DEMONSTRATION PROJECTS:
CASE STUDIES FROM MELBOURNE, AUSTRALIA.

- 60L Building
- Inkerman Oasis
- Aurora Estate
- Lynbrook Estate

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MELBOURNE

National Urban Water Governance Program

MONASH University

Demonstration Projects:
Case Studies from Melbourne, Australia.
(60L Building; Inkerman Oasis; Aurora Estate; and Lynbrook Estate)

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Photo images courtesy of Megan Farrelly.

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National Urban Water Governance Program

The *National Urban Water Governance Program* (the Program) is located at Monash University, Melbourne. The Program comprises a group of social science research projects investigating the changing governance of traditional urban water management in Australia.

The Program is intended to facilitate progress towards achieving ‘Water Sensitive Cities’, a long-term aim of Australia’s National Water Initiative, by drawing from a number of social theories concerning institutional and technological change processes, and by undertaking comprehensive social research across three Australian cities: Brisbane, Melbourne and Perth.

Three key questions guiding the overall Program’s research agenda are:

1. What institutional factors are most important for enabling change towards a Water Sensitive City?
2. How can current reform processes be effectively informed and adapted to advance a Water Sensitive City?
3. What are the implications, and future roles, for professionals in the urban water sector?

The metropolitan regions of Brisbane, Melbourne and Perth were selected as broad case studies because they share similar drivers for re-examining their water management options (drought, waterway degradation, increasing populations). Collectively, the cities also represent a broad range of differing urban water governance structures and systems across Australian cities. This is in addition to differences in traditional water supply sources. For example, Perth’s supply is predominantly sourced from groundwater aquifers, whereas Melbourne and Brisbane’s are sourced primarily from surface, freshwater systems.

Introduction

It is widely recognised that conventional approaches to urban water management are unable to respond and adapt to the emerging challenges of ageing infrastructure (Engineers Australia, 2005); increased demand from growing populations (Birrell *et al.*, 2005), and climate change and sustainability (Marsalek *et al.*, 2001; Brandes and Kriwoken, 2006; Wong, 2006). These challenges introduce great complexity and uncertainty to urban water management; thus, many sustainability commentators are calling for transformative change towards adopting more sustainable practices. Such an approach would emphasise adaptable, inclusive and collaborative practices operating within supportive organisational cultures that embrace learning-by-doing (e.g. Maksimovic and Tejada-Guibert, 2001; Pahl-Wostl, 2007; Wong and Brown, 2009). As van der Brugge and Rotmans (2007: 259) point out: "because the road is unclear, experimentation is essential in order to learn". In Australia, demonstration projects are used as a mechanism to introduce, test and promote (experiment with) new technologies and practices in support of sustainable urban water management.

Demonstration projects act as bounded experiments, trialling the application of structural innovations such as technology, infrastructure or science, as well as non-structural innovations such as education or policy programs. They can occur at a range of scales, and trial any number of innovations. Each project may offer new insights into how a policy or new piece of technology can contribute to change or enhance current practice, and help shift towards more sustainable urban water practices.

In a review of demonstration projects across eastern Australia, Mitchell (2006) determined that while significant progress had been made in integrated water management, there was room to improve on the 'progressive learning experience' of demonstration projects. She concluded that (Mitchell, 2006: 602):

> In order to allow people to build on the experience of others and enable knowledge gaps to be filled, improved dissemination of knowledge gained and lessons learnt, including pitfalls to be avoided and processes followed is required.

In response to this call, these case study reports have been designed to:

a) raise the profile of projects involving new water supply and treatment technologies amongst urban water professionals, and

b) share the key lessons and insights gained from these projects.

The case studies aim to provide a holistic overview of the selected projects, including not just technical aspects, but also the processes undertaken, the challenges encountered and methods for overcoming these challenges during the course of project development and implementation. This set of case study reports contributes towards a larger research project investigating how demonstration projects can assist in the diffusion of sustainable urban water management technologies and practices in the Australian urban water sector. This research also supports the broad research agenda of the National Urban Water Governance Program.

Publicly available literature, alongside interview notes, form the basis of these reviews. Forty-seven individuals were interviewed across Melbourne during February-April 2008 to determine the quality and diffusion of information among urban water professionals in relation to technical and process innovations. Interview participants included representatives from Local Government, State Government agencies, the water businesses, leading consultants, land developers and researchers. Interviewees who had detailed experience with specific demonstration projects were asked a series of questions tailored to capture their experiential insights to help reveal the drivers for initiating the project and to identify the enabling and/or constraining factors involved in undertaking the process of design, construction, and implementation of the projects. Implications for future adoption of new water supply and treatment technologies and practices arising from these case studies are also reported.

CASE STUDY OF
60L BUILDING
CARLTON, MELBOURNE

Introduction

The 60L Green Building in Carlton, Melbourne provides an early example of a commercial retrofit of a multistorey building within the business district of Melbourne. The 60L Green Building was selected because the site includes rainwater harvesting for reuse and includes onsite technologies for recycling (greywater and blackwater). This brief case study provides an overview of not just technical aspects, but also the processes undertaken, the challenges encountered and methods for overcoming these challenges during the course of project development and implementation.

Purpose of the 60l Green Building

The Australian Conservation Foundation (ACF) is a not-for-profit environmental organisation with the purpose of inspiring a healthy environment for all Australians. In the mid-1990s, the then ACF president, Professor David Yencken, recognised the importance of moving towards more sustainable cities, and that the built environment, in particular commercial buildings, was substantially contributing to environmental degradation (ACF, 2008). Commercial buildings consume approximately 30% of the world's resources, 10% of the world's water and approximately 40% of the world's energy (OECD, 2003). In Australia 10% of our greenhouse gas emissions can be linked to commercial buildings, where office buildings contribute 40% of that total (Wilson and Tagaza, 2006). Thus, the ACF's vision was to design and construct a commercially-viable building, from start to finish, that would provide workspace that epitomised their conservation and environmental ideals, using innovative technologies and reusing building materials were possible (ABC, 2004; The Green Building Partnership, 2003).

The overall goals for the 60L Green Building were the building should (Hes, 2001:4):

- be a model of superior environmental performance that gives practical expression to the commitment to ecologically sustainable development;
- use the building and any associated research projects to broadly disseminate the lessons learned during the design and construction process; and
- remain commercially viable, from design through to operation.

An important element of creating the 60L Building was the need to provide a practical demonstration for architects, builders and the real-estate industry, that environmentally sustainable buildings can be commercially viable, with market-comparable rents (Mailer, 2000; The Green Building Partnership, 2003). Furthermore, as this project was intended as a demonstration, the communication of successes, failures and general lessons learned has been an important priority.

60L BUILDING SNAPSHOT

- **Location:** Leicester St, Carlton.
- **Driver:** Australian Conservation Foundation vision for a sustainable office building.
- **Purpose:** Demonstrate the design and construction of a commercially viable 'green' office building.
- **Water Features:** demand management strategies; rainwater harvesting and use; onsite grey- and blackwater recycling and reuse.
- **Successfully demonstrates the potential of office buildings to meet strict environmental performance objectives and remain commercially viable.**

Creating the 60l Green Building

By 1998, the ACF had investigated several possible options for housing the ACF headquarters in sustainable, 'green' premises, including retro-fitting their Fitzroy head office, retro-fitting another building, a more suitable building, and designing and constructing a new building. The investment company, Surrowee Pty Ltd, purchased the site at 60-66 Leicester Street, Carlton (a modified warehouse *circa* 1876) and made it available to the ACF for the development of a sustainable commercial office building retrofit (The Green Building Partnership, 2003; Carey, 2002). Initial feasibility studies were conducted to establish the ecologically sustainable design principles for the development site, with assistance from the University of Melbourne's Department of Architecture and Building and Lincolne Scott Engineering, supported by an Australian Research Council grant.

Surrowee Pty Ltd joined together with Green Building Projects to form the Green Building Partnership, which operates as the owner and manager of the 60L Green Building. The Green Building Partnership provided the financial capital and project management during development of the site. A design consortium, including Spowers Architects and engineering firms Lincolne Scott Australia and Advanced Environmental Concepts, developed a full scale project plan based on the preliminary work from The University of Melbourne's Department of Architecture and Building that involved a reconfiguration of the original building, with the addition of a new, four-level structure on the rear of the property.

In scoping the design of the building, the Green Building Partnership established four key principles of sustainable development to be achieved (The Green Building Partnership, 2003; Mailer, 2000):

- *Materials sourcing efficiency* – reduce material requirements, reuse existing materials, use recycled materials and ensure the environmental impact of all new materials is known and minimised.
- *Energy efficiency and greenhouse gas emissions* - design, construct and operate to achieve a minimum consumption of energy, make best use of natural lighting and ventilation; use 'green' power.
- *Water and waste water efficiency* - reduce demand for water, gather and filter rainwater on-site, use water-efficient appliances and fittings, avoid chemical treatment, treat & recycle wastewater and sewage for on-site re-use, and
- *Involvement of people* - implement a building-wide Environmental Management Plan, improve environmental performance through 'green' leases and systems that enable tenants to know and monitor their consumption of energy and water.

In June 2000 the City of Melbourne issued a town planning permit and construction commenced in February 2001 (Hes, 2001). The ACF provided advice throughout the design stages and developed environmental objectives to be achieved by the overall development and a set of guiding environmental principles for procurement of materials and interior furnishings. Kodo International (a professional services company), Assai (a design and project management specialist), and h2o architects combined to assist the ACF in preparing and implementing the environmental principles and objectives for internal design, fit-out, and furnishing (ACF, 2008). h2o architects and Sustainable Solutions (an Environmental Project Management Consultant) also worked together to assess the most environmentally responsible materials and furniture. The environmental principles and objectives were subsequently adopted during the development, planning, design, construction, and operation of the project and included, among others, efficient water use and wastewater reuse, internal environmental quality, energy and greenhouse gas management, landscaping and community impacts (The Green Building Partnership, 2003).

