment Strategy consistent with EPP, Local community input and WSUD objectives.

LOCAL SUBCATCHMENT/WSPU
Local Action plan for WSPU, consistent with WSMU and EPP.

Figure 12.6

SUSTAINABLE URBAN WATER SYSTEMS
WATER SENSITIVE DESIGN
BAYSWATER CATCHMENT
WATER SENSITIVE PLANNING FRAMEWORK
The Swan River where the Bayswater Main Drain discharges and downstream is primarily designated "recreation and aesthetics".

Each environmental value has a suite of physical, chemical and biological guidelines which, if exceeded, would result in the environmental value not being maintained. It should be noted that these water quality guidelines apply to ambient water quality and not to effluent quality (Masini et al 1992: 2).

Although the EPP is still in preparation the basic thrust of the policy will be to establish a framework for restoration and to arrest the general decline of the estuary system. A programme for the protection of the water quality of the river system could be facilitated within the EPP by incorporating a requirement for:

- **Statements of Planning Policy for specified Water Resource Management Units (WRMU's).** These are to include principles of integrated catchment management and water sensitive best planning and management practices.
- **Encouragement of UICM processes to formulate local goals and objectives.**

Thus UICM processes like BICM and the WSUD Guidelines could be used as the mechanisms to formulate objectives and action which are consistent with the broader EEP objectives for urban catchments.

### 12.4.3 Community Goals - BICM Objectives

The implementation of a water sensitive strategy needs to be based on the BICM strategy, developed as it was by a multi-stakeholder process. This, as outlined above, has the broad goal of "Re-creating the catchment". The process established the following objectives:

- **Historical development of the drain** - Foster an awareness of changes to natural drainage, its routes and the consequence of land development on water quality.
- **Conservation values** - Rebuild a strong and healthy local ecosystem.
• Improving water quality - Improve water quality in the drain and reduce pollution loads to the Swan River.

• Public Access - Provide a recreational resource for the local and regional community.

• Catchment redevelopment - Ensure that redevelopment is consistent with the aims of the strategy.

• Community Awareness - Encourage community involvement in achieving the aims of this strategy.

• Implementation - Obtain sufficient resources to implement this strategy.

12.4.4 Land and Water Integration Goals - WSUD Objectives

Formulating a Catchment Management Strategy needs to incorporate the principles of water sensitive design:

• A total water cycle management approach

• The shift to storage (detention of stormwater) rather than conveyance

• Multiple use of water facilities (including encouragement of water features)

• Water conserving landscaping techniques.

The objectives of Water Sensitive Urban Design as outlined in the Guidelines are listed in Section 9.2.4, Table 9.3.

12.4.5 Integrated Goals and Objectives for Bayswater

The goals outlined above - broad state or city goals, community goals and land and water planning goals - are now merged into a set of specific integrated goals and objectives. The various goals, objectives, strategies and recommendations from BICM have been used here, with some modification to incorporated potential requirements the EPP and the objectives of WSUD. The aim is to reflect the meaning and intent of the BICM committee in a synthesised format, articulating catchment goals, strategies and actions which may have wider application throughout the urban and peri urban
catchments of Perth, or indeed of any city. Thus the Bayswater Catchment strategy could be articulated as such:

**Catchment Goal**
The community of Bayswater wish to "Re-create the Bayswater Catchment" so that what is now referred to as the Bayswater Main Drain becomes a benign contributor to the Swan River and to restore this waterway as an integral part of the urban environment so that it provides social and environmental benefits to the community of the "Bayswater" catchment and broader Perth community.

**Objective 1 - Water balance:** Manage water balance of the Bayswater Catchment to minimise flooding and high water levels in a manner that both protects the catchment from flooding and contributes to the restoration of the aquatic ecosystem of the catchment.

**Issues:** The Bayswater Catchments have been drained to facilitate urban development, lowering water tables (to accommodate septic tanks) and manage flood prone areas. As a consequence the hydrological regime has been highly modified. Any restoration strategy for the catchment will need to maintain these requirements, but in a manner which allows the aquatic ecosystem of the waterway to be restored. This will require a significant shift in stormwater management philosophy, from the traditional conveyance approach to a storage approach.

**Strategy:**
- To manage aquifer levels, recharge and stream flow characteristics to restore environmental and recreational values
- To prevent flood damage in developed areas
- To prevent excessive erosion of waterways slopes and banks

**Actions:**
- Where practical all existing piped drains should be converted to open drains containing detention / retention basins.
- Foster an awareness of changes to natural drainage, its routes and the consequences of land development on water balance
- Direct runoff from all new roads, driveways and car parks to verges and swales or onsite detention facilities.
- Direct runoff from landscaped areas - gardens, road verges and parks to swales.
- Make greater use where possible of the retention capacity of the drainage system through modifications to outlet pipes to slow the passage of water.
- All new developments within the catchments should develop on-site infiltration and or detention facilities
- Implement a program to encourage all premises with inadequate on-site stormwater disposal or connected directly to the stormwater system to install on-site infiltration or retention facilities.
- Encourage the water authority and the local authority to develop detailed computer modelling of runoff characteristics for the area so that detailed drainage design incorporating living stream concepts can be evaluated.
**Objective 2 - Water Quality:** Enhance water quality of the drains so that they become benign contributor to the Canning River where it discharges and so that the waterways are able to support a healthy biofa.

**Issues:** Within the catchment there are various locations of point source pollution which need to be rectified. However, the most significant pollution problem arises from the diffuse sources of contamination from pollution in rainfall runoff, fertiliser runoff, nutrient contamination of groundwater seepage to the drain from septic tanks and numerous other sources including the use of pesticides in the catchment. A long term source control and diffuse pollution mitigation strategy is required throughout the catchment.

**Strategy**
- To minimise water borne sediment loading
- To protect, maintain and enhance riparian or fringing vegetation
- To minimise the export of pollutants to surface or groundwater
- To minimise the impact and export of pollutants from sewage

**Actions**
- Maintain and upgrade an adequate water quality monitoring program
- Redesign detention basin where necessary to retain the "first flush" and recycle nutrients.
- Inspect industrial premises with direct drainage to the street system and encourage them to upgrade their facilities to reduce risk of immiscible liquid discharges.
- Develop pollution stripping ponds in key locations in the catchment (i.e. wetland filter trial).
- Modify vegetation in parkland surrounding compensating basins that will increase their ability to use and recycle nutrients.
- Ensure industrial premises with degreasing bays previously constructed in accordance with the MWS - DB by-laws but discharging to leach drains and/or soak wells be provided with on-site storage facilities and be disconnected from all leach drains and soak wells.
- Minimise the use of pesticides and chemicals in pest control and drain maintenance practices.
- Avoid chemically treated timber for construction in waterways.
- Develop new means of maintenance to reduce dependency on herbicides.
- Incorporate design features which aerate water such as weirs, water falls, baffles and fountains.
- Test oxygen levels in water to assess which locations (if any) are in urgent need of aeration devices.
- Local Authorities to formulate policies to prevent sediments from being transported into the stormwater drain (e.g. use of temporary bunds, site de-watering).
Objective 3 - Maintain and Enhance Water Related Environmental Values: *Maintain and enhance the water related environmental values within the Catchment in a manner that facilitates the rebuilding of a healthy aquatic ecosystem.*

**Issues:** There are a wide range of water related environmental values within the catchment. However, the pattern of development and drainage development has caused much of the environmental resources to be degraded. A long term restoration program which enhances the waterway as an environment asset within the catchment is required.

**Strategy**
- Revegetate and maintain the drain in such a way as to enhance conservation and amenity values.
- Investigate the historical and future changes in land use within the catchment, particularly in relation to the effects on the waterway.
- Develop local action plans which aim:
  - To maintain and enhance drainage reserves for the values of preservation and restoration of indigenous plant species and as water bird habitats.
  - Create linear vegetation and parkway corridors.

**Actions**
- Increase vegetation at detention basins (e.g. with trees for roosting birds, reeds to harbour amphibians and invertebrates).
- Create more shallows (approximately half metre deep) at the water's edge to encourage reed growth.
- Within detention basins create more islands for wildlife.
- Establish small trees along the top of drain banks where access for mowing is not practicable. (Small trees such as paperbarks and sheoaks are more suitable than gums).
- Place rocks and logs into the waterway to provide wildlife habitat.
- Use indigenous plant species for the vegetation of the drainage system.
- Restrict hard walling of open drain banks to locations where it is essential for waterway wall stability or in order to maintain wildlife habitat which could be damaged by erosion or bank instability.
- Redesignate drainage reserves for multi-purpose uses (e.g. recreation, conservation, and water management).
- Trial local nature ground covers on the banks of open drains.
**Objective 4 - Water Related Recreational and Cultural Values:** Enhance the water related recreational and cultural values of the waterway by providing access, facilities and an awareness program.

**Issues:** With the development of the catchment in its present form the recreational and cultural values of the waterways have been diminished. To enhance these values both physical improvements to the water features are required. A program of awareness is needed to enhance the community's perception of the benefits of a healthy waterway instead of a forgotten drain.

**Strategy**
- Develop suitable access ways along the waterway and provide suitable recreational facilities.
- Develop an awareness program to enhance the community's knowledge about the waterway, its problems, its potential and its benefits.

**Actions**
- Conduct an investigation of the changes of land use within the catchment.
- Investigate fenced sections of the drain to establish potential for public access without infringing upon neighbouring properties.
- Where appropriate relocate public open space and integrate with the waterway so that the recreational and cultural values of the system can be enhanced.
- Initiate planting around accessible detention basins to allow access to the waterway at suitable locations.
- Maintain or modify the slopes of the waterway banks at to 1:6 to 1:8 for public safety.
- Create multiple use reserves along drains at the time of subdivision / redevelopment approval.
Objective 5 - Community Awareness

Establish a program of activities designed to raise the awareness of issues of pollution and to promote awareness of the relationship between the drains and the Swan River.

Issues: There is relatively low awareness of the relationship between catchment activities and pollution and the condition of the Swan River and the drains themselves. Before any long term strategy to convert the drains to "Living Streams" could be instigated, the general community would need to be made aware of the benefits and costs of such a program.

Strategy

- Document the environmental effects of historical land use.
- Investigate the historical and future changes in land use within the catchment, particularly in relation to the effects on the waterway.
- Develop local activities which allow community people to get involved in catchment monitoring and repair activities.

Actions

- Encourage the local historical society to prepare specific information on the development of the area and its drainage.
- In association with the Swan River Trust develop information and promotion information such as pamphlets and media releases which increase the awareness of water pollution and drainage issues.
- Develop a registrar of interested community people and groups willing to participate in catchment activities.
- Identify and resource specific clean up and restoration activities.
- Encourage local schools to get involved in the Ribbons of Blue water monitoring program.
Objective 6 - Water Conservation: Encourage water conservation within the catchment to reduce the total amount of water imported, promote reuse and to ensure groundwater sources are not over utilised.

Issues: All additional water imported into the catchment for human use has both an environmental and economic cost. In environmental terms it modifies the hydrology of the catchment and this can often be detrimental. The use of local groundwater for various non potable uses helps to minimise the amount of water imported into the catchment. However, in some situations, groundwater is over used, potentially restricting other users or elements of the water environment. The encouragement of water conservation generally will help raise water awareness and minimise the need for importing water.

Strategy:
- To minimise use of imported scheme water.
- To promote the re-use of stormwater.
- To promote the re-use and recycling of effluent.
- To reduce irrigation requirements.
- To promote regulated self supply.

Actions
- Provide incentives for water conserving household appliances.
- Encourage appropriately managed use of local groundwater for self supply reticulation.
- Encourage recycling of effluent and re-use of grey water in water sensitive housing estates.
12.5 Developing A Local Action Plan

12.5.1 Introduction

To implement the type of strategy outlined above the WSUD Guidelines recommend that a catchment or a water resource management unit (WRMU) be divided into a series of water sensitive planning units (WSPU’s) to better facilitate implementation by means of local action plans. This section provides an example of how a Local Action Plan might be derived.

12.5.2 Local Action Plan - WRPU # 3

In determining appropriate WSPU’s, the sub-catchments of the Bayswater Main Drain were considered as well as the residential or land use precincts of the City of Bayswater’s housing strategy. In this instance it was considered that a mixture of sub-catchment boundaries and the precincts offered an appropriate planning unit. On this basis WSPU’s were defined (see Figure 12.9). Within each unit a water feature has been selected as a point around which water sensitive design could be focused and performance monitored.

In selecting a planning unit for further investigation as part of this study it was considered that WRPU #3 offered major opportunities for water sensitive design. This unit approximates Residential Precinct 4 which is the older developed area of Bayswater. The housing quality south of the railway line varies but in some sections, for example, Slade Street, the housing quality is of uniform condition and quality. The Housing Strategy recommended a density increase together with conservation of some of the existing housing stock. North of the railway line, the housing stock is of mixed quality and condition. Many former State Housing Commission homes are in a condition ideal for redevelopment and increased densities as they are close to open space and public transport (BSD 1991).
Other factors in favour of this area for redevelopment is that all of this precinct is sewered and 66% of houses are single detached. Higher in the catchment, the adjacent housing is of 1960s vintage.

In drainage terms WRPU #3 is served by the Bayswater Main Drain and James Street, King Street, Reman Road and Browns Lake East Branch Drains (see Figure 12.9). In most cases where the drain is open it abuts fences. In no instance is the drain easily accessible to the public nor enhanced for public enjoyment (see Plates 12.1 to 12.4).

Topographically this area is diverse and interesting, by comparison to areas in the northern parts of the catchment. The interface between residential and industrial in the Clavering Road area is indistinct, with some smaller elements of light industry on the north side of the drain (see Plate 12.5 & 12.6). It is possible that in “re-creating the catchment” a rehabilitated creek in a linear public open space network could help facilitate a distinct division.

As the drain proceeds towards Broun Street it is accommodated in an unnatural straight line and then piped until it reappears adjacent to a public reserve, part of which has been created from a closed road reserve (see Plate 12.2).

The drain enters WRPU #3 a short distance south of the Morley Shopping Centre. Plans for the redevelopment of the Shopping Centre have variously examined relocating existing sumps or covering them to allow overhead development. The option to incorporate a water feature in an otherwise vast expanse of bitumen has been overlooked. However, there is still a significant opportunity for a public open space link between Morley and Bayswater along the main drain.

A range of opportunities and constraints for water sensitive urban design within WRPU #3 are detailed in Figure 12.10. Opportunities to restore the drain into creek within that area are illustrated in Figures 12.14a, b, c.
Most of the elements of the Local Action Plan for WRPU# 3 have been primarily taken from the BICM strategy (BICM 1993). However, these actions have been supplemented by the researchers' own investigations. In this document they are drawn together in a plan for the unit (see Figure 12.10). The primary objective of the plan is to provide an overview of how a linear park might be created along the length of the drain. It aims to guide the processes of restoring a healthy aquatic ecosystem. The fulfillment of this plan will, over time, require road closures or traffic calming measures on some roads and acquisition of some private property.

12.5.3 Summary

Thus a Local Action Plan is the first step in setting in process the broader goals of the whole catchment. If successful it could act as a symbol for the total restoration of the drain to a more sustainable system.

The options for redevelopment and restoration to convert the drain to healthy and beneficial community assets are numerous. However, the options presented in Figure 12.8 are relatively minor in the context of the broader objectives of the Catchment Strategy. The benefits to be gained from such a co-ordinated Local Action Plan such as this are significant and include:

- The conversion of the current disused and dilapidated drain reserve to an attractive feature which would ultimately enhance property values
- The restoration of a healthy aquatic ecosystem
- The creation of Public Open Space within Bayswater which is currently deficient in open space.
Plate 12.1  NORA HUGHES RESERVE-Landscaped Wet Detention Basin Incorporating Closed Road Reserve

Plate 12.2  Existing Wet Detention Basin, Bayswater
Plate 12.3  Typical Drain Treatment - Early Residential, Bayswater

Plate 12.4  Typical Drain Treatment - Later Residential, Bayswater
Plate 12.5  Typical Drain Treatment - Industrial Area, Bayswater

Plate 12.6  Typical Drain Treatment - Industrial Area, Bayswater
12.6 Application of WSUD at the Subdivision Level

12.6.1 Introduction

The achievement of most of the objectives of the Catchment Management Strategy will not be achieved unless the mechanisms are established to guide development, in this case redevelopment of the catchment. The following section describes the use of the Water Sensitive Urban Design Guidelines as a tool to achieve catchment objectives during the redevelopment processes that are ongoing in the catchment.

Three forms of redevelopment are examined. The first is a total redevelopment of a five-hectare site. The second is an area where incremental redevelopment, such as dual occupancy is occurring. The third example provides an outline of a redevelopment proposal which uses a localised wastewater treatment system as an alternative to traditional deep sewerage methods.

Although two of the three redevelopment schemes proposed here will not be realised for reasons that are outlined below, what the design examples provide are models (or examples) of how WSUD principles could be applied in any redeveloping urban catchment to achieve the goals of urban ICM processes.

12.6.2 Redevelopment Option

12.6.2.1 The Site

The site selected for the redevelopment exercise is located within WRPU# 3. It is bounded by Lawrence Street to the west, Patterson Street to the north, Coode Street to the east and Hester Street to the south (see Figure 12.9a).

When this investigation was initiated the site was part of a Homestead Redevelopment programme (State Housing Authority) and was largely vacant, apart from a line of houses fronting Hester Street. The site consists of some 23 single residential lots of approximately 1000 square metres adjoined at each end by two
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When this investigation was initiated the site was part of a Homeswest Redevelopment programme (State Housing Authority) and was largely vacant, apart from a line of houses fronting Hester Street. The site consists of some 23 single residential lots of approximately 1000 square metres adjoined at each end by two
triangular recreation reserves, neither of which have been developed. The area of the site including the surrounding road reserves for Lawrence Street and Hester Street comprises 5.04 hectares.

The site occupies the flank of a reasonably prominent hill. The surface levels fall from 29 metres above height datum (m A.H.D.) in the north east corner to 22 m A.H.D. in the south west corner and 20 m A.H.D. in the south east corner adjacent Hester Street. Hester Street runs diagonally across a grid road layout and the Hester Street road reserve contains 350 m length of piped Main Drain. West of Lawrence Street and east of Coode Street the drain is open.

On the south side of Hester Street is a new residential development by Homeswest. Otherwise the surrounding area comprises single residential development from the 1960s.

12.6.2.2 Existing Design Response

When the research commenced, the redevelopment plans for the site were at a very advanced stage of design. In fact the design had been approved by the relevant authorities and preparations for letting the earthworks and servicing contracts was imminent. The approved design is shown in Figure 12.11a. It provides for 28 lots of 560 square metres, plus 10 grouped housing developments of approximately 300 square metres/unit.

The development in this form provides a moderate increase from 23 lots to 35 lots and an increase in density (R12.5 to R20 within the Western Australian residential density coding system). It is reasonably typical of a "green street" type development.

12.6.2.3 Water Sensitive Urban Design Response

Although the researchers were aware of the advanced state of design and approval of the redevelopment planned for the site, it was decided to develop an alternative
WSUD to test both developer, council and Water Authority responses to the design. The existing redevelopment plans also provided a basis for comparison of development alternatives for the sites.

The major difference between the existing proposal and those proposed as a Water Sensitive Urban Design response is the focus in solving both urban water management and urban consolidation objectives within the design. In keeping with the objectives of BICM to "Re-create the Catchment", the WSUD proposals allow for the "opening" and re-creation of a creek along Hester Street where a 350 metre section of piped drain presently exists. This is achieved at the same time as moderate density increases are achieved.

Two water sensitive designs have been prepared. The first provides a complete alternative to the existing design, while the second presents a staged redevelopment option which maintains the bulk of the existing redevelopment proposal but allows for the creek restoration to be achieved.

Both of these designs have been developed to the point where budget estimates for their implementation have been prepared. However, considerably more effort was put into the second design as it had the most potential of being realised. The designs have also been the subject of discussions and a review process involving the BICM group, Homeswest, Water Authority staff, plus elected members and officers of the Bayswater City Council. These discussions have proved both useful in developing the concepts and evaluating the implications of possible implementation in other parts of the catchment or for other areas.

*Unconstrained Water Sensitive Redevelopment*

The initial design for this site involved a complete rethink of the redevelopment opportunities for the site. This is illustrated in Figure 12.9b. The most important element of the proposal is the reallocation of open space from the adjoining small
WSUD to test both developer, council and Water Authority responses to the design. The existing redevelopment plans also provided a basis for comparison of development alternatives for the sites.

The major difference between the existing proposal and those proposed as a Water Sensitive Urban Design response is the focus in solving both urban water management and urban consolidation objectives within the design. In keeping with the objectives of BICM to "Re-create the Catchment", the WSUD proposals allow for the "opening" and re-creation of a creek along Hester Street where a 350 metre section of piped drain presently exists. This is achieved at the same time as moderate density increases are achieved.

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*Unconstrained Water Sensitive Redevelopment*

The initial design for this site involved a complete rethink of the redevelopment opportunities for the site. This is illustrated in Figure 12.9b. The most important element of the proposal is the reallocation of open space from the adjoining small
parcels of open space into a section of linear open space / drainage reserve of a minimum width of 30 metres. This is used to accommodate a restored section of waterway. Within the waterway two wet detention facilities are proposed. These have both flood mitigation and water quality enhancement characteristics.

In terms of layout, the design provides access via new road alignments which are consistent with the WSUD principles, i.e., hard surfaces are minimised. Two roads proposed which are normal to the contours are short with direct access at the bottom to local basins incorporated in the widened public open space reserve. Grouped housing is proposed abutting and fronting onto the public open space. To maintain security, this side of the reserve retains some terracing with public access encouraged on a much more gentle, south side. Two footbridges and a weir are proposed to provide aesthetic relief and recreational enjoyment (See Figures 12.9c and 12.9d).

The land to the north occupying the flanks of the hill, can be developed in a tiered fashion so that all lots will have an aspect over the newly created open space reserve.

Small frontage access roads would be maintained to service housing fronting Hester Street on the south side. On the north side existing houses will need to be acquired and incorporated in overall plans to allow for the creation of the reserve.

*Modified Water Sensitive Redevelopment*

The initial concept outlined above was reviewed by the developers, Homeswest, who pointed out that it was difficult for them to accommodate such a significant change in their development programme as approvals for redevelopment were in place and the letting of contracts imminent. However, it was pointed out that a staged programme may still provide the opportunity for the basic concept to be implemented. An alternative design was prepared for discussion and evaluation (See Figure 12.9e).
The staged water sensitive redevelopment option maintained the linear open space and creek restoration through a re-allocation of open space, while attempting to minimise its impact on the existing development programme. This was proposed to be achieved by maintaining the bulk of the proposed Homeswest redevelopment as Stage 1. Subsequent stages would involve a redistribution of adjoining public open space and drainage reserves, the ultimate purchase of two private residences (on Hester St) and creation of the water features and “creek” and linear open space feature. Proposed group housing sites along Hester Street would be relocated to the adjacent triangular public open space areas.

The staged development scheme could have involved:

Stage 1
- Develop of Homewest's design excluding Lot 1 and a rearrangement of lot 16 and 17.

Stage 2
- Partial closure of Patterson St, Hadrill St, and optional closure of Lawrence St.
- Arrange land swaps of recreation areas and drainage reserves for existing Homeswest land on Hester St.
- Rezone areas involved in land swaps i.e. existing POS and drainage reserve to residential and establish new multiple use POS and Stormwater Management reserve.
- Purchase any additional crown land such as road reserves adjacent to Lawrence, Patterson and Hadrill St.
- Develop former recreation reserves for housing (new lots 32, 33, 34, 35, 36, 37, &38).
- Development of linear park and stormwater system between Hadrill & Coode St.

Stage 3
- Timing dependent on vacation of existing Homewest housing on Hester St.
- Acquisition or joint venture of private properties on Hester St.
- Develop grouped housing lots 1, 17 & 31
• Development of linear park between Patterson and Haddrill St.

Implementation of the staged scheme would have allowed:

• The bulk of the Homeswest development to proceed while the proposed land swaps take place

• The existing Homeswest rental homes on Hester St to become vacated

• The establishment of purchase or joint venture arrangements with the two private property owners on Hester St.

12.6.2.4 Comparison of options, cost and benefits

Table 12.4 provides a comparison of the development options. This data clearly illustrates the increased lot yield provided by both of the two WSUD options. However it must be pointed out that the proposed development prepared by Homeswest could have included higher densities, but was constrained by local community reluctance to density increases. The WSUD options assume acceptance of higher densities through provision of suitable consultation process and as a trade-off for the enhancement of the local waterway. These assumptions could only be tested if the concept was being applied in a real situation.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Prior to redevelopment</th>
<th>Homeswest</th>
<th>Full Water Sensitive</th>
<th>Staged Water Sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area (Ha)</td>
<td>5.0385</td>
<td>5.0385</td>
<td>5.0385</td>
<td>5.0385</td>
</tr>
<tr>
<td>POS /Drainage</td>
<td>1.2600</td>
<td>1.2600</td>
<td>1.2600</td>
<td>1.1706</td>
</tr>
<tr>
<td>Road Reserves</td>
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<td>1.7390</td>
<td>0.8250</td>
<td>1.1036</td>
</tr>
<tr>
<td>Develop. Area</td>
<td>2.2307</td>
<td>2.0395</td>
<td>2.9500</td>
<td>2.7643</td>
</tr>
<tr>
<td>Single Residence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area (Ha)</td>
<td>2.2307</td>
<td>1.7420</td>
<td>1.9500</td>
<td>1.7226</td>
</tr>
<tr>
<td>Lot yield</td>
<td>23</td>
<td>32</td>
<td>33</td>
<td>32</td>
</tr>
<tr>
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</tr>
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</tr>
<tr>
<td>Area (Ha)</td>
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<td></td>
<td></td>
<td></td>
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<tr>
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<td>1.000</td>
<td>1.0417</td>
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<td>30</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>297m² (R40)</td>
<td>333m² (R30)</td>
<td>290m² (R40)</td>
</tr>
</tbody>
</table>

Table 12.4 Land Use And Development Comparisons For Redevelopment Site
However, some financial benefits of the proposal have been calculated simply in terms of real estate benefits of the increased lot yield for the Staged option:

- 3 more single lots @ $75,000  
- 26 unit sites @ $27,500
**Total additional return (estimated)**  
$940,000

This needs to be equated against the costs of the proposal which have been estimated as:

- Estimated purchase of road reserve (0.5 Ha)~  
- Estimated costs development of liner open space and water features  
- Additional development costs associated with extra dwelling units  
**Total additional costs estimate**

$970,000

There are also time delays in relocation of public open space and closure of roads - (approximately one year) plus delays associated with timing of stage three which is dependent on rental properties becoming vacant.

Most of these costs are very conditional as they are new processes to developers. Once this type of practice becomes more normal many of these "extra costs" would become an accepted part of the redevelopment process.

**12.6.2.5 Hydrological Design and Benefits**

As outlined in Section 12.6.2.3 above, the principal change to the stormwater management system proposed by this design is the removal of an approximately 350 metre section of 1500 mm diameter reinforced concrete pipe. This pipe would be replaced by an open system comprising two wet detention basins which would be interlinked by a vegetated creek and weir structure (see Figure 12.9d). This section provides a brief description of an evaluation undertaken of the design.
The hydraulic capacities of the existing system and the proposed modifications were analysed using the computer model ETRAN, a module of the well recognised USEPA - SWIMM 4 package. The program solves dynamic equations for various flow regimes providing a realistic representation of stormwater characteristics.

Since the actual flows for this section of the Bayswater Main Drain are unknown, the hydraulic performance was established by inputting progressively higher peak hydrographs into a EXTRAN model of the existing piped system until failure occurred. The limiting input hydrograph estimated for this piped section was then applied to an EXTRAN model of the open system. As would be expected the downstream hydrograph from the open system was considerably lower, due to the detention effect of the basin.

For major storms greater than 1 in 10 year average recurrence interval events, the reduction in peak flows would be in the order of 50 to 70 percent.

This outcome provides at least two significant benefits. Firstly, the open system could accommodate considerably higher peak flow events while maintaining downstream flow rates at the same or below that presently provided by the piped system. Consequently the open system could accommodate increased runoff generated by higher density and more impervious surfaces without negative impact downstream.

Secondly, if large increases in runoff were not expected, water quality improvements would be achieved via sedimentation and bio-assimilation within the detention basins, due to the detention of 3 to 14 days for small and frequent storms which typically carry the highest pollutant loads.
Apart from the primary stormwater benefits relating to water quality and quantity, the open system potentially provides a secondary community benefit since the open space system forms an attractive linear open space and water feature, providing recreation and conservation opportunities.

In addition to these proposed design features for the open waterway, the design of the redevelopment would incorporate the principles of on-site storage and disposal wherever possible. For example the road system would be used as a default drainage system where minor storms are collected into recharge bores via kerbside side entry pits and disposed of via percolation into soil. Major storms would collect along the kerbside and flow into the detention facilities designed into the open system. In addition the length of road is kept to a minimum, thereby reducing both volume and speed of runoff off the roads.

12.6.2.6 Evaluation

This section is based on discussions with the BICM committee, the Developer, Bayswater City Council staff and Water Authority staff. It aims to provide a brief overview of the comments of the various groups who would need to be supportive for such a development to be undertaken in the future.

BICM Perspective

The adoption of the WSUD concept to the redevelopment of the Haddrill St /Hester St site would have provided an opportunity for the restoration of that section of the Bayswater Drain in a way that met the dual objectives of urban renewal and waterways restoration. The broader benefits of such a project to the community include: recreational facilities, habitat development and assisting in enhancement of water quality discharges to the Swan River.

The other important point to make is that if restoration of this section of the drain was not possible to be incorporated into the redevelopment of the site, it effectively means
that this section of the Bayswater Drain would not be able to be restored until the next phase of urban renewal occurs some time in the future, say in 50 years.

**Developer perspective**

In general terms the concepts presented looked attractive. The estimated cost illustrated the relative magnitude of the costs and financial benefits, however it needed further examination. From a developer perspective, the WSUD concept has the benefit in terms of creating attractive real estate and in this situation a greater lot yield. This illustrates that much of the restoration cost could be offset against development returns if planning mechanisms were in place to facilitate such concepts. Before a developer undertook such a project all of the potential impediments relating to land swaps, road closure, drain restoration and management would need to be resolved.

**Water Authority Perspective**

From a water manager's perspective, it provides the opportunity to undertake a stormwater retrofit project in partnership with the developer which would provide the potential to "offset" some or all of the cost associated with the restoration project. However, in this case the proposed removal of a piped section of the drain, which in engineering terms is seen as an asset, meant that the proposal was not viewed favourably, and the suggestion was made that such concepts may be more favourably viewed adjacent to open sections of the drain. A significant issue that needs to be resolved would be who would be responsible for ongoing management of the restored section of the drain.
Figure 12.9b

SUSTAINABLE URBAN WATER SYSTEMS
WATER SENSITIVE DESIGN
BAYSWATER CATCHMENT

REDEVELOPMENT, HESTER ST BAYSWATER
WATER SENSITIVE OPTION
Figure 12.9c
REDEVELOPMENT, HESTER ST BAYSWATER
MODIFIED WSD/HOMEWEST OPTION
Sketch View to Haddrill Street Footbridge

Sketch View to Patterson Street Inlet
Council Planning Perspective

From a Council planning and administration perspective the WSUD proposal was seen as administratively more difficult, as it included road closures and reallocation of public open space. Thus a substantial effort in planning and negotiating with Land Administration authorities would be required. A long time frame is thus required as a range of administrative procedures need to be followed. It was suggested that to facilitate proposals which include this type of land reallocation there could be some benefit in devising an inter agency policy or policies that would clarify principles and procedures, management and financial / compensation issues.

Summary

In summary the design and review exercise revealed that these types of redevelopment have potential, but a number of policy and practical impediments need to be overcome before concepts of this type could be implemented. Specifically, arrangements for management, transfer of land and multiple vesting of the site would be required. Before developers would become willing partners in such developments incentive schemes would need to be devised. From a coordinated planning perspective it would be useful to have options for these types of water sensitive proposals incorporated into a Town Planning Scheme provision or set out as a Guided Development Scheme so that they become automatic. "Extra Costs" tend to disappear when this happens and provisions could also be made to establish a funding mechanism to facilitate schemes such as these through these mechanisms.

12.6.3 Infill Option

12.6.3.1 The Site

The site selected for a hypothetical infill development is located at the lower end of WRPU #3 (see Figure 12.10). It is bordered by Drynan Street to the north, Beechboro Road to the east, Hudson Street to the south and Langley Road to the west. The site comprises 6.94 Ha in area.
Topographically the site is basin-like with the low point being centrally located. Houses are located on the higher ground around the perimeter. Most are on long narrow blocks which are low lying at the rear and well in access of 1000 m². A unit development is located on the Beechboro Road frontage. Beechboro Road is an important district distributor road and at this point forms an interface between residential/commercial and industrial development. Group housing on the frontage is therefore considered appropriate.

Internally a small detention basin is located on a bend in the main drain which enters the site midway along Hudson Street, takes a right angle bend to run parallel with the rear of existing lots and then a further right angle bend to exit from the site at the Drynan Street/Beechboro Road intersection.