Steve Paul and Partners Pty Ltd provided professional services for the hydraulic engineering, water and wastewater treatment (Hes, 2001). The 60L Green Building's design team specified appropriate technology, rather than leading-edge technology, prioritising solutions which balanced energy and resource use minimisation with the needs of the tenants, while remaining within the project's commercial viability constraints (The Green Building Partnership, 2003). The approach to water conservation in the 60L Green Building comprises three

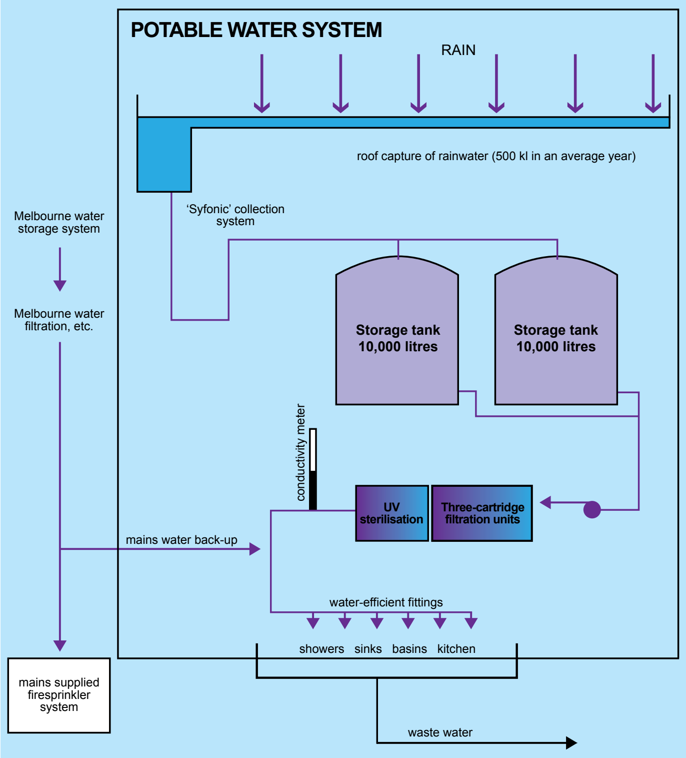


Figure 1: Simplified schematic of the 60L Green Building Potable Water System
Source: www.60lgreenbuilding.com

components: demand management; rainwater collection and use, and on-site recycling (greywater and blackwater).

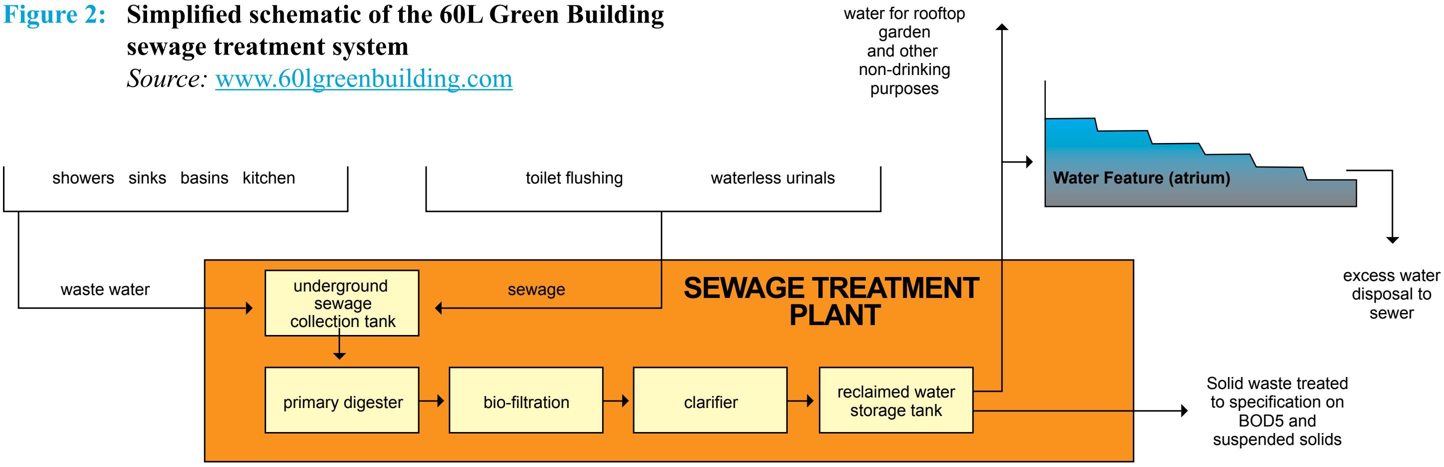
Demand management

The 60L Building is designed with feedback mechanisms to encourage tenants to adopt best water conservation practices. Water efficient fixtures and fittings have been included. For example, low-flow shower heads discharge 5L/minute, 3L dual flush toilets were selected based on efficiency and suitability for flushing with recycled water, and waterless urinals. Waterless urinals trap urine in a cartridge which minimises undesirable odours. A typical cartridge needs replacing after 8,500 uses at a cost of approximately $40/year for each urinal.

Rainwater collection and use

Rainwater is the principal source of water used throughout the building and the system is designed to replace 100% of mains water consumption where ever possible. In an average rainfall year, approximately 500 kilolitres of rainwater will be collected for potable use. Harvested from the roof, the water is then collected in two 10, 000L storage tanks on the ground floor via a system that uses gravity to create a siphon effect (Figure 1), allowing the water to transfer more rapidly while reducing pipe diameter and thus material resources (Pushard, 2008). The rainwater is then filtered and sterilised to provide a potable water supply for use by tenants in taps, showers,

Figure 2: Simplified schematic of the 60L Green Building sewage treatment system
Source: www.60lgreenbuilding.com



and for drinking. The building is designed to be self-sufficient in an average rainfall year. The only mandated requirement for mains water use is when testing the fire sprinkler system (Pushard, 2008).

When required, the rainwater is pumped through a three-stage filtration and UV sterilization system to remove water impurities using a Grundfos vertical multistage pump, which has been selected to save energy, as it is demand regulated. UV sterilization makes it possible to kill potentially hazardous organisms and bacteria without the need for chemicals such as chlorine. The treatment plant also has automatic monitoring for conductivity and is subjected to routine monitoring and testing for microbial activity, which is overseen and managed by a central water and wastewater system controller (Figure 1).

On-site grey and blackwater recycling and reuse

Wastewater from basins, sinks and showers in the building, together with sewage from the toilets is collected in an underground tank. This combined effluent is then treated in the sewage treatment plant, located on the ground floor at the rear of the building. The sewage treatment plant is a biological treatment system, free of chemicals, that allows natural organic processes to convert the organic material in the effluent. The plant has a series of compartments within which the effluent is successively treated by sedimentation and digestion, bio-filtration, and then clarification before being discharged into a water storage tank. The treated water is further processed through the reclaimed water treatment plant, where it is pumped through a two-stage filtration and UV sterilisation system (separate to those used for potable water) to produce water suitable for toilet flushing, sub-surface irrigation of the roof top gardens and other landscape features. This treatment plant also has automatic monitoring for conductivity and is subjected to routine monitoring and testing for microbial activity.

Surplus reclaimed water is channelled through a water feature on the ground floor atrium, which features a succession of cascading tanks containing aquatic plants and organisms which uptake residual nutrients in the treated water before it enters the traditional sewerage system (Figure 2).

As part of the communication strategy, it was determined that water, its use, treatment, and reuse should be prominent in the tenants' and visitors' consciousness. Consequently, the two 10,000 litre storage tanks and ancillary pumping, filtration and water sterilisation equipment are clearly visible on the ground floor. As Mailer states, "the water tanks and the water treatment systems are on display because we want people to think about water" (ABC, 2004). To date, without using the recycled grey/black water, the tenants have achieved an approximate 60% reduction in mains water consumption, and the total building was designed to use 90% less mains water when compared to a traditional commercial building (Hes, 2001; The Green Building Partnership, 2003; Pushard, 2008).

The building officially opened October 18, 2002 by the then Premier of Victoria, the Hon. Steve Bracks. The development contributes 3375 square metres of commercial floor space, with floor plans of up to 960 square metres. The tenancies were all taken up within 12 months of opening and currently 16 businesses are tenants; the ACF is the primary tenant, occupying approximately one quarter of the building. Since opening, the building has been the recipient of a number of sustainability awards and achieved widespread recognition for its sustainable development message.

Throughout the building, key points of difference are clearly sign-posted and also documented online (http://www.60lgreenbuilding.com/). The lessons learned are publicly available because, as the Director of Lincolne Scott Engineering states "we acknowledge our social responsibility here, as environmentally sustainable engineers" (Ecolibrium, 2003:16). There are various communication mediums: signage,

AWARDS WON

- **Banksia Environmental Award (2003)**
  – Leadership in Sustainable Buildings
- **Australian Property Institute (2003): Excellence in Property Development**
  – Environment
- **Planning Institute of Australia (2003)**
  – Ecologically Sustainable Development (Victoria)
- **Premier's Business Sustainability Award (2003)**
  – Business Sustainability

displays, information kiosks and touch screen information points are located throughout the building. In addition, the Building has a resident Project Manager who conducts tours through the building for interested parties. A key element of the demonstration project was communication and to promote replication, thus a document detailing the design process, design development report and the final building designs (worth tens of thousands of dollars) are provided on compact disc for $30 for people to learn about the implementation process, and to 'not reinvent the wheel'.

Key Challenges

From inception of the project, a strong commitment to reducing the environmental impact of the commercial building, at all stages of design and construction, was integral to the project. This mandate initially proved challenging for the Green Building Partnership, who had difficulties composing a design team with sufficient knowledge and experience to successfully implement the environmental objectives. Developing a sustainable building requires shifting long-held traditional practices in design through to implementation. Engineers, for example, were required to modify their traditional approach to building design and construction to help meet the stated objectives. The Director of Lincolne Scott Engineering acknowledged the specialised conditions under which they were hired:

It was a precondition of the project that it be 'green', which forced us to continue to search for ways to reduce running costs, where in a standard engineering setting we may have admitted defeat at an earlier stage and reverted to standard engineering practices. The project was at least two years in the planning partly because, unlike conventional projects, services consultants were brought into the early planning stages in order to maximize potential synergies. Usual planning takes three to four months. Much of this additional time was needed to ensure new approaches were in fact suitable for this building and in line with client vision of the building. We worked a lot with non-engineers to make the Green Building Partnership's vision happen. There were a lot of discussions on how we could make things work and, in effect, we had to tailor existing engineering practices to their ideas (Ecolibrium, 2003:15).