12.6.3.2 Water Sensitive Design Response
The WSUD response for this has been to provide a design framework which aims to facilitate incremental redevelopment in a manner which allows for enhancement of the waterway. The design creates a series of lots at the rear of existing lots wherever possible. In some cases lots may require amalgamation. In all cases these new lots face an internal road which surrounds an area of POS which contains the main drain and a detention basin is created as an artificial wetland, thus creating an attractive outlook.

A Guided Development Scheme would be necessary to enforce the above provisions and if necessary to acquire property for the public open space and the road. In addition some houses will need to be acquired on Hudson Street if a 50 metre public open space reserve is to be maintained in this area.
12.6.3.3 Feasibility

This preliminary design illustrates that an additional 13 single residential lots and an additional 18 unit sites could be created at the same time as providing the opportunity for waterway restoration.

Market advice from local real estate agents suggests that the water sensitive option is likely to add $5,000/lot to those fronting the reserve and $2,500/lot for those in close proximity. Based on these assumptions the capital value of the real estate could be increased by a little less than $1 million dollars. Based on typical site development costs, including consideration for earthworks, retaining structures, roads, stormwater, services and landscaping, a cost of $224,000 for implementing the redevelopment has been estimated. Although these figures are only estimates it can be seen that the infill option could be funded internally and is viable.

12.6.3.4 Implementation

The means by which the above proposals may be best implemented is a Guided Development Scheme. This will allow a group of landowners within a block to co-ordinate themselves, or alternatively be co-ordinated via a Council administered Development Town Planning Scheme. The use of existing rights of way and the protection of existing residences can be incorporated as essential objectives of the redevelopment.

Costs considered to be associated with "scheme works", such as the construction of the internal road and the acquisition and landscaping of the public open space and waterway, are usually allocated to each benefiting existing land owner, in accordance with an agreed formula.

In this way development within a street block can be co-ordinated with consideration given to the streetscape, reducing driveway lengths, retention of existing dwellings,
rationalisation of cross overs, use of rights of way and a sharing of all costs associated with the provision of services. As a means of initiating the proposal and minimising high up front capital costs, an intermediate measure could allow early subdividers to provide temporary access to the rear of their lots until the road is constructed.

These schemes are possible but should only be attempted where the majority of landowners are willing to participate. Councils are often reluctant to invest time and energy into these schemes but such schemes could provide part of the longer term waterway restoration strategy which has broad support and funding mechanisms in place, such as stormwater rate, or other funding mechanisms which provide funding for restoration as redevelopment proceeds. This is not dissimilar to existing headworks charges for connecting to water or sewerage services.

12.6.4 A Redevelopment Option For Unsewered Areas
Since some 60% of the Bayswater Catchment is unsewered part of the research has involved preliminary evaluation of redevelopment using localised wastewater treatment and recycling. Such schemes aim to facilitate local redevelopment while avoiding the need for expensive centralised sewerage schemes. However, since this investigation was undertaken the State Government has announced the Infill Sewerage Programme which will provide sewerage to the Bayswater Catchment. Notwithstanding these events it is worth reporting on the design and the issues such a scheme would face.
Figure 12.10
INFILL DEVELOPMENT, HUDSON ST BAYSWATER
WATER SENSITIVE OPTION
12.6.4.1 The Site

The site is within the Bayswater Catchment, but outside of the WSPU #3. It was formally a school site and was purchased by Homeswest as a redevelopment site. However, redevelopment in line with government urban consolidation policy was constrained by lack of sewerage. Therefore a preliminary design was developed to test the viability of redevelopment using a localised wastewater reuse system.

12.6.4.2 Water Sensitive Design Response

A design was prepared which provided for 46 lots, surrounding a central area of public open space (see Figure 12.11). The proposed design incorporates a number of water sensitive design features, in particular an onsite wastewater and reuse system by means of an aerobic treatment unit (ATU) and reuse for irrigation. The ATU was to be located on a separate lot but incorporated into the open space.

To minimise the area of effluent discharge, a recharge bore is proposed, with a further bore for open space irrigation (and possible supply to households for garden watering) located downstream on the opposite side of the open space. Additional bores were proposed to provide for monitoring around the perimeter of the site.

To utilise the available treated effluent consideration was also given to developing a water-demanding landscape that could tolerate watering during winter as well as summer. This would help to maintain local water balance.

The proposal was presented as a trial to evaluate the performance of such schemes as potential alternatives to reticulated sewerage. However, provisions were made in the design to allow for eventual connection to the main sewer if need be.

12.6.4.3 Evaluation

The proposed scheme was reviewed by the Developer and the Water Authority. Below are some of the concerns expressed.
Developer perspective

In terms of the development concept, the developer saw merit in the concept and the potential for the proposal to be a useful demonstration or research project. However, they were seeking the full support of the Water Authority in terms of management and maintenance. As a research type project they were also hoping to be able to waive the headworks charges likely to be required should the site need to be connected to the sewer in the future.

Water Authority perspective

The Water Authority had a number of concerns, particularly with respect to the need for more detailed design considerations such as: emergency storage, cyclic use of recharge bores to reduce clogging, a detailed plant monitoring and water level monitoring programme, further evaluation of effluent quality in regard to the receiving environment (particularly the issue of not further adding nutrient loads to the drainage system) and a water balance evaluation.

While these issues are not insignificant, with further investigation the design may have been able to be further developed to provide a demonstration if research / demonstration funding had been available. However, before further investigations proceeded the decision was made to proceed with the Infill sewerage programme, therefore negating the opportunity for such a research opportunity.
REDEVELOPMENT, GREY ST BAYSWATER UNSEWERED OPTION
12.6.5 Redevelopment Summary

In this section of the research three subdivision designs using the principles of WSUD have been outlined. All the proposals have illustrated the potential for the WSUD concept to provide meaningful solutions to urban water management problems. The benefits and constraints to the various concepts have been presented. One of the key findings from the investigations is that there is potentially significant scope to use WSUD as a guide to redevelopment. This would allow the processes of redevelopment to aid in the long term restoration of urban waterways (see Figures 12.12a, b, c). While a number of technical issues remain unresolved with all the designs and particularly with the localised treatment concept, the main impediment to implementation of these types of schemes is institutional support, particularly the need for policy and incentive mechanisms.

More than anything these investigations highlight the fact that even in a fully developed urban catchment there are opportunities to achieve incremental benefits for the wider community and the environment as well as the developers in question. In any urban catchment there are many redevelopment proposals under way or yet to be realised which could be guided by the WSUD guidelines in a way that integrates environmental, economic and social objectives. Thus WSUD is a useful a tool for Urban ICM and an important planning instrument for aiding in urban sustainability.
WIER TO DISSIPATE ENERGY AND AERATE RESTORED CREEK

ISLAND FOR WILDLIFE HABITAT:
- REEDS, RIPARIAN SHRUBS AND TREES TO OVERHANG RESTORED CREEK / POND

STILLING BASIN

BRIDGE FOR CONTROLLED SERVICE ACCESS

Figure 12.12 a CREEK RESTORATION OPPORTUNITIES
Figure 12.12 b
CREEK RESTORATION OPPORTUNITIES
WIDENED, RESTORED CREEK, OVERHUNG BY NATIVE TREES, EDGES MAINTAINED SUITABLY FOR PUBLIC ACCESS

ADJACENT RESIDENTIAL AREAS OPEN ONTO RESTORED CREEK

ACCESS TRACK

DENSELY VEGETATED, NEW 'BILLABONG' OPENS OFF RESTORED CREEK: WILDLIFE HABITAT RE-CREATION

Figure 12.12 c

CREEK RESTORATION OPPORTUNITIES
12.7 Summary

This chapter has presented a case for using the concept of Water Sensitive Urban Design as a "tool" for Urban Integrated Catchment Management. The preceding discussion has provided an outline of characteristics of the Bayswater Catchment and the participative UICM process which has been undertaken within that catchment. These processes essentially provide the social and environmental context for the more technically based planning framework of Water Sensitive Urban Design to be applied as a tool for the implementation of the UICM strategies. The aim of these processes and tools is to provide for continued development of the catchment in a way that allows for the ecological integrity of its water environment to be enhanced.

The discussion provides a description and analysis of the Bayswater Integrated Catchment Management process. This illustrated the significance of this form of networking process and highlighted its strengths and weaknesses. The most important feature of this process was its open and participative nature, while its weaknesses stem mainly from the newness of this form of multi-stakeholder process to the participants and agencies involved.

Although the process was not without its detractors, ultimately the process and the committee gained a great deal of respect from those who became aware of, were involved or had been influenced by the process. Although it remains to be seen as to how the strategy developed will be implemented, the process has legitimised the need for action. It has also set a precedent and provides a model for wider application of the Urban Integrated Catchment Management approach to urban stormwater management and drain restoration in metropolitan Perth and for other cities.

The case study illustrated how the conceptual basis of IUWM can be applied through the provision of a dynamic performance based approach to implementing catchment management which links Urban Integrated Catchment Management processes with
Water Sensitive Urban Design as an important "tool" for implementation. Within this framework, the Water Sensitive Urban Design Guidelines act as a non structural control mechanism, which uses the traditional planning and development control system as a means of guiding development and redevelopment, in a manner which enhances rather than diminishes the quality of the urban water environment.

It is stressed that the participative Urban Integrated Catchment Management processes, like that which occurred at Bayswater, also need to be linked to a broader policy framework incorporating the goals of State or City wide policies such as the proposed Environmental Protection Policy for the Swan-Canning Estuary, as well as the land and water integration goals of Water Sensitive Urban Design. A description of how these mechanisms might be linked and applied is provided, as is a possible format for articulating the goals, objectives, strategies and actions of this integrated framework.

To illustrate how Water Sensitive Urban Design can act as a "tool" to achieve these goals the basis of a Local Action Plan for one of the Water Sensitive Planning Units in the Bayswater catchment is provided. This sketches out a possible long term strategy for achieving the objectives of the Bayswater Integrated Catchment Management process. This example highlights the redevelopment opportunities which need to be identified so that they may be incorporated into long term planning processes, such as planning scheme reviews. Once incorporated in the planning system the processes of redevelopment can then be guided, if need be by guided development schemes, in a manner which potentially enhances the development process as well as the water environment.

These concepts are further explored and illustrated through the hypothetical application of Water Sensitive Urban Design to a redevelopment and an infill or dual occupancy situation. In addition a preliminary exploration is provided of the
opportunities and constraints to the use of localised wastewater treatment and recycling at a community scale.

What these examples illustrate is the potential for Water Sensitive Urban Design principles to be applied as redevelopment occurs, illustrating that the most opportune time to capture benefits for the community and the environment is when investment in redevelopment is being made. The examples show that with creative design and strong institutional support there is considerable potential to achieve real long term benefits. However, these types of developments will only become a reality if there is enough political will to apply the planning system for these types of multiple outcomes.

While UICM can be seen as a process which helps to legitimise the repair of the water environment, these processes should also be seen as a potential spring board or "stepping stone" to begin to tackle the wider question of urban sustainability. As Collett (1992) has suggested, as well as being about urban water management, UICM should also aim to more generally improve the urban environment and quality of life, plus optimise energy use and resource conservation (see Chapter 9, Section 9.2.3).

While these goals may be difficult to achieve, a key feature of UICM processes is that they are multi-stakeholder planning processes aimed at bridging the gaps created by the institutionalisation of planning and environmental administration (Paehlke and Torgenson 1990). The aim is to come up with balanced and integrated solutions.

Many authors suggest that the development of the community's capacity to participate in decision making and establishment of more flexible institutional arrangements is a key to sustainability (see for example Lee 1992, Carley and Christie 1992, Attwater 1993, Davis and Weller 1993). In fact some even suggest that "societal innovations today are more likely to originate from grassroots movements than from technical
elites, but innovations are not likely to be successful without the consent and active support of experts" (Masser et al 1992: 539). UICM type processes should therefore be seen as an example of the consensus building required to link community aspirations with technical implementation (in this case using WUSD). Thus they provide a means of transforming professional praxis and may be a starting point for consideration and debate of the wider issues of urban sustainability.
CHAPTER 13

CASE STUDY 3 - CANNING

...the Canning River is the heart of the City of Canning and the surrounding catchments. Without a healthy “heart” the condition of the surrounding area will deteriorate.

The Canning Community

13.1 Introduction

13.1.1 Background

This chapter provides a case study which builds on the experiences gained during research undertaken in the previous two case studies. It focuses on a small part of the Canning River catchment in Perth, Western Australia. It provides an abridged version of an investigation undertaken for the City of Canning in a report titled "From Drains to Living Streams" by Mouritz Environmental Services et al (1995). Again the work presented here is the product of the WSUD team, but importantly the team were undertaking a real project rather than applying the concepts as part of a research project.

The case study does not present an example of a fully Integrated Urban Water Management response, in that its primary focus is stormwater. It does, however, clearly illustrate some of the opportunities that are presented when a transdisciplinary approach is applied to the management of urban stormwater in areas that are facing significant urban transformation. As such it provides a useful example of emerging professional praxis.

13.1.2 Case Study Selection

This case study has been selected because it provides one of the first clear examples of a Local Authority attempting to integrate management of the water environment with the urban development and redevelopment processes. Essentially the WSUD team were asked to apply the techniques they had developed in the preparation of the
WSUD Guidelines and the other case studies to an area facing significant urban re-development pressure. The main difference between this and the other case studies is that in this case a client wanted answers to problems that they understood needed to be addressed. In the previous case studies the focus was exploration of concepts and demonstration of possibilities. In this case, the social and local political context needed to be fully integrated into the study process.

13.1.3 Study Elements

The development of this case study has involved a number of key elements which included:

- **Steering Committee** - The establishment of a project steering committee was an essential part of the project. This group consisted of City of Canning Councillors and staff, relevant government agency staff (Water Authority, Swan River Trust), community groups and business representatives (Chamber of Commerce and representative from the shopping centre redeveloper). This group managed the processes of the study, providing a forum for feedback of the study outcomes into each of the stakeholder's agencies or networks.

- **Student Projects** - As part of the study, Environmental Management students from Murdoch University undertook a review of the drains within the study area in September 1994. They collated information about the history of the area and the landuse issues and were asked to look for restoration opportunities in the drains and detention basins of the study area. In fact they walked the entire length of the open drains, identifying and mapping landuses adjacent to the drains. They also interviewed 151 residents and workers about their perceptions of the drains and the problems of the Canning River. This information was used by the WSUD team as an information base upon which management strategies and design solutions were developed.
• **Community Involvement** - One of the aims of the study was to initiate a longer term Urban ICM process which would involve the wider community in ensuring that the natural and human environment is combined in planning and development processes. To initiate this process and to gain feedback and a level of community input into the study, two public involvement forums were held. The first was a Search Conference on the 30 November 1994, which both informed the community about the project and set the context for ongoing community interaction. Importantly this meeting identified some of the important community attitudes and aspirations about the Canning River and the drains within the study area. The next major element of community involvement was an Information and Feedback evening held on 22 May 1995. The aim of the meeting was to provide feedback on the design concepts developed for the study area. In addition that meeting aimed to identify the groups and individuals interested in establishing an ongoing Urban ICM process in the study area.

• **Water Sensitive Urban Design - Catchment Opportunities & Precinct Design** - The fourth major element of the case study was the application of the WSUD Guidelines by the WSUD team. This was undertaken at a study area level in a strategic way to the catchments of Mills Street, Cockram Street, Wharf Street and at a more detailed design level for the Canning Regional Centre Precinct. Thus a framework has been provided, illustrating how WSUD can be applied as a tool for urban ICM. The primary aim was to develop a ‘model’ example of how to use the WSUD in a manner which guides development to achieve quality development, amenity and sustainability.

**13.1.4 Structure of the Case Study**
This Chapter includes 3 major parts. Section 13.2 provides a brief physical and social context to the study, as well as presenting the key issues identified in the data gathering and consultative phases of the study. In Section 13.3 a Water Sensitive Urban Design strategy and opportunities are presented for the catchments of the study
area. In addition a more detailed design solution for the Canning Regional Centre is presented. This is followed by Section 13.4 which presents a summary of the case study.

13.2 Context and Issues

13.2.1 Urban Context

The study has focused on the drainage catchments referred to as Mills Street, Cockram Street, Wharf Street, Council Depot and River Road. These systems drain into the Canning River Regional Park. They comprise an area of approximately 1500 hectares. These areas are sub-catchments of the Canning River which in its lower reaches forms part of the Swan-Canning Estuary. From the estuary the river extends upstream into the Darling Ranges, to where the Canning River has been dammed to form the Canning Water Reservoir, one of the major water sources for Perth. This catchment is part of the wider bioregion of the Swan Coastal Plain and adjoining lateritic plateau of the Darling Range and hinterland (see Figure 13.1).

Within this broader catchment are a complex mixture of landuses from the rural activities of state forest, conservation reserves, agriculture and water supply, to the urban landuses of industry, commerce and suburbia. It is a rich and varied landscape, socially and biophysically. The catchment has accommodated and continues to accommodate the development pressures of the southern portion of Perth, a city of a little more than 1 million people, predicted to double in population within a 20 to 30 year time frame. In short, like the rest of the Swan Coastal Plain in the vicinity of Perth, it is facing rapid and dramatic change.

The study area focuses on the drainage catchments primarily within the City of Canning (see Figure 13.2). The full extent of these catchment areas includes parts of three local authority areas made up in the following way:
• The City of Canning approximately - 80% - by far the largest local government area.
• The City of Belmont with approximately - 19% - of the total area.
• The Town of Victoria Park was the smallest with only -1% - of the area.

The landuses within the study area are illustrated in Figure 13.2. Central to the study area is the proposed Cannington Regional Centre, which has been nominated as a strategic regional centre within Perth's guiding planning document, METROPLAN (Western Australian Government 1990). This centre complex involves the redevelopment of the existing Carousel Shopping complex and adjacent land into a regional sub centre of Perth. Numerous planning studies have been undertaken to guide the proposed development of this complex (Adam et al 1991, 1994).

The residential areas within the study area centre around the suburbs of Cannington, East Cannington, Queens Park. A significant characteristic of a large proportion of the study area is its low residential density, single detached housing, with a relatively high proportion of large lots and a semi rural character.

Although there is a distribution of light industrial landuses throughout the study area, the most significant industrial area within the study area is Welshpool. This area falls largely within the Mill Street drainage catchment. The Canning River Regional Park provides the western boundary of the study area. This park extends along the Canning River from the Shelley Bridge in Rossmoyne to the Nicholson Road Bridge in Cannington.

A major factor driving the redevelopment pressure of this area is the provision of reticulated sewerage systems to replace septic tanks in what has been refereed to as the Infill Sewerage Program. Within the study area approximately 676.0 ha are presently sewered, while 737.7 ha remains unsewered. Part of the unsewered area
(408.5 ha) will be sewered within the current Infill Sewerage Program. However, over half is not planned to occur until after 1999, unless redevelopment occurs, which will mean that provision of sewerage will be brought forward and funded by developer contributions. During the 1996-1998 period 137.4 ha is scheduled as part of the Infill Sewerage Program.

The population of the City of Canning is approximately 70 000, thirty percent of which is located within the study area (i.e. 21 070 , Australian Bureau of Statistics 1993). According to Council records there has been a steady increase in population in the area during the 1990's.

A notable feature of the population statistics for the whole of the City of Canning is the fact that some 51% of the population was aged less than 35 years in 1991. Within the study area it is believed that the mean age is much older due to the older age of the housing stock. However, it is known that the study area is going through substantial transition as a result of the redevelopment already occurring in the area and a younger population is now being planned for.

13.2.2 Issues and Opportunities

During the summer of 1993-94 it became evident to the wider community of Perth that the Canning River was under stress. Almost daily the media contained stories about the algal blooms in the river. No longer was the river safe for human or livestock use. From the public an outcry that - "something had to done" - began to echo through the community, local government and state government circles. Local and national media attention was given to the declining condition of the river. This concern is expressed in the headlines collated in Figure 13.3.

At a community level the existing resident groups and networks began to mobilise. The existing groups such as the Canning River Regional Park Volunteer Guides were joined
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At a community level the existing resident groups and networks began to mobilise. The existing groups such as the Canning River Regional Park Volunteer Guides were joined
by two new and active groups in - FORCE - Friends of the River Canning Environments and CRREPA - the Canning River Residents Environmental Protection Association. These groups focused on both political and practical action. Their existence has helped to galvanise concern and the need for action. In addition these groups have in fact started the repair process. Thus these groups added profile to the whole question of the health of the Canning River.

At the same time as the community became more active, local government and state government officers, who were well aware of the problems in the river, were beginning to identify ways to move beyond monitoring the problem and reactive strategies, to seeking out longer term solutions. This case study represents one contribution to that overall effort.

Prior to the study commencing water quality investigations had shown the drains within the study area contribute significant loads of nutrients and other pollutants to the Canning River (Thurlow et al 1986, Donohue et al 1994). This had been recognised as a major concern, especially in the context of the increasing redevelopment pressure within these catchments (Wong and Morrison 1994).

At the same time strategic land use planning studies had identified the Carousel Shopping Centre as the focus for a major regional sub centre of the Perth Metropolitan area. Plans and policies were already well advanced to guide the centre’s redevelopment. In addition, the adjoining residential areas of relatively low residential density were progressively being redeveloped as the provision of reticulated sewerage expanded into the area. This combination of factors lead to a recognition by officers within the City of Canning that the water environment needed to be considered as factor in the whole development control process.

While the planning for all these changes was at an advanced stage and redevelopment within the catchments was occurring, the opportunity presented itself to inject some of
the emerging perspectives about the integration of land and water into the planning
process within the City of Canning. Primarily the opportunity existed to guide
development in a manner which:

- Creates opportunities for quality development
- Provides for amenity to the community
- Presents opportunities for catchment repair and mitigation of future adverse
  impacts on the water environment of development.

In essence the investigations looked to promote "win-win-win-win" solutions. That is
where every action, transaction or investment decision provides benefits to those
directly involved (i.e. a win-win situation) and provides a win to the community in
general (i.e. win-win-win situation) and further provides opportunities for benefits to
the environment (i.e. a win-win-win-win situation) (Meier 1994b).

13.2.3 Summary of Background Information

The study process brought together a range of information on the historical, physical
and biological environment. In addition the attitudinal survey and consultative
processes revealed a number of important perspectives. This information was fully
reported in the study document, however, here only the key points are outlined below:

- The development of the Canning Catchment and the study area has been
  facilitated by the establishment of formal drainage systems, allowing what was an
  area prone to seasonal inundated to be developed. The initial European use some
  100 years ago included horticulture and agriculture and since the late 1940s urban
  landuses have dominated the area.

- Thus the maintenance of an adequate stormwater and drainage management
  system is essential to the future of the area for urban uses (see Figure 13.4).

- The drainage system includes approximately 8.9 km of open drain and 37
  detention basins. There are approximately 58 km of piped drains, including street
  drains and a piped section of main drains.
$8m plan to save Perth’s sick rivers

Sewage dumped in drain

River woes threat to wetlands

Pollution feared after petrol leak

Residents say fears for river realised

Sewage spill in river

Deadly algae chokes river

Nutrients warning on Swan

CANCER RIVER INTEGRATED LOCAL PLANNING AREA STUDY
MILL. COCKRAM. WHRAF. COUNCIL DEPOT AND RIVER ROAD CATCHMENTS

Figure 13.3
MEDIA RESPONSE TO RIVER POLLUTION
• However, in the last few years a clear recognition has emerged that the ecological integrity of the Canning River is declining largely due to a variety of pollutants (nutrients and other pollutants) entering the water system from the various landuses that occur in the Canning River Catchment Area.

• Although the drains in the study area are only a minor part of the whole Canning catchment, these drains are known to transport excessive levels of nutrients, metals and pathogens to the Canning River.

• The source of this pollution is from the various activities in the catchment including: residential, commercial, industrial and semi-rural activities.

• There is a recognised need to undertake a detailed review of all forms of pollution in the catchments. In particular the importance of undertaking an audit of waste streams in the industrial area has been highlighted. However, it is also recognised that the dispersed (or non point source) pollution sources of urban runoff need to be targeted, including residential, commercial and semi-rural holdings. To raise the profile of this issue a major awareness campaign is required.

• The drains in the study area have typically been designed to manage the quantity of water required to be discharged to the Canning River. In their present condition they have a low conservation value. There are, however, a number of detention basins which include remnant wetland vegetation and water birds (including some migratory species) are known to use these areas. This illustrates the habitat enhancement or “living stream” potential of the area (see Plates 13.1 to 13.4).

• Outside of the existing drainage reserves there are only a small number of potentially important areas of remnant bushland vegetation and wetland vegetation.

• Drainage planning and design to date has not included specific consideration of water quality, conservation or the aesthetic and educational values of the drainage system to the local community.
• From a hydro-geological perspective the study area catchments are relatively complex, with perched water tables and complex soil associations. More information is urgently needed about the hydrology and stratigraphy of the area to aid better water management (see Figure 13.5).

• The study area is undergoing rapid change, with the potential to double the residential density. This means an increase in impervious surfaces and corresponding increases of stormwater. There is a potential for pollution loads in the drains and river to increase as a consequence.

• The proposed Canning Regional Centre is envisaged as a modern urban centre, as such it too has the potential to substantially add to the quantity of runoff and equally has the potential to reduce the quality of water entering the Cockram Street drainage system and thus the Canning River.

• The community of the City of Canning consider the Canning River to be the "Heart of Canning", its health and integrity are recognised as vital to the surrounding areas.

• There is only a relatively moderate level of awareness in the community about the relationship between the transport of pollution in the drainage system and the health of the Canning River.

• Since much of the redevelopment has only just commenced there was a significant opportunity to guide all future development in the study area in a manner which enhances the quality of the development, provides amenity and enhances the quality of the environment generally and the water environment in particular.

This synthesised information provided an important background to the development of WSUD solutions for the study area presented in the following sections.
Plate 13.1 Typical Detention Basin in Study Area

Plate 13.2 Typical of Partly Naturalised Detention Basins in Study Area
Plate 13.3 Typical Section of Drain in Mills Street Catchment - Welshpool Area

Plate 13.4 Typical Section of Drain in Mills Street Catchment - Welshpool Area
13.3 Applying Water Sensitive Urban Design

13.3.1 Introduction

This section of the case study presents a range of management proposals aimed at addressing the issues summarised in the previous sections of this chapter. Initially a discussion is provided about the evolving policy framework for implementation of catchment management in the urban context. This is followed by the development of a goal or vision for the catchments of the study area.

To aid in the process of achieving this goal, a Water Sensitive Urban Design strategy and opportunities are presented for the study area. This aims to provide a framework for guiding the ongoing processes of development and catchment repair. The final part of this section presents a more detailed design for the Canning Regional Centre Precinct. This provides a ‘model’ which helps to illustrate how urban development and better water quality can be achieved.

13.3.2 Evolving Policy Framework

The policy framework within which this case study was developed were essentially the same as that presented for the Bayswater Case study in Chapter 12, Section 12.4, although it had evolved further. It was seen as essential to communicate an understanding of the policy issues to the community and the City of Canning, thus recognition was made of the inter-relatedness of the:

- **Catchment Scale Goals:** such as the objectives and strategies of the Swan-Avon Integrated Catchment Management process and the proposed Swan-Canning Environmental Protection Policy, potentially representing the overarching statutory policy requirements.

- **Urban land and water integration goals:** such as the objectives of Water Sensitive Urban Design (WSUD) guidelines and proposed policy framework,
representing the generic environmental planning framework aimed at integrating land and water planning.

- **Council and Community Aspirations for the Catchments in the City of Canning**: such as the views articulated at the Search Conference and the actions of community groups like CRREPA and FORCE.

The relationship between these issues are illustrated in Figure 13.6 which shows the linkages in the evolving policy framework of Urban ICM in metropolitan Perth (and is adapted and updated from the Figure 12.6 from the Bayswater case study).

### 13.3.3 A Goal for the Study Area Catchments

#### 13.3.3.1 Issues

The consultation process and the review of the environmental context of the study area has clearly highlighted that the "Canning River is the heart of the City of Canning" and the surrounding catchments. A strong message generated through the consultative process was the sentiment that without a healthy "heart" the condition of the surrounding area will deteriorate. The drains and waterways which lead into the river are now being seen as the arteries and veins of the study area. There is a growing recognition that the health and integrity of the river are of critical importance to the social, economic and environmental conditions of the surrounding community. This is demonstrated by the fact that Canning River has been incorporated within the Canning River Regional Park. To date, however, little effort has gone into managing the various inputs into the system from the various activities and landuses within its catchment. Very little attention has been given to the drains. While the study area represents a very small fraction of the wider Canning River Catchment area, the major changes occurring in these sub-catchments represented an opportunity to begin to rectify some of the problems caused by past practices, particularly in relation to restoring the drains to "living streams".
TOTAL CATCHMENT SCALE
SWAN AVON ICMCG
Swan Working Group
Possible Environmental Protection Policy
for Swan- Canning

STUDY AREA CATCHMENTS
Develop local goals, which
incorporate WSUD objectives.

LOCAL PRECINCT SCALE
Local Action plans
Apply WSUD, BPP's and BMP's

Figure 13.6 CANNING RIVER INTEGRATED LOCAL PLANNING AREA STUDY
VILL.COCKRAM.WHARF.COUNCIL DEPOT AND RIVER ROAD CATCHMENTS
INTEGRATED CATCHMENT
MANAGEMENT FRAMEWORK
13.3.3.2 The Goal

Based on a recognition of these issues a goal for catchment repair within the City of Canning was articulated as part of the study as:

*The City of Canning and community wish to see the open drains in the study area converted into named "living streams and creeks" where possible, so that they can be an integral part of the urban landscape and carry better quality water to the Canning River.*

The establishment of this goal, as a vision or target image for the area has the potential to provide a focus for integrating the various programs and projects being undertaken by the City of Canning, the relevant state government agencies and community groups within the area. It will help guide the development of a practical stormwater management system that also enhances the amenity of the local environment. This statement has now been adopted as a goal within the City of Canning's Corporate Plan. Thus the City of Canning have illustrated leadership, providing a catalyst for a wider program of catchment protection and repair throughout the Canning River Catchment.

13.3.4 Strategy & Opportunities

13.3.4.1 Introduction

A description of a WSUD catchment strategy and opportunities devised as means of achieving this goal, are presented in the following sections. This material is based on the fieldwork of the Murdoch University Students, advice from the Steering Committee and field inspection of the study area by the WSUD team. The outcome of these investigations was the development of a planning framework designed to integrate land and water planning in a way that could lead to the overall catchment goal.
To fully realise the goal, however, it will be necessary for the City of Canning to undertake more detailed planning studies with a view to incorporating relevant provisions in its town planning scheme and in its other programs. However, what was presented below provided a clear direction towards achieving the goal.

13.3.4.2 The Strategy

The overall strategy for the study area is presented in Figure 13.7. This illustrates the key feature of the strategy - establishment of a multiple use corridor along all available sections of drain. This would combine the drainage function of the existing drainage system, with recreation, conservation, habitat creation and public access, providing a means to achieve the "living streams" concept. Such a strategy would enable the establishment of an identifiable linear park system in the urban landscape, linking key facilities and functional elements of the area. Drawings 13.1, 13.2 & 13.3 help to illustrate the potential that exists in many areas. As redevelopment of the area progresses and population increases, such a feature will become increasingly important, not only from a drainage point of view, but as a landscape feature and as a focus for reinforcing the identity of the area and its links to the Canning River.

The achievement of this strategy should be seen as a long term process. In some locations within the study area, ample space and conditions exist for integration of the goal in the short term. In other areas ideally more space needs to be allocated to this proposed multiple use corridor. This can best be achieved through the use of planning mechanisms, such as provisions within the Town Planning Scheme, guided development schemes and building by-laws.
Before the strategy can be developed in detail each of the main drains in the study area needs to be investigated in more detail, with a view to converting them into "living streams". This review needs to evaluate the opportunities which are available in the land surrounding the drain to serve as a multiple use corridor. Further detailed investigations are required to devise specific actions for any given location. However, at this strategic level it is possible to envisage that this strategy could be achieved in the medium to longer term through a process of carefully guiding redevelopment. To do this, a framework of precincts are presented on the strategy map (see Figure 13.7). Within these areas a large number of opportunities have been identified to highlight areas where more detailed investigation and prioritising of action is warranted (see Figure 13.8). Detailed descriptions of all these locations were provided in the full study report.

Although there is a considerable amount of further work to done to fully implement the strategy a number of general design principles and actions for the study area were presented, including:

- **Best Management Practices** - It needs to be recognised that as the area redevelops and porous surfaces are replaced with impervious surfaces, provisions for the retention and detention and where appropriate, recharge of stormwater, will need to increase proportionately. As part of the stormwater management function of the multiple use corridor a range of Best Management Practices (BMPs) needs to be applied to aid in the provision of improved water quality of stormwater discharging into the Canning River. A specific suite of BMPs needs to be selected for each of the planning units and precincts, based on the local site conditions and the particular features and performance objectives to be achieved.