Another challenging aspect of the development was attempting to stay within 'commercially viable' limits. This was achieved through cost savings due to no air conditioning and no allocated parking (although bike racks and showers are provided and public transport is encouraged), which allowed for greater expenditure on sustainability technologies, such as the rainwater tanks and the on-site recycling system. While there was greater scope to include more sustainability initiatives in the design, this would have cost substantially more than a 'traditional commercial building'. For example, the CH2 building, where the City of Melbourne offices are located, cost approximately 25% more than a conventional commercial building, whereas the 60L Building demonstrated it is possible to design and construct a sustainable commercially-viable office building, while still achieving substantial reductions in water consumption and energy demand.

The 60L Building was also challenged by its own success. Demand management approaches and water efficient fixtures meant the water savings were so great the on-site wastewater recycling system could not function appropriately. Therefore, much time was spent improving the technology to allow for higher concentrations of waste. As of early 2008, the recycling system was functioning properly; however, the water was yet to be used in the building due to a colour problem (most likely related to a high concentration of tannins in the wastewater). The treated water is currently discharged into the conventional drainage system.

The regulatory environment also posed a series of significant hurdles for the Green Building Partnership. For example, when enquiring about substituting conventional potable water with treated (potable quality) rainwater, no policy, guidance or regulations were in place within the agencies consulted (i.e. Yarra Valley Water, Environmental Protection Authority). Furthermore, representatives from these agencies were unwilling to either approve or disapprove of the project. The situation was further complicated as there is also no guidance or documentation regarding onsite wastewater recycling systems producing less than 5000L/day, highlighting a significant regulatory gap in the policy framework. Thus, the Green Building Partnership was required to assume the potential public health and environmental risks themselves. Lack of State Government approval meant the Green Building Partnership was presented with a commercial-risk situation that would have acted as a major disincentive to many regular commercial operators. However, the Green Building Partnership was confident they had invested in suitable safety features to remain confident their water recycling system would work.

Case Study Implications

The 60L Green Building has been successful in demonstrating the potential of office buildings to meet strict environmental performance objectives and remain commercially viable. The project successfully engaged a wide range of stakeholders early in the planning and design process to ensure that all organisations and individuals involved in the project were subscribed to the principles and intent of creating a sustainable building. Furthermore, the case study highlights how being involved in the project that challenges the status quo can successfully challenge traditional disciplinary perspectives of what can be achieved in, design, architecture and engineering, among others.

Demonstration projects support technical learning such as addressing the challenges facing the onsite wastewater recycling system, but they also reveal the often 'invisible' processes influencing innovation adoption. At the time of construction, no State Government authority or relevant water utility was willing to approve or even disapprove of the treatment and reuse of less than 5000L of wastewater per day. This is not surprising given previous research has revealed Australian urban water practitioners remain highly concerned about the implications for public health when introducing alternative water supply and technologies, and subsequently preference conventional systems in new developments (see Brown *et al.*, 2007; Brown *et al.*, 2009). Consequently, the Green Building Partnership carries the potential commercial, environmental and public health risks associated with the unconventional approach. While the stakeholders involved in this project were committed to completing the project, a limited risk sharing profile may prevent the replication of such approaches in other commercial building retrofits.

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CASE STUDY OF
INKERMAN OASIS
ST KILDA, MELBOURNE

Introduction

'Inkerman Oasis' is a multi-storey, residential apartment building located in St Kilda, Melbourne. This development was selected as a case study for it includes an alternative water supply source (treated greywater) for toilet flushing and outdoor landscape irrigation.

Drivers and Purpose of Inkerman Oasis Development

Following local government amalgamations in 1994, the City of Port Phillip agreed to rezone and redevelop the now redundant St Kilda Council Municipal Depot (Inkerman Street) into residential apartments that incorporated public housing. The size of the site (1.223 ha) and the associated costs of a large-scale development led the Council to enter into a public-private partnership with Inkerman Developments Pty Ltd. The Council imposed strict criteria on the developers to ensure the development was sustainable. The development was required to have: a percentage of housing designated for community housing purposes; high quality urban design, architecture, and integrated art; and, environmentally sustainable design features (passive and active). In return for meeting these Council objectives, the developer was able to build the remaining units as private housing.

While community housing benefits were a key objective for the City of Port Phillip, the council also wanted to be recognised as a sustainability leader. Many environmental proposals were put forward, but the emphasis throughout the development was on the capture, on-site treatment and reuse of greywater and stormwater. Other proposals, such as solar power, roof-top gardens and blackwater recycling were not considered financially viable at the time of development.

South East Water Ltd became involved with Inkerman Oasis in 2003 and approached the decentralised greywater treatment and reuse system as an opportunity for research and development. Inkerman Oasis presented the water utility with the occasion to explore and understand the technical challenges, water quality challenges, risk management, monitoring requirements, and associated costs of operating and maintaining a decentralised water supply system. Also, South East Water perceived their involvement in such a project as a mechanism for proactively influencing and encouraging policy makers to develop regulatory guidelines for the use of recycled water in high-density residential developments so that "South East Water is better equipped to provide solutions for a water-sustainable future" (Vinot *et al*., 2007).

INKERMAN OASIS - SNAPSHOT

- **Location:** Inkerman St, St Kilda
- **Driver:** Urban renewal that was leading the way in social and environmental development; secondary driver was as a demonstration project.
- **Purpose:** trial an on-site (decentralised) greywater recycling system for capture, treatment and reuse.
- Privately developed directed by carefully constructed Master Plan.
- Captures Greywater– treats with UV and chlorine for reuse in dual-flush toilets throughout complex and sub-surface irrigation.
- Stormwater diverted to onsite wetland, treated and discharged to traditional drainage system.
- Project the recipient of numerous sustainable development awards.

Process of Implementation

A team of consultants were engaged to develop a Master Plan for the site, which comprised of the Urban Land Corporation, Ecumenical Housing Inc, William Kelly and Associates, and Williams Boag Pty Ltd Architects. The Master Plan took four and a half years to complete and during this period the 'book' value of the property increased from $5.2 million to $7.2 million (due to natural price increases and the value-adding Master Planning process). A series of steps were undertaken to develop the Master Plan (City of Port Phillip, 2007):

- Preparation of an initial Master Plan design and associated cost estimation which included environmental design features;
- Facilitation of the planning process and Council acceptance of the building heights and unit density;
- Undertaking community consultation;
- Preparation of a soil contamination report and remediation strategy;
- Site remediation (at a cost of $1.7 million);
- Title conversion from General Law to the Torrens System under the Transfer of Land Act; and
- Rezoning from Public Purpose-Local Government to Mixed Use.

In 1999, the City of Port Phillip accepted the tender from Inkerman Developments Pty Ltd (a joint venture of Riverside Melbourne and Contract Control Constructions) to develop the site; however, Council maintained control of the project through the use and further development of the Master Plan. In 2000, stage one (of three) began development; in total 245 apartments will be developed to cater for both the private and public sector (32 units, 13% of total apartments were allocated for community housing).

Various ecologically sustainable design features were suggested for the development, but most were rejected due to perceived poor commercial viability (i.e. roof top gardens and solar power), but on-site greywater treatment and reuse was considered acceptable (commercially viable). Blackwater recycling was also considered as a possible feature, however, regulatory authorities insisted that the Council would have to remain responsible for the operation and maintenance of such a system, not the Body Corporate, hence this was not adopted. Eventually, a combined greywater and stormwater recycling process was selected as the preferred wastewater treatment and reuse system. The combined reclaimed wastewaters were to be used for toilet flushing and landscape irrigation. This system was to be the first of its kind in Victoria and was regarded as extremely innovative. Indeed, this initiative received a Commonwealth grant of $267,214 from the Living Cities, Urban Stormwater Initiative Program (2000/2001). The grant also allowed for the provision of water balancing flow control devices in the plumbing system throughout the project to reduce water pressure and maintain pressure consistency. Funds were also contributed by Inkerman Developments, the City of Port Phillip, the Port Phillip Housing Association, and the Body Corporate. The design of the system was expected to significantly reduce potable water use (40% in summer and 20% in winter), reduce sewer loads and reduce nitrogen loads to Port Phillip Bay by approximately 14 tonnes, thus satisfying the Council's requirements for their environmental objectives.

Figure 1: Stormwater diverted to and treated in the onsite bioretention system (wetland)

Inkerman Developments Pty Ltd sub-contracted Integrated EcoVillages to supply, install and operate an on-site greywater system, based on their experience with similar technology in Canberra. Integrated EcoVillages were also contracted to negotiate the required regulatory approvals, for at the time of development there were no clear guidelines or regulatory approvals processes established to facilitate the implementation of a decentralised, on-site greywater recycling system. Confusion about the regulatory requirements meant substantial construction of the system had occurred before any conversations were held with regulatory authorities (Department of Human Services; Environmental Protection Authority). The early construction also led to complications with the physical infrastructure which did not meet with required occupational health and safety requirements due to the lack of distinctive purple-piping; a requirement by the Plumbing Industry Commission for dealing with recycled water.