- **Opportunities to create multiple use corridors** - Appropriate provisions need to be incorporated in the town planning scheme to ensure adequate land is set aside for
the corridors and a funding mechanism established to purchase land where necessary, particularly along the Mills Street and Cockram Street main drains.

- **Appropriate conditions** - There is a need to develop and apply appropriate conditions to subdivision applications to enable progressive acquisition of the required land. A minimum reserve width of 30 metres (ideally 50 metres or wider) should be sought for each corridor.

- **Appropriate design guidelines** - There is a need to develop design guidelines to ensure development adjacent to waterways enhances the amenity of the multiple use corridor through an attractive and functional interface.

- **Within the multiple use corridor** - The existing drain needs to be redesigned to allow:
  - widening
  - gentle banks
  - meandering watercourses,
  - landscaped surrounds,
  - dual use paths,
  - incorporation of best management practices
  - incorporation of recreation areas, and
  - incorporation of conservation areas.

- **Activity Nodes** - Whenever possible community activity nodes need to be linked or located adjacent to multiple use corridors to maximise their amenity value and usage.

Within Council's existing planning and development control system and works programs a number of practices for the study area can be introduced which can contribute significantly to achieving the goal. These include:

- Retention of stormwater for longer periods onsite before entering the stormwater system through introduction of suitable onsite detention BMPs.

- Reduce road verges and road pavement widths.

- Adopt zero lot line provisions where appropriate.

- Local detention of stormwater in road reserves using appropriate BMPs.

- Encourage a reduction of private open space and increase of public open space particularly in development adjacent to detention basins and drains (creeks).
• Encourage clustering of lots, group units etc to allow application of the strategy and develop a lot yield incentive system to encourage developers to adopt the strategy.

• Use of innovative design e.g. roll-over kerbing, control road drains, use of porous surfaces, soil, sub soil and pavement design, frequent road sweepings to remove debris from system.

• Incorporate WSUD as part of its ongoing works program of stormwater provision and replacement.

• Develop a landscape management plan which identifies and retains all existing remnant vegetation and enhances the use of indigenous species in appropriate areas.

• Develop and apply turf, irrigation and nutrient management strategies for all sports fields and grassed recreational areas to reduce fertiliser and mowing costs and reduce nutrient losses.

In addition to these general principles the study also provided a framework of Objectives, Strategies and Actions based on those developed within the Bayswater case study and presented in Chapter 12, Section 12.4.5. These are not repeated here as they are very similar in scope and intention.

Another recommendation of the study was the establishment of an ongoing Urban ICM Steering Committee. It was proposed that this group have a similar composition to the existing Steering Committee. The aim of such a group would be to coordinate the input from the key stakeholders, and find ways to implement and more importantly refine the strategy and design solutions presented below. It was also pointed out that the maintenance and where possible widening of community ownership of the process would be essential. A mix of 50% professional and 50% community representatives was in fact a suggestion from the Search Conference. Opportunities for local Councillors and even local members of parliament, both state and federal, to become
involved was recommended. Further it was recommended that establishing smaller task groups, with specific functions, such as: Community Awareness, Strategy Implementation and Technical Support may be required.

13.3.5 Canning Regional Centre Precinct

13.3.5.1 Introduction

This section presents the WSUD option for the Canning Regional Centre Precinct, providing more specific design responses at local action plan level. It was prepared generally within the context of the previous planning and design studies and policies that had been developed for the Regional Centre (Adam 1994). There is, however, a significant difference; in this design explicit WSUD criteria were included. The most significant of these was the recognition of the need to incorporate water quality treatment techniques within the complex. Equally important was the concept of using water as a linking and integrating feature of the redevelopment. Thus a design was developed which provides a functional drainage system, but also incorporates consideration of water quality management, amenity, habitat enhancement and improvement of micro-climate.

The adoption of the design has the potential to provide a unique character - a sense of place - for the Canning Regional Centre where the importance of the Canning River and its catchment is recognised. Under this design solution the processes of urban redevelopment creates opportunities for the enhancement of waterways and the river environs, rather than causing further degradation.

13.3.5.2 Background

Planning and Design Context - The Canning Regional Centre is one of eight Strategic Regional Centres identified by the State Government for the metropolitan region. As such it will become a major employment centre and important focus for community activity. This expansion envisages not only further development of retail facilities but also the introduction of offices and higher density residential development.
To this end, an indicative development plan and set of policies have been formulated to guide future development. The plan has identified the main elements and landuses within the centre complex. The policies that have been developed provide a framework of objectives which articulate the character and features that the centre should aspire to incorporate. The primary focus of these design considerations has been to achieve an urban centre, where consideration has been given to:

- Human scale
- Mixed density and use
- Pedestrian focus and quality design
- Distinct local identity and character

Consequently general policies for the centre have been developed to guide key elements of the centre including:

- Residential Development
- Urban Design
- Public Streets and Places
- Landscaping/Planting
- Advertising signs
- Car Parking
- Movement
- Public Art
- Community Facilities
- Security

The provision of a policy framework incorporating these issues was seen as positive, however, one of the most fundamental ‘natural processes’ occurring within the site - the water cycle - had been overlooked as a potential ‘integrating’ design feature.
The existing planning and design considerations for the centre had treated stormwater primarily as a engineering problem of disposal. But to provide for this disposal a substantially upgraded conveyance stormwater system had been proposed at a cost of approximately $1 Million. The cost of this system is initially at Council's expense, and would be funded over the medium term from developer contributions. In that design no consideration had been given to the water quality issues or the potential amenity or habitat creation ("living stream") opportunities provided by the redevelopment. Although the planning for the centre's redevelopment was well advanced there was an opportunity provided by this study to incorporate the WSUD principles into the design and policy framework which was in the process of being finalised to guide the centre's redevelopment.

Centre Design Features - Some of the key objectives articulated in the plans and policy for the centre which are consistent and could be enhanced by adopting a WSUD approach include the desire to have:

- An attractive environment within the centre in terms of physical comfort and character.
- A recognisable characteristic identity for the Centre.
- Easy accessibility to facilities within the Centre for people on foot including a continuous and attractive pedestrian/cycle route between the Railway Station and the Canning River footbridge.
- Attractive development of the Canning River Regional Park, providing for the needs of flora and fauna conservation and recreation.
- A high standard of soft and hard landscape works.

The Structure Plan for the Centre provides for:

- Cecil Avenue, the Southern Link Road and Central Avenue to be developed as dual carriageways with tree planting to the medians and verges.
• In the short to medium term, land adjoining the Western Power\textsuperscript{1} terminal which is surplus to the technical requirements of the terminal is to be identified and negotiations for its sale entered into between the Council, Western Power and other State agencies.

• Provision is made for the relocation of Council Offices and a Civic complex is proposed north of Western Power land. The Indicative Development Plan indicates a realigned Central Avenue which provides additional ground to the east to accommodate Council Offices abutting the Western Power site. The land at present comprises a drainage reserve with open drain and a strip of land owned by Western Power which is part of the Canning Terminal Site and serves as a buffer. A second option for the relocation of the Council Offices has been identified as a site adjacent to the Australian Taxation Office, opposite the Station.

• An accompanying landscaping policy encourages the "use of water in open space and urban spaces" and identified the longer term possibility of developing a water feature within the Western Power site.

The Council envisages a range of dwelling types with strong emphasis on medium to high density housing types of two storey height or more. Intensive uses (i.e. retail and commercial) are envisaged along Central Avenue built up to the street alignment. A pedestrian link is proposed to link with the Cockram Street pedestrian overpass which should incorporate good quality "public" spaces within the development. This area is considered suitable for offices, showrooms, service industry and medium density housing.

On the North side of Cecil Avenue a regional educational facility is envisaged which is to incorporate open space and landscaped park areas.

\textsuperscript{1} The so-called Western Power Terminal is a large electricity transfer sub station occupying a central location within the Regional Centre Precinct. In previous planning studies it had been argued that this substation would need to be retained until its economic life was over, then the site would be given up for public open space.
Existing Stormwater System Proposals - In drainage terms the City Centre precinct is bisected by the Cockram Street Main Drain with the southern section proposed to be serviced by the Liege Street Branch Drain (which is partially installed). Works envisaged in the original plan include piping the Cockram Street Main Drains and upgrading of the piped drain between Central Avenue and Albany Highway through the Carousel Shopping Centre site. Additionally the Liege Street drain is to be extended, approximately 650 metres using 1.5 metre diameter pipe to service proposed residential development in the south east portion of the precinct. The proposal included a detention basin in the vicinity of Franklin and Bent Street. The provision of these upgraded facilities would be at Council’s expense, as the proponent of the Regional Centre Complex. This design is shown in Figure 13.9.

The existing stormwater design was based around provision of flood protection for the 1 in 10 year return interval for storms. Longer term consideration was given to provision of 1 in 100 year storms by incorporating detention features within what is now the Western Power transformer site. No explicit consideration had been given to water quality treatment, apart from partial consideration of detention within the lower portions of the Liege Street Branch Drain.

13.3.5.3 The WSUD Design

With this background as a context for introducing a WSUD design solution, the WSUD team focused on preparing a design which would enhance the overall objectives of the Regional Centre and better manage the impacts of that development on the water environment. The task was to provide specific guidance for the development of the Canning Regional Centre precinct in a way that would provide a ‘model’ for application of WSUD in other parts of the study area and throughout the wider Canning Catchment.
Objectives and Performance Standards - Multiple objectives were considered for the design. These included consideration and incorporation of:

- water quality management
- flood protection (volume, peak discharge rate)
- water conservation
- water reuse
- habitat creation
- aesthetics
- amenity and recreation

A commonly applied basic principle for new developments is that post-development peak discharge rate, volume timing and pollutant loads do not exceed pre-development levels. While this site is not a new development site this principle was used to guide the design. As a minimum requirement the design needs to perform to the existing 1 in 10 year flood protection requirement. Provision was also made to factor the 1 in 100 year requirement into the design over the longer term.

The inclusion of these design criteria provided a motivating force to re-look at the whole stormwater design solution posed for the precinct. The most significant of these criteria was considered to be water quality. In terms of performance standards for the precinct the design seeks to incorporate treatment techniques (BMPs) to deal with pollutant loads, primarily from "first flush" and to treat 90% of that pollution load. This objective is based on techniques and regulatory provisions devised in Florida, USA where some of the most advanced stormwater management systems have been devised (Livingston 1994). Another important design objective was to use the existing drainage infrastructure as far as possible to ensure that the design was cost competitive in comparison to the existing proposal.
**Structural Design Features** - The overall design concept is presented in Figure 13.10. This design presents an option which includes the long term removal of the Western Power site. However, the main features of the design can be incorporated in the short term as depicted in Figure 13.11, which allows for this facility to be retained in the short to medium term.

The main features of the design involved:

- Relocating the proposed detention basin in the vicinity of Franklin and Bent Street in the south east sector of the precinct to the north. This would allow for the interception of upstream water from the Cockram Street catchment beyond the Railway line, as well as from the residential development proposed for the south east sector. This feature could then provide detention, water quality amelioration and serve as a landscape feature. This eliminates the need for the expensive piped extension of the Liege Street Branch Drain (approximately $1 Million).

- The existing Cockram Street Drain would be left open, but realigned adjacent to the Western Power Site. This would save on the need to pipe the drain along its present alignment which had been proposed to allow for realignment of Central Avenue. The realigned drain would run past the rear of the proposed Civic Buildings and be developed as ‘urbanised’ living stream. The stream would provide detention and some filtering practices to improve water quality.

- In the long term, when Western Power has relocated, this waterway could be incorporated into development of this site by provision of additional water features. Note that the Western Power site has been identified as a possible open space, incorporating 1 in 100 year storm detention facilities. This design offers the option of incorporating detention facilities and mixed use development of the site. This has the advantage of increasing the potential commercial value of the site, potentially providing an incentive for Western Power to relocate sooner rather than later. Alternatively in the short term an open stream would be used to separate the Civic buildings from the Western Power site (see Figure 13.11).
• Installing a weir on the Cockram Street drain which diverts all 1 in 10 year storm events into an open creek link from Cockram Street to Liege Street branch drain (or at least a 750 mm piped link). This would allow for approximately 90% of storm events to be diverted through this system allowing it to pass through an enhanced wet detention basin within the Park where sedimentation and bioassimilation could aid in water quality management. Larger storm events would be handled through overflow of the weir and discharge via the existing piped sections of the Cockram Street drain directly into the Canning River, ensuring flood management.

• At an appropriate location within the modified system (possible at the proposed weir within the Cockram Street Drain) flow and water quality monitoring facilities were proposed to monitor performance of the system.

The design option presented aimed to maximise the benefits of the existing infrastructure and provides for a reallocation of expenditure away from a piped drainage system to the provision of a system which provides for flood protection, water quality amelioration, amenity and habitat creation. Theoretically providing a win-win-win-win situation.

**Detailed Design Elements** - The WSUD concepts were further developed and illustrated through provision of a set of design concepts for BPPs and BMPs for the remainder of the site away from the main drainage lines. These features are presented in a set of drawings (see Drawing 13.4 to 13.10) which illustrate a range of onsite treatments which aim to both enhance the water theme and provide functional drainage and water quality improvements.
Figure 13.9 Existing Stormwater Design

NOTE
1. UNLESS OTHERWISE NOTED, PEAK AND AVERAGE DISCHARGES IN COCKRAM STREET MAIN DRAIN ARE INCLUSIVE OF THE HIGH-Peak (Collar) DISCHARGE OF 0.75 m³/s FROM NORTH OF BENT STREET.
2. UNLESS OTHERWISE NOTED, PEAK Q, AND Q, FLOWS IN WATER AUTHORITY LIEGE STREET-2% K, DRAIN ARE INCLUSIVE OF THE 112-HOUR COMPENSATED DISCHARGE OF 0.26 m³/s FROM NORTH OF BENT STREET.
Figure 13.11

ALTERNATE LAYOUT FOR CIVIC PRECINCT
Assumes retention of Western Power Terminal
The concept proposed was to use water as a key design linking and integrating places and spaces throughout much of the development. This includes the use of:

- Water channels within residential areas with the use of surface (exposed) systems as opposed to underground (hidden) systems. This provides opportunities to ‘celebrate’ water as design feature.

- A tiered system of water harvesting is envisaged with water collected from roofs and other hard surfaces, initially in small open channels, then into somewhat larger, more evident channels, eventually into a water course which leads to wetland/detention areas.

- Throughout the system use is made of landscape facilities to slow down the water flow. This is achieved by running water through small planted areas, using rocks to prevent erosion. In specific locations reed bed systems could be used as pollutant and nutrient stripping devices as well as form part of the design (see Drawing 13.10).

- On-site detention within the street system is augmented by agricultural type drains and gravel filter beds, fed by gullies within the drainage channels, allowing localised infiltration to occur.

- Additionally water can be siphoned off into planting wells for street trees.

- In car park areas surface drainage is proposed to be picked up in a channel system, filtered within the car park in planted areas and linked to either main drainage systems or separate detention wetlands.

- Within the car park and throughout the complex it was also proposed that a series of interpretive information signs be used to provide ‘a story’ about the links between the site and the River. This would include both formal signs and more informal street art, or paving features which have water symbols or wildlife.

- Water is also celebrated within a proposed Town Square area which would have water as an integrating feature and many of the features outlined above.
Apart from the visual amenity created by use of water as a feature of the development, the linking of these features creates a potential pedestrian network which has legibility and permeability (Bently et al. 1985). A pedestrian spine was proposed with a number of water 'events' along route. The spine begins 'up stream' near the Railway station and passes through the office and residential areas. This streetscape would be a pedestrian dominated area, with vehicle traffic restricted by design details and traffic management techniques. The route then passes by the first of the detention basins, which forms a wetland and more formalised entry statement. The Civic Buildings are next on the path, leading to the wholly pedestrian town square and eventually to the Regional Park and the River via a footbridge over Albany Highway.

All of these concepts are featured within the overall design (Figure 13.10) and are illustrated in the Drawings 13.4 to 13.12. Both at the broad site scale and at the detail level, the intention is to create a design solution which marries functional needs with a respect for the natural processes (primarily water) or urban ecology of the site. Throughout the intention is to deal with the products of this process on the site or pass it on to the wider environment as a benefit rather than a costly liability to present or future generations (Hough 1984).
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Drawing 13.4

Drawing 13.5
Drawing 13.8

Detail sketch of water harvesting channels and nutrient sinks in car park.