The confusion regarding the regulatory guidelines was based on a lack of understanding about whether a works approval and/or licence was required from the Environmental Protection Authority because there would be no discharge of greywater to the environment, and whether existing guidelines for 'Use of Reclaimed Water[1]' (EPA, 2003), which relates primarily to blackwater (reclaimed water from sewage treatment plants), needed to be met (Coulthurst *et al*., 2004). To overcome these issues, the City of Port Phillip and the developers contracted South East Water in 2003 to produce an *Environmental Improvement Plan*, required by the guidelines for the 'Use of Reclaimed Water' (EPA, 2003). In 2004, following further discussions, South East Water agreed to enter into a contract with the development's Body Corporate, where South East Water's responsibility is to maintain and operate the onsite greywater treatment and reuse system, and to undertake regular monitoring of the system for a period of six years (until October 2010). South East Water also set the pre-condition that the Department of Human Services (DHS) and the Environmental Protection Authority (EPA) had to support the project. Consequently, the EPA and DHS provided their written consent supporting the implementation of the system, with the extra requirements of producing a community education plan, a plumber awareness plan and a verification plan (Coulthurst *et al*., 2004).

The original intent of the reuse system was to treat greywater and stormwater together in the membrane bio-reactor tanks and reuse the water for toilet flushing and landscape irrigation. However, when South East Water finally assessed the system they determined that treating stormwater in the membrane bio-reactor tank would compromise the biological

[1] 'Use of Reclaimed Water' was published in June 2003 providing an updated of the 'Guidelines for Wastewater Reuse' (EPA, 1996) and taking into account advances in technology and scientific knowledge, community expectations, and the development of the national framework - the National Water Quality Management Strategy.

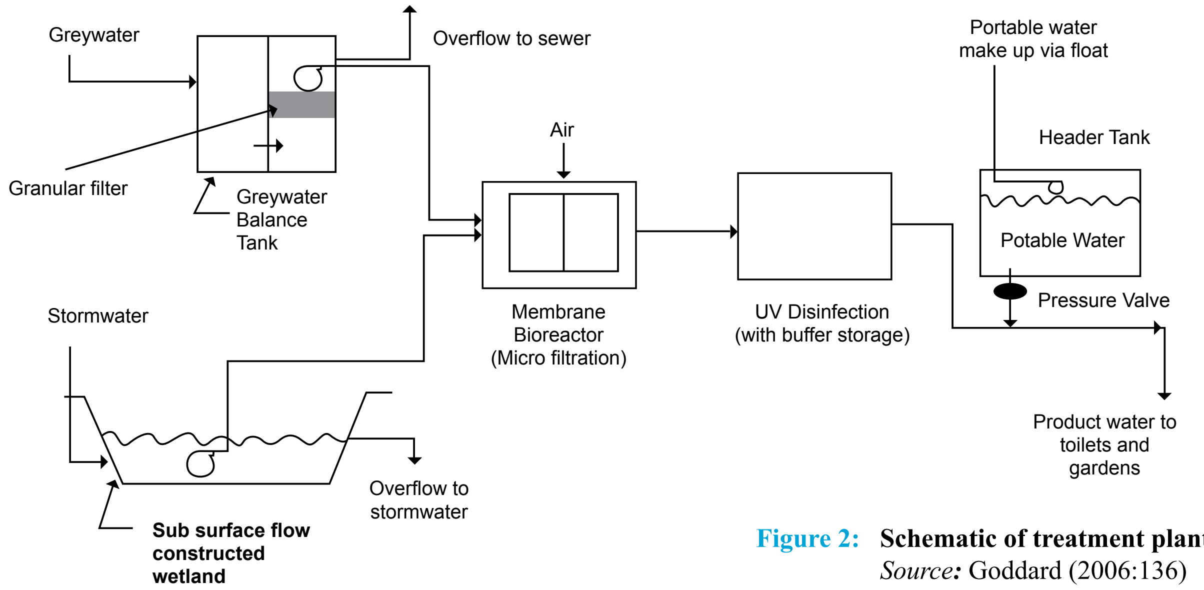

Figure 2: Schematic of treatment plant process
Source: Goddard (2006:136)

activity and also introduce excess water required for reuse purposes (toilet flushing and landscape irrigation). As a result, stormwater is now limited to wetland discharge (biofiltration systems), with excess stormwater conveyed by the traditional drainage network. Also, in reviewing the treatment system, South East Water determined that to secure the necessary support from regulatory agencies, a chlorine dosing step would be required. Further funding for the recycling system was provided through a $125 000 innovation grant from South East Water.

The greywater recycling and stormwater treatment at Inkerman Oasis involves the following:

Domestic greywater treatment and reuse

- Primary treatment of domestic bathroom greywater (basins, baths and showers) from approximately 50% of units in 3 buildings in a 15,000 litre aeration balance tank to remove suspended solids;
- Tertiary level treatment in a 10,800 litre membrane bio-reactor tank acts as a first step biological and physical filtration process. This tank is duplicated to permit maintenance on each membrane module without the system having to revert to conventional waste disposal.
- The partially treated greywater is stored in a 45,000 litre tank. When required the recycled water passes through an ultraviolet disinfection unit and chlorine dosing before being reticulated by two constant pressure pumps for sub-surface irrigation and toilet flushing (Figure 2).
- Sub-surface garden irrigation network throughout the development supports the landscaped features of primarily native and indigenous plants. Water is released to dry areas through slow release dripper piping regulated by 12 solenoids triggered by moisture sensors.

Stormwater

- Capture of roof runoff and overland flow from across the total site (with peak stormwater flows diverting to the conventional stormwater system).
- Filtration through two gross pollutant traps on both ends of the wetland.
- Primary treatment of the water in a 400m^2 wetland by filtration through a soil- gravel medium and absorption by wetlands plants to remove particles and nutrients (Figure 1).
- Excess water is then discharged into the traditional stormwater drainage system.

In 2004 the greywater system was commissioned so that the plant operates to treat the greywater without the recycled water going to residential units. However, the greywater recycling system continued to experience delays regarding regulatory and policy approvals from the Environmental Protection Authority and the Department of Human Services as 'guidelines still do not exist' specifically for operating and maintaining a decentralised greywater recycling system, despite updated Victorian and National water recycling guidelines (this remains under review)

The Environmental Improvement Plan developed by South East Water contained the requirement for an education campaign for residents and plumbers. While plumber education is primarily the responsibility of the Plumbing Industry Commission in Victoria, an awareness programme, run with assistance from South East Water, aims to ensure that plumbers are aware Inkerman Oasis has a dual-reticulated system. For example, clear identification of above and below ground pipe work (purple piping) and erection of signage both internal and external to the apartment buildings help communicate the message (Goddard, 2006: 140). Furthermore, community awareness raising is completed through interpretative signage at the site of the recycling technology and protected, glass-domes allow residents to witness the treatment process (Figure 3).

Figure 3: Greywater System Interpretative signage and visible processes.

Eventually, in late May 2008, the greywater recycling and reuse system was 'switched on' to supply dual flush toilets with reclaimed water. To date the system appears to be meeting all necessary requirements. Ongoing monitoring and service provision will be provided by South East Water to ensure the technology continues to perform as expected until October 2010, whereupon the infrastructure asset will become the sole responsibility of the Body Corporate.

Key Challenges

The Inkerman Oasis development revealed a number of interesting challenges around regulatory arrangements, technological issues, the capacity of the sector (human, organisational, economic), and risk management.

The selection and installation of the on-site greywater recycling system occurred prior to the involvement of South East Water and preceded the development of any regulatory approvals processes. The existing guidelines for using reclaimed water explicitly focus on blackwater sourced from large-scale, centralised treatment plants, not decentralised, on-site systems. At the beginning of this project, the only established regulatory approvals processes existed for recycling schemes producing more than 5000 litres/day. Such schemes require an EPA licence and/or approval prior to work commencing on the site; however, only an environmental improvement plan is required for the installation of the third-pipe network, which details how the scheme will meet the reclaimed water guidelines (EPA, 2003).

Complicating the process further was the length of time taken by regulatory authorities (EPA, DHS) to approve a piece of technology they were unfamiliar with; no standards existed at the time to determine the quality of water required for fit-for-purpose uses (Goddard, 2006). Much of the confusion and subsequent problems were the result of limited engagement of the regulatory authorities by a contractor who was unfamiliar with the Victorian regulatory framework. Furthermore, while hydraulically sound, the pipe network required re-installation to meet with occupational health and safety standards (i.e. the introduction of purple piping required by the Plumbing Industry Commission). The regulators required the production of Class A water, thus South East Water added another step in treating the water (chlorine dosing) (Coulthurst *et al*., 2004). This was related to the lack of confidence regulators have in the performance of multi-media filters to consistently produce Class A quality water (Goddard, 2006:139).

At present, South East Water has an agreement with the Body Corporate for operation and maintenance, and thus the risks of poor water quality have been mitigated following extensive monitoring and evaluation of water quality outputs from the recycling system. However, there is a risk that if the service contract is not renewed, and the responsibility for managing the on-site recycling systems is handed back to the Body Corporate, the system may be shut down. For example, the Body Corporate may shut down the system if there are unanticipated or ongoing costs associated with general operation and maintenance (i.e. equipment replacement) (Coulthurst *et al*., 2004; Vinot *et al.* 2007).

AWARDS WON

- **United Nations Association of Australia World Environment Day Awards 2000**
  - Local Government, Best Specific Environmental Initiative
- **Stockholm Partnership for Sustainable Cities Award (2002)**
  - One of 13 International recipients assessed on social, cultural and environmental sustainability features.
- **Save Water Award (2003)**
  - Sustainable Built Environment –Residential Subdivision/Medium Density/Urban Renewal (Victoria)
- **Commendation Award – National Built Environment Exemplar (2004)**
  - Sustainable Communities Category
- **National Royal Australian Institute of Architects Special Jury Award (2005)**
  - Business Sustainability
- **Howard Desbrowe-Annear Award (2005)**
  - Residential Architect (Victoria)

Case Study Implications

This case study reveals the importance of engaging with all relevant key stakeholder groups from the beginning of a project to ensure successful, timely outcomes. While the original stakeholder groups (City of Port Phillip and Inkerman Developments) had good sustainability intentions, they lacked the technical capacity and experience to assess the suitability of the greywater recycling and reuse technology they were proposing to install. Although South East Water was eventually commissioned to maintain, operate and monitor the water recycling and reuse system, their late intervention revealed several technical issues with the existing infrastructure which created further delays. This emphasises the importance of identifying which organisations will be operating and managing the recycling system early in the design processes. It is also important to clearly establish the roles and responsibilities of all parties involved in implementing such a project, including those of the regulatory agencies.