WATER HARVESTING, IN CAR PARK

DRAWING 13.8

Drawing 13.9

WATER HARVESTING AND NUTRIENT SINK IN CAR PARK

DRAWING 13.9
Drawing 13.10

CARK PARK DEVELOPMENT WITH INTEGRATED WATER HARVESTING, AND NUTRIENT STRIPPING

Drawing 13.11

COMBINED DETENTION BASIN AND ENTRY STATEMENT.
13.4 Summary

This case study recognised that the Canning River is under threat from the range of pressures within its catchment. The ecological integrity of the river and its value to human users has been gradually diminishing as a consequence of the processes of development and use of the catchment since European settlement.

The catchment of the Canning River is in the order of 5000 square kilometres and includes a complex mixture of landuses from rural activities, such as forestry, agriculture and water supply, to the urban landuses of industry, commerce and residential. It is a rich and varied landscape, socially and biophysically. The focus of the study was a very small portion of the Canning Catchment, incorporating the sub-catchments of the Mills St Main Drain, the Cockram Street Main Drain and Wharf Street Main Drain, within the City of Canning, some 9 kilometres from the centre of Perth. These areas represent approximately 1500 hectares.

Although the study only addressed issues in a small part of the larger Canning Catchment, this area is facing significant change. That change involves the establishment of the Canning Regional Centre and the intensification of urban development within the Cannington and Queens Park areas and environs. This redevelopment process is being driven by the provision of reticulated sewerage infrastructure. The intensification of urban development will increase the impact on the waterways within the study area and on the Canning River directly.

The case study illustrated that with the timely incorporation of WSUD principles an opportunity exists to guide that redevelopment in a manner which:

- Creates opportunities for quality development.
- Provide improved or enhanced amenity to the community.
• Presents opportunities for catchment repair and mitigation of future adverse impacts on the water environment by development.

In essence the study illustrated that it is possible to create "win-win-win-win" solutions with respect to stormwater. That is where every action, transaction or investment decision provides benefits to those directly involved (i.e. a win-win situation) and provides a win to the community in general (i.e. win-win-win situation) and further provides opportunities for benefits to the environment (i.e. a win-win-win-win situation). Thus the study presents solutions which go beyond environmental protection and aims for catchment repair as a by-product of more sustainable development. This case study has not however, attempted to deal with the much bigger issue of reorienting the sewerage design toward more sustainable outcomes.

This case study sets out a broad strategy for minimising the impact of urban renewal and redevelopment on the study area and the drains which lead to the river. It provided specific guidance on how to manage that impact through the integration of land and water planning. More importantly the goal of converting the drains of the study area into named "living streams and creeks" has been incorporated as goal in the City of Canning’s Corporate plan. This provides the direction required for the City of Canning to interact with the other partners in the land and water planning process to realise this goal.

A framework for implementation of the strategy was presented which relies on the establishment of an ongoing Urban Integrated Catchment Management Committee which would involve the Council, appropriate state agencies, business and community representatives. A range of specific objectives, strategies and actions were provided. A broad Water Sensitive Urban Design Strategy for the catchments of the study area was presented and numerous opportunities which need further investigation were identified.
Importantly the study presents detailed design concepts which will lead to the achievement of the goal within the Canning Regional Centre complex. These designs illustrate how the concepts of Water Sensitive Urban Design can be integrated as a design feature within a highly urban environment.

It is argued that by adopting these designs, expenditure which would have been spent on 'piping the problem' to the River, can now be better spent on enhancing the water quality, amenity, habitat enhancement and local identity. By adopting the concept of using water as an integrating element throughout the complex there is now an increased potential to set the character of the Canning Regional Centre apart from other similar complexes. It provides the potential for the redevelopment to have its own sense of place - as the "Heart of the Canning Region" where the river and the commercial and civic centre are linked through the celebration of water.

The City of Canning has begun to address these opportunities by upgrading its policies (particularly for planning approvals and engineering design) to bring about the desired and needed development and repair outcomes. The credo "pay now or pay later" has been recognised as an incentive, as further degradation means it will be "pay much more later". This was an argument presented by Livingston (1994) which the City of Canning staff used to help promote the ideas to the elected officials and general public.

This case study has shown the most important technique for achieving sustainable outcomes is the development of a "willingness to integrate". This was able to occur at a policy or steering level by incorporating a mix of stakeholders in the steering committee and importantly within the design team. This willingness to integrate has provided the context which will help to begin the process of redressing the imbalance between urban development and the water environment.
CHAPTER 14

CONCLUSION

Water is a source of life, power, comfort and delight, a universal symbol of purification and renewal. Like a primordial magnet water pulls at the primitive and deeply rooted parts of human nature.


(The) challenge (for) us (is) to re-engage our hearts and minds in the search for truly appropriate and accountable technology. If we are to live as part of an harmonious web of social and ecological relations, we must re-discover ways to work with other people and species, finding tools which enhance these relations, and renounce those which threaten the web, whatever their short term “benefits” to ourselves. We must shift not only our attitudes and actions, but through conscientious decisions concerning our tools, our very habits of thought.


14.1 Introduction

This chapter draws together and synthesises the findings of the analysis presented in the preceding literature review and case studies. Initially the central question of the thesis is revisited before pointing out how each of the chapters in turn have added insights which help present the case that a sustainable urban water management paradigm is emerging. Finally the chapter is concluded with an indication of what further work is required to support the hypothesis and accelerate the changes already under way.

14.2 Hypothesis and Framework

This thesis presents the case that the availability of adequate water, wastewater and stormwater services are basic prerequisites for healthy human settlements. However, it is becoming increasingly clear that there is a mismatch between the evolving ethic of sustainable development, and the existing paradigm of urban water management.

Urban communities in both the developed and developing world are facing the twin

---


challenges of developing and restoring urban water systems, in all their guises in a manner which is both economically efficient and environmentally sensitive.

The central argument of this thesis has been directed towards advancing the notion that the only way to overcome this apparent dilemma is for a new paradigm of urban water management to emerge. The hypothesis presented in Chapter 1 was:

_The sustainability of cities requires that land and water planning be better integrated at a range of scales and time horizons in urban planning and redevelopment processes._

_However, for a more sustainable city to be achieved, the emerging sustainable urban water paradigm needs to become institutionalised and merge into a form of transdisciplinary professional praxis which links ecological design and urban management._

A framework for describing and analysing technology has been used to help organise the argument. This framework consists of a number of interacting dimensions, including: artefacts and technical systems (i.e. the technology and knowledge systems), professional praxis and socio-political context (i.e. institutions, culture and politics) and biophysical realities and world views (i.e. the environment and underlying values). Collectively this framework provides a way to analyse the change process - both how it is occurring and how it needs to occur. The framework also helps to illustrate the link between environmental values and the process of technological innovation. It highlights the need for the evolving ethic and innovations arising out of the sustainable urban water management paradigm to be institutionalised into professional praxis and socio-political context of society. As a tool for understanding and evaluating the complexities of the society and technology interactions, the framework has the potential to be applied across a range of technology areas, potentially helping to illustrate key policy and practical changes required for the facilitation of more sustainable technologies.
14.3 Synthesis

After presenting the hypothesis and framework in Chapter 1 each of the chapters builds the case that a sustainable urban water management paradigm is emerging in the form of a transdisciplinary professional praxis that links ecological design and management. An historical context to the emerging paradigm was provided in Chapter 2, pointing to the need to link ecological planning with ecological engineering as an underlying basis for the emerging paradigm. In Chapter 3 the concept of sustainable development was outlined, indicating that this evolving ethic is influencing professional praxis and the wider socio-political setting. Thus illustrating the significance of changing world views and the need for new soft and hard technologies and new forms of social organisation.

The basic features of the emerging science of complexity were outlined in Chapter 4. These concepts represent a revolution in scientific thinking which is reinforcing the need for flexible and adaptive approaches to deal with complexity and uncertainty. The implications of these insights are echoed in Chapter 5 which reviews the emergence of new forms of management that are finding ways to deal with the rapidly changing world. Significantly, transdisciplinary praxis and more flexible institutions, and network structures are presented as ways of dealing with the 'messy and turbulent' nature of environmental problems. These ideas are explored in Chapter 6 in relation to the sustainable cities movement. This provided some images of what the sustainable city might be like and pointed to the changes needed in both decision making and professional praxis to support the emerging sustainable urban water management paradigm.

In Chapter 7 the focus returns to the existing milieux of professional praxis in the urban water sector. This highlighted the main issues and contemporary responses before presenting an indication of the key tools and management concepts that represent the emerging opportunities presented by the shift that is underway. In
Chapter 8 a small sample of emerging artefacts are reviewed, illustrating that an active research and development process is underway, however, not all of these technologies demonstrate a clear shift from existing practice. This review illustrated that there are both technical and ideological constraints for those involved in developing alternative technologies. To overcome these barriers changes are needed in both the socio-political and professional praxis.

Acknowledging that the emerging sustainable urban water management paradigm is broader than artefacts and technical systems, the focus of the argument shifts towards emerging forms of professional praxis. The basic assumptions of Integrated Urban Water Management (IUWM) were outlined in Chapter 9 by presenting the conceptual foundations of Urban Integrated Catchment Management (UICM) and Water Sensitive Urban Design (WSUD). These concepts are shown to have philosophical and technical dimensions and illustrate a shift in the basic approach to urban water management. Chapter 10 provided an analysis of the process and ingredients that were necessary to introduce WSUD into the urban development and renewal arena. This illustrated that although there is a recognised need for such approaches, existing professional praxis and the socio-political setting tend to impede the implementation of such a systemic innovation.

Chapters 11, 12 and 13 provided case studies which illustrated the growing potential of IUWM approaches, in particular the opportunities that present themselves when a transdisciplinary form of praxis is attempted. Chapter 11 presented a feasibility study of applying WSUD, illustrating the potential of the concept to significantly change the way water services are provided at a technical and management level. In Chapter 12 an analysis of UICM is provided before illustrating how WSUD can be used as a tool to link the urban planning and water management. In Chapter 13 the focus was again an illustration of UICM and WSUD. This case study showed that if there is a 'willingness to integrate', then environmental repair, urban amenity and
quality urban design can be produced at no more cost than traditional approaches which tend to pipe the problem to some other location.

Collectively, the literature review, the evaluation of selected technologies and technical systems and the case studies, illustrate that a new form of transdisciplinary professional praxis is emerging. This forms the basis of the sustainable urban water management paradigm and it needs to be further cultivated.

However, for a significant transition to occur there is a need to acknowledge that urban water systems involve complex interrelationships between the biophysical, human and metaphysical worlds. The use of the technology framework has helped to isolate some key policy areas which need to be addressed to cultivate the emerging sustainable urban water management paradigm. These important features include:

- **The link between world views and biophysical realities needs to be made a more explicit part of the design and management of urban water systems.** A key basis of designing any water system must be establishing an adequate understanding of the 'nature of the place'. For too long “development” has been considered more important than “life”. Scientific uncertainty should not be used as an excuse to postpone cost-effective measures to mitigate impacts on the environment. Adopting the precautionary principle and recognising uncertainty could provide a basis for creative change.

- **In terms of the artefact and technical system dimension, choice of technology is particularly constrained by the shape of the existing system and the technical knowledge system that surrounds it.** New systems may not fit the existing fabric because of technical mismatch, but more often due to lack of technical know-how and limited institutional support. Ensuring that there is an adequate system of support for any new artefact or technical system must be a key element of any reform process.
The design of water systems needs to respond to the multiple objectives of reducing resource consumption, maintaining ecological integrity and human health.

- *In terms of professional praxis a combination of existing power relationships and institutions constrains change.* It appears that for substantial innovation to occur at a technical level, institutional arrangements would also need to be transformed to respond to ecological linkages and realities. Wherever possible, mechanisms need to be found to integrate land and water planning in ways that minimise sectoral approaches. The localising of management responsibility within a broader framework of government policy and community goal setting presents significant opportunities for better management.

- *The socio-political dimension of technology choice represents real challenges.* Existing prejudices have the potential to restrict change, but societal attitudes can change quite rapidly, probably more quickly than some might expect. Awareness, education and maximising opportunities for exchange of ideas and views are key processes. Developing and enhancing programs in community participation are likely to provide real dividends in the process of developing and applying policy. But these programs must respect the community as equal in the management process. The introduction of technologies into different cultural contexts must respect local traditions and must be empowering rather than create dependence.

- *Some of the most creative innovations are likely to come from those outside of the established ‘system’.** Enhancing opportunities for these innovations at the policy and technology level should be a major priority for those involved in setting the broad direction for urban water systems. New forms of management and institutions must evolve to encourage rather than resist change. Transdisciplinary knowledge must be sought and applied.
14.3 Further Work

While this thesis has illustrated the potential of the sustainable urban water management paradigm there is substantially more work required to both develop the concepts and evaluate their significance in practical settings. The focus of these evaluations should ideally follow the 'learning by doing' model echoed throughout the thesis. There is more work required on the conceptual framework which will only come from the iterative process of demonstration and evaluation. Full scale demonstrations of applied WSUD are required in terms of catchment strategies, stormwater management solutions and in terms of the more fully integrated systems of the type proposed in Chapter 11. Importantly these concepts need to be applied, tested and further refined in different physical, cultural, social and political contexts.

Research is required to evaluate more thoroughly the participative processes of UICM so that the lessons learnt from a cross section of examples can help to improve the approaches adopted. The process of linking water resource and related environmental objectives to the land use planning system, while seemingly practical, is yet to be fully demonstrated. At the very least the planning profession needs to be encouraged to incorporate these wider objectives into development control frameworks.

While the concept of Least Cost Planning is well developed in energy planning it has not been applied very rigorously to the evaluation of water infrastructure and demand management options. A high priority should be placed on developing and testing these economic tools.

At the technical level, the stormwater management design would be enhanced by the development of new design techniques to help optimise everything from stormwater quality management to drainage restoration techniques. Ultimately new design manuals are required which codify the new values into practice. In the wastewater
area more work is required on developing the localised wastewater reuse systems and techniques.

While there is an important need for research to be directed towards specific parts of the emerging paradigm the priority should ideally be directed to developing systemic approaches that are transferable at a conceptual level. Thus the overall focus should be on developing and demonstrating integrative frameworks for applying ecological planning and ecological engineering solutions. These approaches have to both provide the physical design as well as developing appropriate administrative and managerial responses.

To conclude we need to think creatively and seek transdisciplinary solutions as the interface between people, water and cities is nothing if not complex. As Kenneth Boulding\(^3\) suggests in this apt little poem:

\[
\text{Water} \\
\text{Water is far from a simple commodity,} \\
\text{Water's a sociological oddity,} \\
\text{Water's a pasture for science to forage in.} \\
\text{Water's a mark of dubious origin,} \\
\text{Water's a link with a distant futurity,} \\
\text{Water's a symbol of ritual purity,} \\
\text{Water is politics, water is religion,} \\
\text{Water is just about anyone's pigeon.} \\
\text{Water is frightening, water's endearing,} \\
\text{Water's a lot more than mere engineering.} \\
\text{Water is tragic, water is comical,} \\
\text{Water is far from the Pure Economical.} \\
\text{So studies of water, though free of aridity,} \\
\text{Are apt to produce a good deal of turbidity.}
\]

Hopefully this thesis has helped to clear just a bit of the turbidity.

---

Appendix I

Technical and Cost Data
for Palmyra Woolstores Site

Note: The information presented in this Appendix was provided by:

Evangelisti and Associates Pty Ltd- Engineering Design and Costs
Hydro Plan Pty Ltd- Irrigation Design and Costs
Thompson Palmer Pty Ltd Landscape Design and Costs

in association with the author.
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1.0 ENGINEERING AND WATER SYSTEM DESIGN APPROACHES

The design approaches used in the two alternative designs are listed below. Design criteria are listed for both approaches in the attached table, whilst objectives used in formulating design criteria are discussed here:

1.1 Proposed/Toward Sustainable Design

The objectives important to provision of drainage for the subdivision are:

(i) The water balance existing prior to development should be maintained as closely as possible.

(ii) Infiltration to soil should be maximised and net runoff minimised.

(iii) Infiltration should be directed towards:

(a) aquifer recharge;
(b) utilisation by vegetation in keeping with xeric landscaping principles

(iv) Adverse impacts of stormwater upon ground water quality should be minimal.

(v) Access within the street system should be maintained for minor storm events.

(vi) Moderate storm events may cause temporary inundation of roadways, but should be confined to the street-drain system.

(vii) Rare storms (major events) should not cause damage to dwellings or other buildings.

1.2 Conventional Design

(i) Net export of runoff from the urban subdivision should be minimal.

(ii) Trafficability with street systems should be maintained for minor (10 year) storm events.

(iii) Road runoff should be conveyed safely to a point where storage/infiltration can take place gradually (drainage basins).

(iv) Adverse impacts of stormwater upon ground water should be minimal.

(v) Rare storms (100 year or greater) may cause inundation of privately owned land, but not cause damage to dwellings or other buildings.
1.3 Comparison of Objectives

The design criteria for the three alternative designs are presented in Table 1.1 and described below.