The innovation of an on-site greywater recycling system was ahead of State policy guidelines and regulatory frameworks, despite a State policy requiring 20% recycling of wastewater by 2010 (as of 2003). A lack of clear standards and guidelines were often referred to during interviews as a major limitation to the timely completion of the project. Whilst the regulatory agencies are generally supportive of new initiatives, to date policy and regulation in terms of decentralised water technologies have been largely reactionary and slow to occur. This indicates a level of disconnection between the regulatory bodies and the innovations and initiatives occurring within the industry, resulting in a breakdown in the flow of information. In the absence of such communication and learning, the ability of regulators to provide clear policy, guidance and direction for developers and/or project managers wishing to innovate is significantly reduced. The difficulties and delays in the project associated with the regulatory issues demonstrate a need to address this gap.

South East Water have concluded from their involvement in the project to date, that for decentralised greywater recycling systems to become cost effective for a water utility, while still operating within a robust risk management framework, there is a clear need for standardised, or even accredited, technological systems (Vinot *et al*., 2007). South East Water does not anticipate subsidising another project like Inkerman Oasis, for they remain "convinced that it is not the solution" to integrated water management. Overall, the project was perceived to be too expensive and that the appropriate economies of scale were currently not evident because centralised systems "do it well, without risk". The lessons learned from the experiment at Inkerman Oasis, however, have informed South East Water's application of broad scale third-pipe networks to deliver treated recycled water to large, greenfield residential developments at Sandhurst and the Hunt Club.

The reported reluctance of South East Water to develop, operate or manage decentralised water treatment and supply technologies in the future indicates a need to further investigate the role and capacity of other organisations to undertake such operation and maintenance roles. This is particularly vital in relation to the Inkerman project, as the long term success of the recycled water scheme is dependent on the capacity of the Body Corporate to operate and manage the system.

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CASE STUDY OF
AURORA ESTATE
EPPING NORTH, MELBOURNE

Aurora Estate Development

Aurora Estate is a large-scale, greenfield residential development approximately 20km north of Melbourne in Epping North and is expected to provide approximately 8500 dwellings for more than 25, 000 people (Figure 1). The developer, VicUrban, is a State Government-owned company with a strong commitment to creating sustainable communities through five core objectives: community well-being, environmental leadership, housing affordability, urban design excellence, and commercial success.

Aurora Estate includes a number of sustainable features focussing on water, energy, recycling and biodiversity. This case study, however, will focus on the water features associated with the development. Sustainable water components in Aurora Estate include, among others, water conservation and demand management measures at the household scale, rainwater harvesting for hot water (optional for households), wastewater recycling for toilet flushing and outdoor landscape irrigation, stormwater treatment and management through incorporating principles of water sensitive urban design.

AURORA ESTATE - SNAPSHOT

- **Location:** Epping North.
- **Driver:** lack of existing water services infrastructure; vision for a sustainable community development.
- **Purpose:** demonstrate sustainable development, particularly integrated water management in a greenfield development.
- Developed by VicUrban.
- **Features:** demand management techniques; stormwater sensitive urban design (raingardens, bioretention swales, etc); dual reticulation (recycled wastewater).
- Paved the way for third-pipe infrastructure in Melbourne.

Drivers for Development

Rapid population growth has fuelled a strong demand for housing in Melbourne over the last two decades, which has in turn put pressure on the State Government to convert and release land previously zoned rural on the outskirts of the Melbourne urban growth boundary. Following the development of the Western Ring Road and Hume Highway, new tracts of land became available along Melbourne's urban residential growth boundary. VicUrban began acquiring land to develop the "next big thing", building on the past successes of developments at, for example, Lynbrook Estate, Roxburgh Park and Cairnlea. At the time of purchase, the land did not have the necessary trunk sewerage infrastructure services to support all of the new residential development. The local water utility, Yarra Valley Water, had not planned on extending its infrastructure in the area until at least 2012, whereas VicUrban wanted to have the land developed and ready for sale by 2004. While a temporary local sewerage treatment plant could have sufficed for the development until the main extension was completed, the lack of existing infrastructure also provided an opportunity to explore more innovative, integrated water management options.

To assess the options for integrated water management at the development site, VicUrban engaged an enthusiastic and dedicated individual who had long advocated for using recycled water in greenfield developments. A previous attempt to include dual-reticulation systems for providing treated water in residential developments had been unsuccessful due to the economic conditions (at the time), the socio-political environment, and external stakeholder disinterest in challenging the status quo (i.e. water utilities, government regulators). However, the opportunity to realise a vision of a sustainable water community was presented when planning for the Aurora Estate development.

Figure 1: Master Plan for Aurora Estate
Source: www.vicurban.com

Process of Implementing Aurora Estate

VicUrban began acquiring land on Melbourne's urban growth boundary in 1998, with the intent of creating a point of difference in the residential market by acting on the organisation's sustainability principles: affordable housing, community well-being, commercial success, urban design excellence and environmental leadership. To support VicUrban in achieving their sustainable water goals for the development, Coomes Consulting were engaged to review the appropriate integrated water management approaches. Overall, the conceptual design of the development aimed to reduce potable water consumption by approximately 70% when compared to conventional service arrangements.

The vision for sustainable water components focused on:

- ***Demand management***: water efficient fixtures in houses and the (optional) installation of a rainwater tank for hot water supply to kitchens and bathrooms.
- ***Wastewater treatment and reuse***: all wastewater produced from dwellings is to be treated to Class A and piped back to the development for toilet flushing and outdoor irrigation via dual-pipe reticulation.
- ***Stormwater quality retention and treatment***: household raingardens, streetscape swales and biofiltration systems and precinct scale wetlands to detain and treat stormwater before entering local waterways.

However, as features such as the rainwater tank are optional, if they are only taken up by a limited number of residents the actual water savings will be more likely around 35-40% compared to conventional developments.

Coomes Consulting spent over nine months developing an Integrated Water Management Plan for the Aurora Estate development. To support the decision-making processes regarding the range of possible options for integrated urban water management at Aurora Estate, an independent expert panel was assembled to review the Integrated Water Management Plan. The panel included well-regarded professionals working in integrated water management and had representation from across Australia including individuals from the Department of Human Services in South Australia and the Queensland's Department of Natural Resources and Water. The panel's purpose was to review and assess the initial proposals, make comment on the appropriateness of the proposed water management system and make recommendations (Austin & Gan, 2003). Recommendations included, among others, support for using recycled water for toilet flushing and external uses (provided a Hazard Analysis and Critical Control Points (HACCP) approach to risk management is taken); that rainwater for hotwater was an acceptable option, and that collection and treatment of sewage should be staged as required by the technology adopted.

In 2001, Yarra Valley Water was approached by VicUrban to discuss the options of building a localised sewage treatment plant for Aurora Estate. To facilitate this process, a series of workshops were held with key stakeholders in the project including VicUrban, Coomes Consulting Group, the City of Whittlesea and Yarra Valley Water, with the purpose of discussing preliminary aspects of the project (Austin & Gan, 2003). Yarra Valley Water, however, were originally reluctant partners in this process because they were not convinced that building a local sewage treatment plant and introducing dual reticulation would deliver a more sustainable solution. Initial discussions ended with no fixed outcome; however, following further investigations into the potential of supplying recycled water to customers by key individuals, Yarra Valley Water agreed to investigate the option and included recycling into their Water Plan. Although Yarra Valley Water had agreed in principle that the idea was sound, they would not financially support the project in any different way to normal development, requiring VicUrban, the developer, to provide the necessary infrastructure.

In October 2002, VicUrban and Yarra Valley Water signed a Memorandum of Understanding which established a commitment from both organisations to a partnership approach in the investigation and implementation of a local sewage treatment plant and water recycling system at Epping North (Austin and Gan, 2003). The Memorandum set out key principles behind the project including the understanding that: this was a 'learn as you go' project; organisations need to foster mutual trust; a high level of resources needed to be committed, and they needed to secure commitment from their Boards and senior management. Efforts were made by Yarra Valley Water to ensure that the whole business was behind the project. Consequently, internal seminars were held, senior managers were regularly briefed at meetings and Aurora targets were included in staff and executive performance plans. A full-time project manager was appointed to coordinate internal business and operational requirements and to manage relationships with external stakeholders. In addition, a steering committee, coordination team, infrastructure team, pricing team and customer service team were established to determine the changes required within the organisation to support the treatment and provision of recycled water to customers (Austin and Gan, 2003). To ensure the safe delivery of water and assist in minimising risk to the business, a Hazard Analysis and Critical Control Points (HACCP) approach was required (Austin and Gan, 2003).

To build a local wastewater treatment and reclaimed water plant, VicUrban was required to rezone part of their land in order to separate it from the primary development. This was done to ensure regulations requiring wastewater to be treated 'off-site' were met, before the recycled water is supplied back to the development through separate pipe networks for toilet flushing and outdoor use. This caused some delays during the negotiations around the urban design associated with the project, which took close to two years to finalise. The long timeframe was perceived to be a result of the economic context (at the time of the proposed development) and the 'vagaries of the planning system'. Eventually these issues were addressed and two plants were constructed, the Aurora Sewage Treatment Plant and the Aurora Water Reclamation Plant. Two plants were necessary to produce different qualities of water, to maximise the opportunity for reusing all wastewater. Class A water will be supplied to the community for toilet flushing and outdoor household irrigation and public open space irrigation (Messenger *et al.*, 2006), while excess recycled water will be delivered to other users off-site through the Yarra Valley Water pipe network.

All reclaimed water supplied to households undergoes a three barrier removal process (two physical filters and UV light disinfection) then the water is chlorinated, as required by Yarra Valley Water (Messenger *et al.*, 2006). The treatment plants are designed as modular systems to allow for ongoing expansion (McLean, 2004). The Class A water is supplied to customers via a third-pipe network (purple pipes) and there are two reservoirs, one that holds 1ML of Class A water and a 280ML dam for Class B water for peak summer demands and for storage during winter months (Messenger *et al.*, 2006).