Table 1.1 Drainage Design Criteria

<table>
<thead>
<tr>
<th>Item</th>
<th>Conventional</th>
<th>Proposed</th>
<th>Towards Sustainable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Recurrence Interval:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Pipes/SEP</td>
<td>10 years</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>• Infiltration Bores</td>
<td>N/A</td>
<td>10 years</td>
<td>10 years</td>
</tr>
<tr>
<td>• Infiltration Basins</td>
<td>100 years</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>• Swales</td>
<td>N/A</td>
<td>N/A</td>
<td>20 years</td>
</tr>
<tr>
<td></td>
<td>N/A</td>
<td>100 years</td>
<td>100 years</td>
</tr>
<tr>
<td><strong>P.O.S. Drainage</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catchment:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Road Reserve(RR)</td>
<td>16 m</td>
<td>16 m</td>
<td>15 m</td>
</tr>
<tr>
<td>• Pavement Width</td>
<td>6 m</td>
<td>6 m</td>
<td>5.5 m</td>
</tr>
<tr>
<td>(crowned)</td>
<td></td>
<td>(one-way crossfall)</td>
<td>(one-way crossfall)</td>
</tr>
<tr>
<td>• Contributing Area</td>
<td>0.6 x RR</td>
<td>0.6 x RR</td>
<td>0.6 x RR</td>
</tr>
<tr>
<td><strong>Conveyance System:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Road</td>
<td>Kerb, SEP, pipes</td>
<td>Kerb, SEP, pipes</td>
<td>Kerb, SEP, swales</td>
</tr>
<tr>
<td>• Laneway</td>
<td>N/A</td>
<td>N/A</td>
<td>Pervious pavement, swales</td>
</tr>
<tr>
<td><strong>Storage/Retention System:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Disposal Method</td>
<td>Infiltration in Basins for both minor and major events</td>
<td>Infiltration in POS for major events only</td>
<td>Infiltration in bores &amp; swales for minor events &amp; POS for major events</td>
</tr>
<tr>
<td>1.0 m/day</td>
<td>1.0 m/day</td>
<td>1.0 m/day</td>
<td>1.0 m/day</td>
</tr>
<tr>
<td>• Permeability</td>
<td>Rectangular base, steep sided [1(V):2.5(H)]</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>• Basin</td>
<td>N/A</td>
<td>Landscaped</td>
<td>Landscaped</td>
</tr>
<tr>
<td>• P.O.S.</td>
<td>N/A</td>
<td>Depression - Dia. 0.9 m, Depth 7 m</td>
<td>Depression - Dia. 0.9 m, Depth 7 m</td>
</tr>
<tr>
<td>• Bores</td>
<td>N/A</td>
<td>N/A</td>
<td>V-shaped channel, flat-sided [1(V):6(H)]</td>
</tr>
<tr>
<td>• Swales</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the 'conventional' approach, flows are confined to roadways by kerbed gutters and piped conveyance systems. The concentrated flows are then vented into combined storage/infiltration basins. Infiltration, taking place at a discrete, concentrated point, largely results in aquifer recharge. There is little opportunity for utilisation of such flows by the vegetation and landscape. In addition, the water quality amendment capacity of the soil beneath the drainage basin is rapidly exhausted due to the short period of detention and concentrated flow.

By way of contrast in the 'proposed' and 'toward sustainable' approach, use of recharge bores and open grassed drainage swales within the road reserve enables adequate drainage of paved roadways and provides detention/infiltration capacity
within the conveyance system. This results in increased times of concentration, consequently lower peak flows, and more diffuse infiltration of runoff. The water is thus more "widely" available to landscape vegetation which can be integrated into the swale/P.O.S. linked system. From the water quality perspective the less concentrated vertical flows within the unsaturated soil and much longer "residence times" allow more effective water quality amendment. Water reaching the aquifer is less likely to have adverse quality impacts.

2.0 WASTEWATER DESIGN APPROACHES

The design approaches used in the two alternative designs are listed below. Design criteria are listed for both approaches in the attached table whilst objectives used in formulating design criteria are discussed here.

2.1 Towards Sustainable Design

The objectives important to the provision of sewerage for the subdivision are:

(i) To promote the use of localised on-site treatment of effluent.

(ii) To maximise the re-use and recycling of sewerage effluent.

(iii) To minimise the export and impact of pollution from sewerage.

2.2 Conventional/Proposed Design

(i) The collection and treatment of sewerage at an off-site treatment facility.

(ii) Net export of sewage from the urban subdivision should be maximised.

2.3 Comparison of Objectives

In the 'conventional/proposed' approach, sewage is to be collected via a piped reticulation system and conveyed to the wastewater treatment by a combination of gravity and pumps.

By way of contrast, in the 'towards sustainable' approach sewage will be collected via pipes and conveyed by gravity to the localised treatment unit, comprising an anaerobic digester, ECOMAX, Tertiary polishing chamber and chlorination or UV disinfection unit. The treated effluent stored in the polishing chamber for up to three days is then re-used for irrigation of vegetation in P.O.S and road/laneway verges, as indicated in the attached Figure A1.
### Table 2.1 Wastewater Treatment Design Criteria

<table>
<thead>
<tr>
<th>Item</th>
<th>Conventional</th>
<th>Proposed</th>
<th>Towards Sustainable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disposal Method</strong></td>
<td>Off-site</td>
<td>Off-site</td>
<td>On-site/Re-use</td>
</tr>
<tr>
<td><strong>Wastewater Quantity</strong></td>
<td>180 l/day</td>
<td>180 l/day</td>
<td>120 l/day</td>
</tr>
<tr>
<td>• Based on 1/day per equivalent person (EP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Treated Effluent Available for Re-user per Treatment Unit</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>6 kl/day</td>
</tr>
<tr>
<td><strong>Process/Treatment</strong></td>
<td>Pipes/Pumps</td>
<td>Pipes/Pumps</td>
<td>Anaerobic treatment, ECOMAX, tertiary polishing, disinfection</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>$400 /lot</td>
<td>$400 /lot</td>
<td></td>
</tr>
<tr>
<td>• Operation &amp; Maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Capital Replacement Fund</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.0 ENGINEERING COSTS

#### 3.1 Option 1: Conventional

Estimate of Development Costs:

1. **Earthworks**
   - Bulk earthworks to reshape land designed to balance cut to fill
   - $110,000

2. **Sewers**
   - 1300 Lm × $110/Lm (reticulation)
   - $143,000

3. **Drainage**
   - a) Basins - 3 No at $25,000 each
   - b) Pipework, drainage pits and access holes
   - $75,000
   - $180,000

4. **Roads and P.A.W**
   - a) Internal culs-de-sac - 16 m reserve, 6 m wide pavement - 920 Lm at $140 Lm
   - b) Pathways - 3000 m2 at $25/m2
   - $129,000
   - $75,000

5. **Walls**
   - a) Retaining wall - 1 m Limestone Wall at 3 x POS, 346 Lm at $120/Lm
   - b) Periphery wall - no earth bund - Carrington St, Leach Hwy & Golden Egg Farms 980 Lm at $200/Lm
   - $41,520
   - $196,000

6. **Water Reticulation**
   - Lead in main along Carrington St, main in McGregor Road and internal mains
   - $384,000

7. **Headworks**
   - a) 117 lots at $1949/lot Oct. 1993 rate (water)
   - $228,033
b) 117 lots at $1348/lot Oct. 1993 rate (sewerage) $157,716

(8) Telecom $4,000

(9) SECWA
Underground power 117 lots at $1,000 each $117,000

TOTAL $1,840,269

3.2 Option 2: Proposed

Estimate of Development Costs:

(1) Earthworks
Bulk earthworks to reshape land designed to balance cut to fill $110,000

(2) Sewers
1300 Lm x $110/Lm (reticulation) $143,000

(3) Drainage
a) Overflow Depressions in POS - 3 No at $10,000 each $30,000
b) Recharge bores - 20 No at $3,300 each $66,000
c) Oil/Grit traps 20 No at $1,400 each $28,000

(4) Roads and P.A.W.
a) Internal culs-de-sac - 16m reserve, 6 m wide pavement - 920 Lm at $140/Lm $19,920
b) Pathway - 3000 m2 at $25/m2 $75,000

(5) Walls
a) Retaining Wall - 1m Limestone walls, 166 Lm at $120/Lm $19,920
b) Periphery wall - no earth bund - Carrington St, Leach Hwy and Golden Egg Farms - 980 Lm at $200/Lm $196,000

(6) Water Reticulation
Lead in main along Carrington St, main in McGregor Road and internal mains $384,000

(7) Headworks
a) 117 lots at $1949/lot Oct 1993 rate (water) $228,033
b) 117 lots at $1348/lot Oct 1993 rate (sewerage) $157,716

(8) Telecom $4,000

(9) SECWA
Underground power 117 lots at $1,000 each $117,000

TOTAL $1,687,669
3.3 Option 3: Towards Sustainable

Estimate of Development Costs:

(1) **Earthworks**
   a) Bulk earthworks to reshape land and earth bund along Leach Hwy $20,000
   b) Additional earthworks to shape depressions in POS and swale drains etc. $20,000

(2) **Sewers**
   a) 1500 Lm x $100/Lm¹ (reticulation) $150,000
   b) 5 ECOMAX at $60,000 each (treatment unit) $300,000

(3) **Drainage**
   a) Recharge bores - 14 No at $4,000 each $60,000
   b) Oil/Grit traps 14 x $1,400 $20,000

(4) **Roads and P.A.W**
   a) 15m reserve 5.5 wide road 850 m x $130/Lm $110,500
   b) 9m reserve, 3.5 m laneway 450 m x $80/Lm $36,000
   c) Pathway - 5500 m2 at $25/m $137,500

(5) **Walls**
   a) Retaining Wall - 2 m limestone wall, 220 Lm at $200/Lm $44,000
   b) Periphery Wall - Carrington St. and Leach Hwy - 980 Lm at $200/Lm $196,000

(6) **Water Reticulation**
   Lead in main along Carrington St, main in McGregor Rd and internal mains² $345,600

(7) **Headworks** (Water Retic only)
   117 lots at $1949/lot Oct 1993 rates plus assumed 20% discount³ $182,426

(8) **Telecom**
   $4,000

(9) **SECWA**
   Underground power 117 lots at $1,000 each $117,000

**TOTAL** $1,1813,233

---

¹ Lower rate due to less excavation depth.
² A reduction by 10% in cost reticulation due to pipe size reductions is assumed.
³ A reduction by 20% due to efficiency gains and overall reduction in peak demand achieved by the use of the community bore system.
4.0 IRRIGATION DESIGN

4.1 Options

As with any irrigation system design, there are a number of alternative approaches to the irrigation design of this system.

Some of these options are:-

(1) Use mains water to supply all or some irrigation needs.

(2) Install one bore to irrigate all areas with a central control system.

(3) Utilise a bore supply to feed a header tank which then reticulates water to all or some areas.

(4) Multiple bores feeding into a common system with either central control or control by sub-section.

(5) Use Ecomax treated effluent to supplement the irrigation needs.

(6) Use separate bores for POS supply and group housing supply.

(7) Collect grey water from all residences and use to supplement irrigation needs.

(8) Utilise stormwater run-off to supplement irrigation.

4.2 Design Concept and Methodology

Hydro-Plan has recommended a design concept which incorporates a mix of the above options to best incorporate a mix of efficient water and power use whilst maintaining a degree of acceptability and manageability.

Our design calculations have been based on the following areas:

<table>
<thead>
<tr>
<th>Public Open Space</th>
<th>2.57 ha in total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road and lane verges</td>
<td>1.17 ha in total</td>
</tr>
<tr>
<td>Single housing areas</td>
<td>0.82 ha in total</td>
</tr>
<tr>
<td>Grouped housing</td>
<td>0.29 ha in total</td>
</tr>
<tr>
<td><strong>Total area</strong></td>
<td><strong>4.85 ha</strong></td>
</tr>
</tbody>
</table>

The design concept recognises three distinct areas:

(1) Road and Lane verges
(2) Public Open Space
(3) Housing areas

Drip irrigation has been used throughout the system with subterranean in-line drippers being used for lawn areas and on-line drippers being used in landscaped areas. The pressures and flows available would require the stipulation that property occupiers adopt a specific methodology when irrigating their property.
The system utilises six low yielding bores each supplying a sub-section of the site and being controlled independently.

The concept of drip irrigation is one of "small amounts of water applied frequently", the aim being to maintain the plant root profile at field capacity. This concept, therefore, requires daily watering of all road areas.

4.2.1 Road and Lane Verges

We have assumed 80% of the total planted area such as shrubs, which do not require wetting of the full area. Assuming a peak daily demand of 6 mm, the total demand for these areas is approximately 56 kL/day.

These areas will be watered with the Economax treated water which produces a total of 30 kL/day. Submersible pumps installed in each of the Economax 30 kL storage tanks will run this system. The deficit in requirement will be met with bore water topping up the tank level ensuring that the tanks always maintain at least one day's required volume in storage.

Each pump would have its own control system and would be run during night time. The pump discharge head and fittings would be installed below ground level in a specially designed pit. The verge areas best suit the flow available from the Economax system as well as being areas which would have little direct use or contact by the residents.

At times of lower irrigation demand, the Economax volume could meet the full demand and during Winter the irrigation system could be used to distribute the Economax flow over an extensive area for final filtration and ground water recharge.

4.2.2 Public Open Space

Irrigation of this area will be achieved by installing 6 low yielding bores, with each one watering one POS plus a number of single and group residences. Each sub-section would operate independently, but have the ability to be linked to other areas if the need arose. The public open space would be watered during night time using subterranean drip on the lawn areas and surface drip lines on the landscaped areas.

4.2.3 Residential (Single and Group)

The pressurised main referred to above would also service the residential blocks. To minimise pump and pipe sizes, each group of blocks serviced by a particular pump would be segmented into four sections with water being supplied to each section at a predetermined time.

Each housing block would be connected to the pressurised main by an electric solenoid valve. Irrigation water use on each block would be categorised as follows:

- Low Use - Baskets/Pots
- Medium Use - Landscape Gardens
- High Use - Lawns

Each of these areas would have a moisture sensor installed. The main valve to each block would be activated by the sensors, i.e. if the moisture sensor indicated "moist"
conditions, the valve would not open. This system would require residents to be aware of the system requirements before committing to a purchase.

An assumed peak irrigation requirement is used of: -

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Dwellings</td>
<td>1 kL/day</td>
</tr>
<tr>
<td>Grouped Dwellings</td>
<td>0.5 kL/day</td>
</tr>
</tbody>
</table>

Each section would represent a demand unit of approximately 4 kL/hour with the water being available during a three hour "window" each day. The advantage of this system is that the need to design a system to meet the potential peak demand of all users wanting water at the same time is negated. Each section pump would have its own irrigation controller programmed to irrigate the POS during night time and the residential blocks during day time.

4.3 Costs

4.3.1 Capital Cost Estimate

(1) The supply and installation of five pumps, fittings and control equipment in existing Economax tanks and the supply of automatic drip irrigation system to road and lane verges. $70,000

(2) To construct and equip six x 100 m bores with pumps, electrics and control system $55,000

(3) To supply and install the irrigation and supply system for POS, single housing and group housing areas using a combination of subterranean and above ground drip irrigation. $155,000

Total Cost $280,000

4.3.2 Running Costs

Our running cost calculations have been based on an annual usage of 7,500 kL/ha/yr.

On this basis the power consumption would be: -

- Road/Verge system 980 units/annum
- P.O.S. 4,930 units/annum
- Residential areas 2,132 units/annum

Total 8,042 units/annum

The daily use rate for this system does not justify connection to off peak tariffs. Based on L tariffs costs of 15.98 cents per unit, the annual running cost would be $1,285.

The broader running includes provision for the following items:
- Maintenance of the irrigation facilities for public open space and for the households
- Maintenance of the water reuse system
- Maintenance and replacement of bore and pumps
- Electrical maintenance
- Bore life - 15 years
- System life - 30 years

To provide an adequate level of service and replacement for these facilities along with the energy costs above an annual rate would need to be struck of 51 cents/kl. This would provide an adequate revenue base to maintain the system at a high level. This rate is a reasonable rate on the basis of the real costs and is equivalent to the normal Water Authority rate for water for outside use.