The regulatory agencies, Environmental Protection Authority and the Department of Human Services were engaged early in discussions about the proposed activity at Aurora Estate. Early engagement was designed to ensure a smooth approvals process for the required Works Approvals and Health and Environmental Management Plans (HEMPs) necessary for development approval. In August 2006, the Aurora Sustainability Covenant was signed by the Environmental Protection Authority, VicUrban, Yarra Valley Water and the City of Whittlesea, to ensure the partners work together to increase the efficiency of resource use and to reduce the ecological impact of Aurora Estate development. Although not binding, the objectives of the covenant related to requirements stated in the HEMPs.

At the household scale, the intention was to include a rainwater tank, situated underground, for each property. Rainwater tanks are now an 'optional extra' for each new home, and if adopted, will supply hot water for the bathrooms and kitchens. Despite having support for the technology from the peer-review panel, the concept of 'rainwater for hotwater' was questioned by various stakeholders; thus to secure acceptance and build confidence in the system, a pilot project was conducted at the Centre for Education and Research in Environmental Strategies (CERES). The purpose of this trial, which began in 2003 and was completed in 2005, was to demonstrate the capability of the hot water system to provide a suitable quality of water for kitchens and bathroom use.

In addition to rainwater tanks, raingardens were originally applied at the household scale as a stormwater management device. Biofiltration units were to be established in each new home with the aim to treat stormwater as close to the source as possible, therefore improving the quality of the runoff before it enters the underground easement drainage system at the rear of most properties (McLean, 2004). Also, building on the success of trialling landscape-scale application of a stormwater quality treatment train at Lynbrook Estate, extensive use of swales and biofiltration systems at the streetscape and precinct scales were incorporated throughout the development (Figure 2). In combination, the above systems are designed to reduce stormwater flows by, on average, 750ML/year (Hunter, 2006). Throughout the development there are interpretative signs to inform the community of the function and benefits of swales and biofiltration systems.

Figure 2:
Examples of swales and biofiltration pits from Aurora Estate

Challenges and Opportunities

The traditional core business of Victorian Water Authorities supports a linear system of providing potable water and removing/disposing of wastewater. As such, any challenge to this approach is likely to encounter difficulties. Yarra Valley Water was tested throughout the process of planning and developing the infrastructure of Aurora Estate. Conceiving of wastewater as a resource was a fundamental shift in the organisation's operation, which impacted on almost all elements of business. For example, challenges at the customer interface included, among others, developing dual metering and billing methods. Other challenges involved convincing the Yarra Valley Water Board to expose the organisation to what they perceived was a higher level of risk without there being a direct business benefit. However, open, honest and ongoing dialogue was maintained to ensure successful sign-off on each stage of development. Also, to further mitigate any public health risks, chlorine dosing was introduced for treating reclaimed water to ensure it was suitable for non-potable uses.

Although Yarra Valley Water agreed to work with VicUrban and contribute to the project, they originally declined to contribute to the cost of establishing the required infrastructure. However, in 2005 a review was undertaken by the Essential Services Commission into the pricing of water services in Victoria, which led to the developer contribution charges for new connections being capped at $1000/lot for Aurora ($500 as new customer contribution and $500 for new sewerage charges). This provided a legal requirement for Yarra Valley Water to change its approach.

Over the same period, Yarra Valley Water initiated research through RMIT and CSIRO in order to discover the most sustainable infrastructure solution for servicing new developments in both greenfield and infill sites (Sharma *et al.*, 2005; Grant and Opray, 2005). Through the methods of Life Cycle Assessment, Life Cycle Costing and Total Cost Assessment, the research revealed favourable sustainability results for alternative servicing options in comparison to traditional centralised infrastructure solutions, in the significant areas of environmental impact, total community costs, and community risk (Pamminger, 2008; Sharma *et al.*, 2009). These results were in direct contrast to common industry perceptions regarding decentralised services, and thus had a significant impact on the organisation's attitude towards alternative arrangements.

VicUrban predicted that by early 2005 residents would begin moving into the Estate. However, at the time of interviewing in early 2008, the critical mass of residents required to support the operation of a fully-functional sewerage treatment plant had not yet been met. It was suggested, however, that by the end of 2008 there will be enough people living within the Estate to support the operation of the recycling plant. As of 2009, recycled water is available to houses located in Aurora Estate.

The Environmental Protection Agency (EPA) and the Department of Human Services were engaged early in discussions with the land developer and the water authority; yet the state agencies were unable to develop regulation and guidance to support the implementation of third-pipe systems, for this was the first time such a project had been undertaken in Victoria. Without guidance from the regulatory bodies, the process of planning and developing the site was significantly delayed for the water authority. Furthermore, the land developer did not know what standards the system should be designed to support. The 1996 guidelines for reuse of recycled water did not provide any guidance on the standards required for wastewater reuse. To address this regulatory uncertainty, and as other similar water recycling projects emerged, a Water Recycling Committee with representatives from across government, helped develop a strategic framework for increased water recycling in Victoria. Eventually, the EPA, with assistance from key stakeholders involved in the Aurora Estate development, helped to create a revised set of guidelines for the *Guidelines for Environmental Management: Use of Reclaimed Water* (EPA, 2003) and *Guidelines for Environmental Management: Dual Pipe Water Recycling Schemes – Health and Environmental Risk Management* (EPA, 2005).

Furthermore, the Plumbing Industry Commission of Victoria, following consultation with the various water authorities, began preparing technical guidelines (fact sheets) for accredited plumbers to be aware of standard requirements for plumbing non-drinking water and greywater to houses. Over the last five years, the Commission has continued to revise and release Recycled Water Plumbing Guides, with the latest released late 2008/early 2009 (Plumbing Industry Commission, 2009). Dual-reticulated pipes and taps must be visibly different from traditional, potable supplies, hence the purple pipes and taps, also there are warning signs posted above each outdoor household tap to remind customers not to drink this water (Figure 3).

Figure 3: Construction of new homes at Aurora include dual-pipe reticulation

Introducing more localised technologies has also proven challenging for industry and residents. For example, while stormwater quality treatment technologies, such as swales and biofiltration systems have been used in urban developments for close to a decade, such technologies are still considered 'new' by many areas of the industry. Consequently, there were problems encountered during the construction and implementation of swales or bioretention systems, but these are expected to be resolved over time, as the development is built out. Building on the lessons learned from VicUrban's experience with Lynbrook Estate, signs were erected to prevent the interference of bioretention systems while building was underway.

Raingardens, another key feature in the design of Aurora Estate aimed at improving the quality of stormwater runoff, failed to gain traction amongst local residents and subsequent subdivisions will not have raingardens incorporated. It was reported by interviewees that a number of residents in existing houses have applied to the City of Whittlesea to remove their raingardens for aesthetic reasons. This will have implications for the quality of stormwater runoff in the development. Furthermore, despite the success of the CERES trial investigating the feasibility of rainwater systems for delivering hot water to bathrooms and kitchens, these systems are remain 'optional' to the land purchaser.

Case Study Implications

VicUrban set out to achieve a vision of a sustainable community development at Aurora Estate. However, there have been substantial delays in achieving this vision. Some interviewees expressed concern that since the inception of the project in 1998 when land was purchased for development, the sustainability vision has been eroded, due in part to the departure of key individuals from the lead organisation, VicUrban.

Nonetheless, there have also been many positive implications arising from the project. The case study of Aurora Estate demonstrates the importance of entering into a project or development with the explicit intention of treating the 'new' process as a learning opportunity. Yarra Valley Water's involvement in Aurora Estate, although initially reluctant due to their concern it did not represent a sustainable option, has been instrumental in shifting the way the organisation operates, challenging the conventions of traditional urban water management. The utility's experience at Aurora, in combination with other development opportunities occurring in their jurisdiction and the dedication of individuals within the organisation encouraging investigation into alternatives, led to the initiation of a research project which had a profound impact on the organisation's attitude and operation (see Sharma *et al.*, 2005; Grant and Oprey, 2005; Pamminger, 2008; Sharma *et al.*, 2009).

The aim of the research was to investigate some of the key industry perceptions hindering the uptake of alternative service options, including the perception that the water saving benefits of a third-pipe systems would be outweighed by the environmental costs associated with the energy and materials required for additional infrastructure, that the systems were too costly to operate sustainably, and that there would be a greater risk to the community (Pamminger, 2008). Therefore, the research focused particularly on gaining insight into ways to quantify environmental impacts, total costs to the community, and compare the risks between alternative infrastructure solutions (Pamminger, 2008). The result revealed that (Pamminger, 2008):

- All of the alternative servicing options investigated (third pipe from sewage treatment plant; third pipe from stormwater; and onsite water supply (rainwater tanks) and treated greywater) delivered environmental benefits (including reduced water consumption, greenhouse gas emissions and nutrient impacts) in comparison to conventional services.
- Decentralised options have the lowest total community cost, including environmental, capital and operating costs.
- When comparing dual reticulation, decentralised and centralised service arrangements, centralised systems had the highest cost-risk over time, due largely to large number of people that would be affected by water crises, given the high probability of drought, fire in the catchments, and algal blooms in the future.

These results were able to provide quantitative data showing the viability of alternative systems in contexts such as the Aurora Estate development. The use of scientific methods to present information to an engineering-focused industry, where decisions are based on scientific principles and risk mitigation, "has been instrumental in bringing about change." (Pamminger, 2008: 5). Such research has contributed to the now exemplary business approach of Yarra Valley Water to sustainability and water management (the organisation recently won the Premier's Sustainability Award for Large Business), particularly at the management level. Senior management commitment and ongoing support was revealed to be an important element to the success of the Aurora Estate project.

In addition, key projects such as Aurora Estate have also helped to illuminate the policy and regulatory gaps that constrained the adoption of innovation. The project demonstrated the importance of building and maintaining good relationships with all key actors, in particular the regulatory bodies, to ensure an open and smooth approvals process. This project has strengthened the foundations for future application of integrated urban water management in Victoria.

There are also implications for future replication of certain aspects of the Aurora project, connected with the learning approach taken by project participants. Building the requisite confidence, trust and understanding in the technologies to be applied was important to the key actors, as demonstrated by the peer-review process and the trial being undertaken with rainwater tanks. Developing the requisite capacity amongst professionals is important to the successful application of new technologies (Brown *et al.*, 2007).

Aurora Estate was originally lauded as Melbourne's first greenfield urban residential development with a third-pipe network supplying recycled water for toilet flushing and outdoor irrigation. However, largely due to the groundwork established by the Aurora project in the policy and regulatory environment, other urban greenfield residential developments have leapfrogged Aurora to be the first successful developments to have fully functional, integrated third-pipe networks. For example, South East Water began supplying treated reclaimed water to the Sandhurst Club and the Hunt Club in 2007. Thus, those individuals involved in promoting the use of recycled water for non-potable uses at Aurora Estate have facilitated a more rapid shift towards the implementation of sustainable urban water management measures in Melbourne. More recently, the Clause 56 Amendment to the Victorian Planning Principles has mandated the use of WSUD principles in all new urban greenfield developments. This includes providing the power for water utilities to mandate the inclusion of third pipe infrastructure for recycled water provision in new growth areas, where third-pipe systems ensure the delivery of an "optimal" servicing arrangement (Clause 56, Victorian Planning Provisions). Consequently, new residential developments will see more homes connected to recycled water in the coming years (i.e. Blustone Green Estates; Marriot Waters, Blue Hills Rise Estates and many others). Overall, the Aurora Estate development has significantly strengthened the foundations for the future of integrated urban water management in Victoria.

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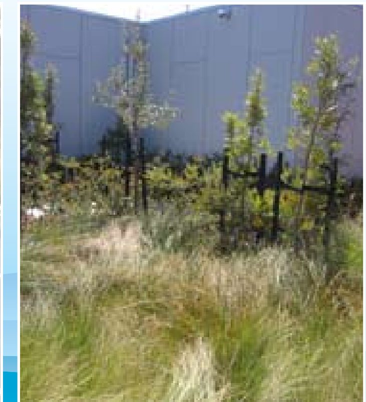

CASE STUDY OF
LYNBROOK ESTATE DEVELOPMENT
LYNBROOK, MELBOURNE

Lynbrook Estate Development

Lynbrook Estate is located 35kms south east of Melbourne and was selected as a case study because it provides a useful example of attempting to introduce a new technology which challenges the status quo of stormwater conveyance and treatment. Lynbrook also represents the first broad scale application of water sensitive urban design in Melbourne, with the implementation of a 'treatment train' to detain and treat stormwater flows.

Drivers for the Project

Growing concern for the health of receiving waterways in Melbourne, in particular Port Phillip Bay led to numerous research and development activities throughout the 1990s dedicated to addressing diffuse pollutant sources entering Melbourne's waterways (Brown and Clarke, 2007). As a result, wetlands were trialled as a way of improving stormwater quality at regional and precinct scales, including greenfield urban developments. The State-based land developer, Urban and Regional Land Corporation (now VicUrban), recognised the potential market benefits of including landscaped water features in their urban developments. At this time, water sensitive urban design (WSUD) was being promoted within the Melbourne urban water sector by sustainable urban water management champions (Lloyd *et al*., 2002a). WSUD is both a philosophical and practical approach to urban planning and design that aims to minimise the hydrological impact of urban development on the surrounding environment.

In 1997, Melbourne Water prepared a document entitled *Urban Stormwater Best Practices Environmental Management Guidelines* which was released in 1999, containing a chapter on WSUD. Further refining this document, the State government in collaboration with local governments and research institutions (through the auspices of the Victorian Stormwater Committee) set out clear guidelines for individuals and organisations involved in the planning, design and/or management of urban water. Best practice performance targets for new urban developments were established by the Stormwater Committee, commonly referred to as the "80:45:45 Principle", where developers are required to meet 80% retention of annual load of suspended solids, 45% retention of total nitrogen and 45% retention of total phosphorous (Victorian Stormwater Committee, 1999). At the same time, Melbourne Water, in collaboration with the Cooperative Research Centre for Catchment Hydrology, set about extending the application of stormwater treatment technologies beyond individual regional and precinct scale constructed wetlands to demonstrate how small scale technologies, such as biofiltration systems and swales could be included at the streetscape or sub-catchment scale (Brown and Clarke, 2007). By applying WSUD principles at the Lynbrook Estate development, the purpose was to raise awareness of the principles and practices of WSUD and to build sectoral confidence in the technologies.

Staged development had been ongoing at Lynbrook Estate since 1994. The Urban and Regional Land Corporation (URLC) (now VicUrban following a merger with Docklands Authority in 2003) provided a section of the development to trial WSUD. Lynbrook Estate was the first application of a 'treatment train', where a sequence of structural 'best management practices'

LYNBROOK ESTATE - SNAPSHOT

- **Location:** Lynbrook Estate, Lynbrook 35kms from CBD.
- Developed by Urban and Regional Land Corporation (now VicUrban).
- **Driver:** trial site established by Melbourne Water to determine effectiveness of WSUD in the landscape.
- **Purpose:** demonstrate stormwater can be successfully attenuated and treated to protect the health of receiving waterways.
- **Features:** Roof and street runoff are captured and directed towards a WSUD treatment train including grass swales and underground gravel trench.
- Treated stormwater is delivered to a constructed wetland system prior to discharge into an ornamental lake.

Figure 1: Main Boulevard, Flush kerbing, bioretention wetland at Lynbrook Estate

cumulatively work to achieve optimal flow management and pollutant removal from stormwater runoff (Lloyd *et al*., 2002b). Lynbrook Estate development became the "first residential development in Melbourne… to integrate water sensitive urban design principles and features for stormwater management" (Melbourne Water, 2003).

Process of Implementing the Project

Key individuals from Melbourne Water, together with key researchers from the Cooperative Research Centre for Catchment Hydrology (CHCCH), were determined to implement their vision of a stormwater treatment train at the streetscape level. Melbourne Water approached the URLC and asked them to nominate one of their urban development projects to be used as a working demonstration site for the application of WSUD principles. Stage 12 of the development was suggested as a potential site, for the URLC considered Lynbrook to be "their worst performing Estate in Melbourne", thereby minimising exposure to financial risk if the development was to fail (Brown and Clarke, 2007).

A collaborative approach was adopted amongst key stakeholders, which included:

- Melbourne Water (regional water authority),
- URLC (land developers),
- KLM Development Consultants (engineers),
- Murphy Design Group (landscape architects),
- and the CRCCH (scientific research organisation)

Local Government representatives from the City of Casey were invited to participate in stakeholder meetings to build awareness and understanding of key WSUD principles (Lloyd *et al*., 2002b). Together, these organisations worked to design, implement and monitor the WSUD demonstration project (Wong, 2001; Lloyd *et al*., 2002a). It was considered important that the design and consultant team share and understand the common vision for the project, and be able to understand the backgrounds of other stakeholder groups to support the translation of the vision into a reality. Therefore, initial meetings spent time on background information including a presentation on the broad WSUD principles and techniques, for these concepts were new to the majority of participants (Lloyd *et al*., 2002b). Eventually, a compromise on the "optimal" design was accepted because there remained uncertainties amongst stakeholders regarding a number of factors, for example, ensuring system integrity, maintenance requirements, cost-effectiveness and the design of the bio-filtration system (see Lloyd *et al*., 2002a).

Design and construction plans were developed over a series of meetings between key stakeholders, and local government officers were regularly updated to ensure there were no unfamiliar issues (Lloyd *et al*., 2002b). Despite regular meetings regarding the design of the treatment train, there remained significant hurdles when seeking approval for the project from the City of Casey. Although councillors were supportive of the project, a lack of internal awareness and familiarity with capabilities of the new sustainable technologies within the local government hampered the process. Also, concerns were expressed by local government officers regarding their responsibility to residents, and concerns regarding replacement and maintenance costs. Furthermore, the Council did not have the appropriate systems in place to approve of such a project, as the approvals system was based on the traditional drainage system and requirements. The concern regarding system failure by the Local Government threatened to derail the project; therefore, Melbourne Water agreed to re-establish conventional drainage if the system did not perform to its design standards, thereby mitigating the economic risks to the council, and the URLC agreed to maintain the system for a period of two years to provide an understanding of maintenance requirements (Lloyd *et al*., 2002a).

Eleven Stages had already been developed at Lynbrook Estate when the demonstration project began construction in 1999. The 32ha demonstration site at Lynbrook Estate included Stages 12 of the development, totalling 270 allotments plus public open space.

Planning and design features of the stormwater WSUD treatment train at Lynbrook Estate include (Figure 1 and Figure 2) (Lloyd *et al*., 2002b):

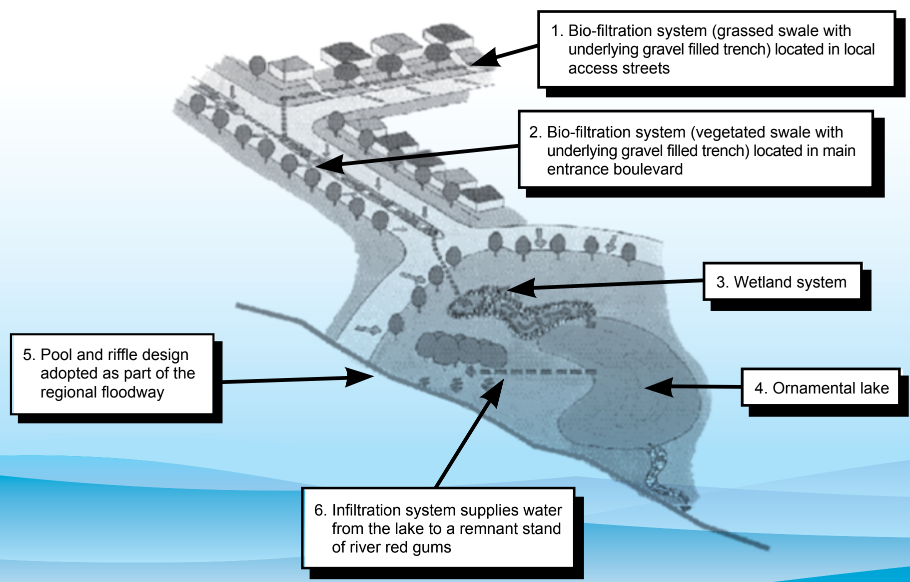

Figure 2: Layout of Best Management Practices incorporated into the Lynbrook Estate Demonstration Project treatment train (*Source*: Lloyd *et al.,* 2002b).