5.0 LANDSCAPE COSTS

5.1 Option 1: Conventional

(1) **Grass**
   Minor levelling, supply and plant couch runners at 0.1 m centres, fertilize
   24,500 m² at $2/m²  
   $48,800

(2) **Trees**
   Supply, plant, stake and fertilise trees of approximately 1.5 m height 375 No at $15/each  
   $5,625

(3) **Shrubbery**
   Minor levelling, supply and install 0.1 m depth of soil improvement material, supply and plant 0.3 - 0.5 m height shrubs at 1/m², supply and place 0.1 m depth surface mulch
   15,500 m² at $15/m²  
   $232,500

(4) **Shrubbery Edge**
   Supply and install extruded concrete mowing edge to shrubbery: grass interface
   1350 1m at $10/1m  
   $13,500

(5) **Irrigation**
   Bore and pump
   Irrigation delivery system to all grass and shrubbery areas
   40,000 m² at $3.50/m²  
   $140,000

**Total**  
$475,000
• Maintenance of the irrigation facilities for public open space and for the households

• Maintenance of the water reuse system

• Maintenance and replacement of bore and pumps

• Electrical maintenance

• Bore life - 15 years

• System life - 30 years

To provide an adequate level of service and replacement for these facilities along with the energy costs above an annual rate would need to be struck of 51 cents/kl. This would provide an adequate revenue base to maintain the system at a high level. This rate is a reasonable rate on the basis of the real costs and is equivalent to the normal Water Authority rate for water for outside use.

5.0 LANDSCAPE COSTS

5.1 Option 1 : Conventional

(1) Grass
Minor levelling, supply and plant couch runners at 0.1 m centres, fertilize
24,500 m² at $2/m² $48,800

(2) Trees
Supply, plant, stake and fertilise trees of approximately 1.5 m height 375 No at $15/each $5,625

(3) Shrubbery
Minor levelling, supply and install 0.1 m depth of soil improvement material, supply and plant 0.3 - 0.5 m height shrubs at 1/m², supply and place 0.1 m depth surface mulch
15,500 m² at $15/m² $232,500

(4) Shrubbery Edge
Supply and install extruded concrete mowing edge to shrubbery; grass interface
1350 1m at $10/1m $13,500

(5) Irrigation
Bore and pump
Irrigation delivery system to all grass and shrubbery areas
40,000 m² at $3.50/m² $140,000

Total $475,000
5.2 Option 2: Proposed

(1) **Grass**
Minor levelling, supply and plant couch runners at 0.1 m centres, fertilise
26,500 m² at $2/m²

$53,000

(2) **Trees**
Supply, plant, stake and fertilise trees of approximately 1.5 m height
375 No at $15/each

$5,625

(3) **Shrubbery**
Minor levelling, supply and install 0.1 m depth of soil improvement material, supply and plant 0.3 - 0.5 m height shrubs at 1/m², supply and place 0.1 m depth surface mulch
15,500 m² at $15/m²

$232,500

(4) **Shrubbery Edge**
Supply and install extruded concrete mowing edge to shrubbery: grass interface
1350 1m at $10/1m

$13,500

(5) **Irrigation**
Bore and pump
Irrigation delivery system to all grass and shrubbery areas
42,000 m² at $3.50/m²

$147,000

**Total**

$486,500

5.3 Option 3: Towards Sustainable

1) **Grass**
Minor levelling, supply and plant couch runners at 0.1 m centres, fertilise
28,200 m² at $3/m²

$84,600

(2) **Trees**
Supply, plant, stake and fertilise trees of approximately 1.5 m height
250 No at $15/each

$3,750

(3) **Shrubbery**
Minor levelling, supply and install 0.1 m depth of soil improvement material, supply and plant 0.3 - 0.5 m height shrubs at 1/m², supply and place 0.1 m depth surface mulch
15,500 m² at $15/m²

$232,500

(4) **Shrubbery Edge**
Supply and install extruded concrete mowing
edge to shrubbery: grass interface  
250 1m at $10/1m  $2,500

(5)  Irrigation  
Bore and pump  
Irrigation delivery system to all grass and shrubbery areas  
43,700 m² at $3.50/m²  $152,950

Total  $511,500

*Unit rate for grassing $1/m² higher than for Options 1 and 2 to allow for soil conditioning (for water conservation).

6.0 LOCALISED WASTEWATER TREATEMENT AND REUSE OPERATING COSTS

For "Towards Sustainable" design's localised sewerage and effluent reuse system it is assumed that a rate would need to be set on the basis of annual operating costs and longer term replacement costs for the five localised wastewater systems. The following assumptions have been applied:

- Annual maintenance of the proposed wastewater system has been calculated to include an annual pump out of the anaerobic tanks. This has been costed at $75/hour for one day of the year ($500) which is based on commercial quotations of the rate of hire of one truck and two personnel. In addition, the pump out has associated liquid waste disposal costs of $30/kl ($4,500 assuming tanks are at capacity). These costs were converted to Net Present Costs (NPC) using a discount rate of 6, 10, 15 & 20%, an inflation rate of 5%, and a time frame of 20 years.

- In addition, an accumulated fund for part replacement and other operating expenses has been factored in. This was set at a conservative 50% of the capital cost of the system (i.e. $150,000) and put into NPC value at the same rates previously mentioned.

- The rates for this wastewater system also include the replacement of the red mud leach drain after twenty years at a cost of $50,000 (as quoted by supplier). As with other costs, this was put into NPC terms.

- These figures were then combined to arrive at the gross cost to be borne by the proposed management body. This was then divided among the housing configurations in accordance with their expected contribution to the wastewater load (57% for single housing and 43% for grouped).

- A profit margin of 30% was added to the gross cost to the management body at the time of calculation. This cost is then transferred to the householder resulting in wastewater charges which provide an adequate incentive for a water service management company to take on the role of operator.

The estimate of annual costs to manager and annual costs to householder at various discount rates is shown in Table 6.1
TABLE 6.1 ESTIMATE OF ANNUAL COST OF LOCALISED WASTEWATER REUSE SYSTEM

<table>
<thead>
<tr>
<th>Discount rate</th>
<th>Cost estimate to manager</th>
<th>Rate estimate to Householder</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single House</td>
<td>Grouped House</td>
</tr>
<tr>
<td>6%</td>
<td>$181.21</td>
<td>$159.49</td>
</tr>
<tr>
<td>10%</td>
<td>$225.98</td>
<td>$198.89</td>
</tr>
<tr>
<td>15%</td>
<td>$307.79</td>
<td>$270.89</td>
</tr>
<tr>
<td>20%</td>
<td>$379.03</td>
<td>$333.59</td>
</tr>
</tbody>
</table>

7.0 SUMMARY

The overall development statistics and capital costs for the three options are presented in Table 7.1. A comparison of the costs of the three design options shows the following:

- The capital cost for the "TS" design is 3% higher than the "Conventional" design and 10% higher than the "Proposed".

- The "TS" design has savings in costs in the areas of earth works (due maintenance of the terraced site) and stormwater infrastructure (due to application of the most effective BMP).

- All designs have comparable costs in the areas of retaining walls.

- The landscaping costs, exclusive of irrigation, are slightly higher for the "TS" design due to slightly larger area and better site preparation.

- In the "TS" design the Community Self Supply System includes irrigation of all dwellings, which is not part of the other two designs.

- The "TS" design incurs increased cost in the areas of roads (due to added road length) and sewerage (due to the localised treatment facility).

- Water supply headworks costs assume a reduction by 20% due to efficiency gains and overall reduction in peak demand achieved by the use of the community bore system. A reduction by 10% in cost reticulation due to pipe size reductions is also assumed. If these savings are not achieved the water supply costs would be constant across the designs. This would mean that the capital cost for the "TS" design would be 6% higher than the "Conventional" design and 12.5% higher than the "Proposed".

- The capital cost for the community self supply and reuse system in the "TS" design includes the establishment of the reticulation within each of the dwelling units, which is not the case in the other two design options. Thus each dwelling unit in the "TS" design has added value which would be recouped in the land prices.
This assessment of the capital costs for the proposed development illustrates the "Towards Sustainable" design is slightly higher than the other design options, but clearly illustrates that it is cost competitive in overall capital costs.

**TABLE 7.1 DEVELOPMENT STATISTICS AND CAPITAL COSTS**

<table>
<thead>
<tr>
<th>Item</th>
<th>Conventional</th>
<th>Proposed</th>
<th>Towards Sustainable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design features</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total area</td>
<td>8.8150 Ha</td>
<td>8.8150 Ha</td>
<td>8.8150 Ha</td>
</tr>
<tr>
<td>Area Public Open Space (POW)</td>
<td>2.2285 Ha (25%)</td>
<td>2.5103 Ha (26.5%)</td>
<td>2.6472 Ha (27.6% including PAWs)</td>
</tr>
<tr>
<td>Area of Roads</td>
<td>1.1520 Ha</td>
<td>1.1520 Ha</td>
<td>1.2280 Ha</td>
</tr>
<tr>
<td>Drainage / Public Access Way (PAW)</td>
<td>0.3698 Ha</td>
<td>0.0860 Ha</td>
<td>0.1120 Ha</td>
</tr>
<tr>
<td>Lot yield -Single -Grouped</td>
<td>63</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>54</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td><strong>Development capital costs to be met by the developer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earthworks:</td>
<td>$110,000</td>
<td>$110,000</td>
<td>$40,000</td>
</tr>
<tr>
<td>Roads &amp; Paths:</td>
<td>$204,000</td>
<td>$204,000</td>
<td>$284,000</td>
</tr>
<tr>
<td>Walls:</td>
<td>$237,520</td>
<td>$215,920</td>
<td>$240,000</td>
</tr>
<tr>
<td>Stormwater:</td>
<td>$255,000</td>
<td>$124,000</td>
<td>$80,000</td>
</tr>
<tr>
<td>Sewerage: Headworks charge</td>
<td>$157,716</td>
<td>$157,716</td>
<td>-</td>
</tr>
<tr>
<td>Reticulation</td>
<td>$143,000</td>
<td>$143,000</td>
<td>$450,000</td>
</tr>
<tr>
<td><strong>Water supply:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headworks charges</td>
<td>$228,033</td>
<td>$228,033</td>
<td>$182,426</td>
</tr>
<tr>
<td>Reticulation</td>
<td>$384,000</td>
<td>$384,000</td>
<td>$345,600</td>
</tr>
<tr>
<td>Irrigation</td>
<td>$140,000</td>
<td>$147,000</td>
<td>$280,000</td>
</tr>
<tr>
<td>Landscape (for POS &amp; verges)</td>
<td>$355,500</td>
<td>$339,500</td>
<td>$358,550</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>$2,194,769</td>
<td>$2,053,169</td>
<td>$2,260,576</td>
</tr>
</tbody>
</table>

4 Complete reticulation, localised wastewater and reuse system, thus no sewerage headworks charge is appropriate.

5 A reduction by 10% in cost reticulation due to pipe size reductions is assumed.

6 A reduction by 20% due to efficiency gains and overall reduction in peak demand achieved by the use of the community bore system.

7 This irrigation cost includes provision of irrigation to public open space and households as part of the community water supply system within the Towards Sustainable design.
Palmyra Wastewater Treatment/Reuse System

Sustainable Urban Water Systems Project

Quality & Quantity Control

UV Disinfection

Tertiary Polishing

ECOMAX Nutrient & Metals Removal

Anaerobic Digestion

Recharge Bore

Sewage Reticulation System

Public Open Space
Appendix II

Summary of Results for the Palmyra Woolstores Site

Presentation Material
Water Sensitive Design - A Tool for Urban ICM
Palmyra - Design Options

Legend
- existing road
- road reserve
- single residential
- grouped housing
- public open space
- drainage reserve
- roadway
- lane way
- public access way

Sustainable Urban Water Systems Project - IST?
Total Water Use

kl/annum

61,120

59,180

43,582

Conventional

Proposed

Towards sustainable

Sustainable Urban Water Systems Project
Household Water Use - Outside

kl/annum

Conventional: 14,375
Proposed: 14,375
Bore Water: 13,104
Towards sustainable

Sustainable Urban Water Systems Project
Public Open Space Water (Bore)

kl/annum

Conventional: 26,850
Proposed: 24,910
Towards sustainable: 18,310
Effluent re-use: 4,500

Sustainable Urban Water Systems Project
### Capital Costs of Development

#### Landscape Irrigation
- Conventional: $355,500
- Proposed: $339,500
- Towards Sustainable: $358,550

#### Water
- Conventional: $612,033
- Proposed: $612,033
- Towards Sustainable: $528,000

#### Sewerage
- Conventional: $300,716
- Proposed: $300,716
- Towards Sustainable: $450,000

#### Stormwater
- Conventional: $255,000
- Proposed: $124,000
- Towards Sustainable: $80,000

#### Walls
- Conventional: $237,520
- Proposed: $215,920
- Towards Sustainable: $240,000

#### Roads Earthworks
- Conventional: $204,000
- Proposed: $204,000
- Towards Sustainable: $284,000

#### Conventional

#### Proposed

#### Towards Sustainable
Costs to Manager

Sewerage

Water

Conventional & Proposed

Single Residential

Group Housing

Towards Sustainable

6% Discount Rate

10% Discount Rate

15% Discount Rate

Sustainable Urban Water Systems Project
Charges to the Consumer

Sewerage
- Single Residential: 653.43
- Group Housing: 575.82
- Total: 1229.25

Water
- Single Residential: 450.00
- Group Housing: 400.00
- Total: 850.00

Discount Rates
- Conventional & Proposed
  - 6% Discount Rate
    - Single Residential: 220.18
    - Group Housing: 175.82
    - Total: 396.00
  - 10% Discount Rate
    - Single Residential: 220.18
    - Group Housing: 194.03
    - Total: 414.21
  - 15% Discount Rate
    - Single Residential: 220.18
    - Group Housing: 194.03
    - Total: 414.21

Towards Sustainable
- Single Residential: 513.95
- Group Housing: 452.58
- Total: 966.53

Footnotes
- Sustainable Urban Water Systems Project - ISTIZ
REFERENCES


Cameron, D., Research Director, Dowmus Pty Ltd., Personal communication, May 1995.


Department of Planning and Urban Development (1990) *METROPLAN*, Government of Western Australia, Perth.

Department of Planning and Urban Development (1992a) *Morley Regional Centre Structure Plan*, Government of Western Australia, Perth.

Department of Planning and Urban Development (1992b) *Draft Metropolitan Region Residential Density Policy*, Government of Western Australia, Perth.


Hedgcock, D., Planner involved in design and community workshop, personal communication between 1991 and 1994 regarding the planning and community process at Palmyra Woolstores Site.


MacCormich, T., Marketing Manager, Memtec Ltd., personal communication during the period 1992 to 1995.


Martin, B. (1993) "Is the new paradigm of physics inherently ecological?" Chain Reaction, No. 68, Friends of the Earth, Australia.


Meier, R. (1994a) "Comments on Earth Day Reflections - Sentiments and Ideologies, back to Ecotechnologies" discussion in ECOTECH'94 Papers & Discussion. <ETTOR%SERN.BITNET@SEGATE.SUNET.SE>

Meier, R.L. (1994b) "The Place of Knowledge in Ecosystems and its Future Use in Design", Symposium on Knowledges, Berkeley, USA.


Metropolitan Water Authority (1985) Domestic Water Use in Perth, Western Australia, Metropolitan Water Authority, Perth.

Mitchell, B. (1991a) Integrated Catchment Management in Western Australia: progress and opportunities, Centre for Water Research University of Western Australia, Perth.


Seddon, G. (1972) A Sense of Place, a response to an environment, the Swan Coastal Plain, Western Australia, UWA Press, Perth.


Sumner, N.R. (1990) The Effect of Residential Land Use and Block Size on Scheme Water Consumption. A report for the Water Authority of Western Australia, CSIRO Division of Water Resources.


Waite, I., Marketing Director, Durrant and Waite Pty Ltd., personal communication, May 1995.


Water Authority of Western Australia (1992) Perth a City of Wetlands: Wetlands of the Perth to Bunbury Region: Coastal Wetlands from Wedge Island to Mandurah, A Mapping and Classification project of the WAWA in association with Dept of Land Administration.

Water Authority of Western Australia (1994a) A Supply Strategy for Perth and Mandurah to 2021 (with a focus to 2010), Water Authority of Western Australia, Perth.

Water Authority of Western Australia (1994b) Wastewater 2040 Discussion Paper, Water Authority of Western Australia, Perth.

Water Authority of Western Australia (1993) Water Topic #15 The effect of block size and type of dwelling on Perth's domestic water use, Water Authority of Western Australia, Perth.


Weinberg, M. (1994a) "Technology and the Environment: the Search For Balance" presented in *ECOTECH'94: Papers & Discussion*< ETOR%SEARN.BITNET@SEGATE.SUNET.SE>

Weinberg, M. (1994b) Discussion on "Technology and the Environment: the Search For Balance" 13 April in *ECOTECH'94: Papers & Discussion* < ETOR%SEARN.BITNET@SEGATE.SUNET.SE>