- Rather than a traditional kerb and channel, the median strip incorporates a bio-filtration system to collect, infiltrate, treat and convey road and roof runoff along the main entrance boulevard. The nature strips incorporate the same feature, a grass swale overlying a gravel trench with perforated pipe);
- Secondary treatment of catchment runoff occurs in a wetland system prior to discharging flows into an ornamental lake system;
- The infiltration system is gravity fed from the lake to ensure adequate water supply to remnant river red gums; and,
- A pool and riffle design is included as part of the regional floodway

The main entrance, Lynbrook Boulevard, is a divided road with the cross-fall towards the median strip, which includes a bio-filtration system, and an even distribution of road runoff is promoted by having no kerb and gutter system. A grassed swale pre-treats stormwater runoff before it infiltrates to an 800 mm deep gravel trench. A 150mm diameter perforated pipe runs along the trench close to the base to collect and convey the infiltrated runoff downstream to the wetland system (Lloyd *et al*., 2002).

The entire system was constructed using conventional excavation methods and machinery. Trenches were excavated and root barriers placed along sections where eucalyptus trees would subsequently be planted to minimise the risk of roots penetrating the bio-filtration system. Roof runoff flows directly into a gravel trench via an underground pipe from each dwelling. A geotexile fabric lines the length of the trench and is backfilled with between two millimetres and seven millimetres gravel screening (Lloyd *et al*., 2002). To protect the biofiltration system from excessive sediment loads during landscaping the geotextile fabric was temporarily used. This was later removed and 10mm gravel added to create the base of each swale, which was designed as a dry gravel channel fringed by tussock grasses, eucalypts and hardy turf grass (Lloyd *et al*., 2002).

Figure 3: Entrance Boulevard into Lynbrook Estate (Nov 2007)

The gravel trench is designed to convey stormwater runoff up to the six month average recurrence event (ARI) while the bio-filtration system (i.e. trench plus swale) are designed to carry the five year ARI flow. Stormwater runoff in excess of the five year ARI and up to the one hundred year ARI is conveyed within the roadway (Lloyd *et al*., 2002).

The staged development of Lynbrook Estate meant that much of the open space and street layouts were non-negotiable, therefore limiting the integration of urban design provisions in the overall layout of the stormwater management scheme. For example, not being able to diagonally orientate the roads to run across contours (to achieve a grade of less than 4%) limited the range of WSUD opportunities available (Lloyd, 2004). However, the staged development approach applied at the Lynbrook Estate demonstration project proved useful, allowing for swale design refinements during later development stages (Lloyd *et al.,* 2002a). Importantly, the same construction group, KLM Development Consultants, bid for and were granted, each successive Stage of the development, which meant ongoing relationships were forged among the engineers, designers, and implementers.

AWARDS WON

- **Urban Development Institute of Australia (2000)**
  – Presidents award for excellence
- **Cooperative Research Association 2001**
  – Technology Transfer Award

A benefit of undertaking the project at Lynbrook Estate, was having the opportunity to compare, side-by-side, the performance and impacts of the traditional drainage system against the water sensitive urban design approach. The CRCCH, through a PhD student Dr Sara Lloyd, monitored the sites for water quality, hydraulic impacts, social acceptance data, capital costs and maintenance tasks. Monitoring the performance of the treatment train was perceived as important opportunity for supporting technology improvement within the staged development and to provide the industry with the opportunity to learn and improve on designs and technology.

Monitoring the performance of the treatment train technology indicated that hydraulic performance of the unconventional drainage system performs exceptionally well. For example, the development received above the one in five year ARI, proving the non-traditional drainage system was capable of performing under extreme conditions, thereby providing strong evidence to support the theory and design principles embodied within the system. The treatment train was considered to have "performed [hydraulically] better than the other conventional drainage systems in the estate" (Brown & Clarke, 2007:30). Monitoring of pollutant loads has demonstrated that the treatment train approach significantly improves the quality of stormwater runoff in comparison to conventional drainage; the results of the demonstration project at Lynbrook Estate show a reduction of 60% of total nitrogen, 80% reduction in total phosphorous and 90% reduction of total suspended solids (Wong, 2006). In addition, the stormwater is draining efficiently through the system, remnant red river gums are reviving and water is being appropriately filtered and cleaned before being discharged into Dandenong Creek (Melbourne Water, 2003).

Early concerns regarding consumer acceptance by developers were quickly overcome following the strong land sales in Stages 12, 13 and 14 of the development. On the strength of market acceptance, URLC (now VicUrban) approached the City of Casey for further approval to include WSUD drainage systems in subsequent stages of Lynbrook Estate (stages 15-25) (Lloyd, 2004). Sale prices for subdivisions that incorporated WSUD reported increases in the order of 20% to 30%. Various stakeholders involved in the project relate this strong market acceptance to the improved aesthetics of the development relative to others at that time; however, Melbourne Water believed there were also additional reasons relating to market changes that contributed to the development's success (Brown & Clarke, 2007). VicUrban now applies WSUD in all new greenfield, urban developments where appropriate, such as developments at Aurora, Cairnlea and the forthcoming Officer development.

Challenges within the Project

The Lynbrook Estate demonstration project revealed a number of key challenges related to introduction a new technical innovation that challenges traditional practices for stormwater management in developing greenfield areas. Such challenges included obtaining the necessary local government approvals, the limited experience and understanding in the sector about the new technology, construction site issues and the limited evidence/data to build the necessary professional confidence to support such systems.

Any land development proponent is required to meet a number of established standards for drainage system design based on conventional engineering practices. Any deviation from these standards requires local government approval. Despite in principle support from the City of Casey councillors and staff, and the numerous workshop meetings with staff members, there remained a poor level of internal awareness regarding the technical design and performance of the proposed stormwater management system. This was considered a major impediment to the project. Key concerns raised by local government officers related to the potential economic burden of a failed system and the ongoing maintenance schedule and costs. Following a series of meetings, the system was essentially 'over-engineered' to ensure that it could not fail, but final approval was only granted following the contract signed by Melbourne Water who agreed to underwrite the risk of failure, where they agreed to re-establish traditional drainage if they system did not perform as designed. Similarly, addressing the City of Casey's concerns over the long-term maintenance burden required the Urban and Regional Land Corporation to agree to maintain the system for a period of two years before asset handover.

Following their experience with the demonstration project, Lloyd and colleagues point to a number of key divisions within the local government office that need to be targeted in supporting changes to stormwater management. For example (Lloyd *et al*., 2002a):

- Senior levels of management need to understand how WSUD fits into local government policy.
- Middle management is concerned with the broad issues of WSUD, including costs of maintenance, public safety, visual quality and level of protection of flooding.
- City planners and assessment officers need to understand how to assess a submitted design which current codes of practice do not support, thus making this a more complex process.

The lack of awareness and understanding of the WSUD technology extended beyond local government officers and included individuals involved in the building/construction phase. Bio-filtration systems are highly susceptible to sediment build-up, particularly during housing construction. Despite the adoption of best practices to control sediment-rich runoff, such as hydro-seeding, sediment fences and hay bales (Lloyd *et al*., 2002b), damage to the system still occurred. For example, vehicles would drive and park on swales, and building material would be stockpiled on swales. To address this issue, swales were temporarily fenced off and signs erected at each allotment stating "WARNING Infiltration Trenches Below: no vehicles, building material or excavation on this nature strip"; these were found to be effective methods for reducing negative impacts (Lloyd *et al.,* 2002b). Furthermore, in support of holding construction workers to account, the City of Casey introduced a by-law requiring builders to minimise their impact on the environment by providing a rubbish container, a portable toilet and adequate sediment controls on each allotment and failure to do so incurs a financial penalty (Lloyd *et al*., 2002a). Furthermore, to address the lack of awareness regarding the purpose and function of the new technologies, interpretative signs were erected.

Capital costs are traditionally a barrier to the introduction of any new technology, thus predicting the cost of applying the new technology was important. A cost comparison between the conventional and WSUD stormwater drainage systems demonstrated only a 5% difference in costs when applying WSUD (Lloyd, 2001; Wong, 2001). Furthermore, when considering that drainage works represents only 10% of the overall cost, incorporating WSUD at Lynbrook Estate only increased the total budget by approximately 0.5% (Wong, 2001). Construction of future developments will become more straightforward, as familiarity with the innovation and technologies increases, and therefore extra costs will decrease as uncertainty is decreased. Other social research, also conducted by Lloyd (2004), revealed that the local community found the development more aesthetically attractive than the traditional (earlier) developments. It is further presumed that the inclusion of water features, preservation of remnant vegetation and an emphasis on environmental issues made the development more desirable and marketable (Wong, 2001).

Case Study Implications

The demonstration project of an innovative treatment train for improving stormwater quality at Lynbrook Estate presented some key challenges. As with any demonstration of a new piece of technology and/or approach many questions are raised regarding technology design, economic feasibility, long-term maintenance, public safety and community acceptance. Many of these concerns are difficult to dispel until construction is complete and the technology is operational. For example, the City of Casey, and other stakeholders identified concerns relating to the potential for mosquito breeding, increased snake habitat and local safety issues (Melbourne Water, 2003). However, little could be done to reduce these concerns until the allotments were for sale. This underscores the importance of collecting 'tangible' data on technical feasibility and performance, but also on 'intangible' socio-economic factors to help provide a stronger, multiple benefits 'business' case when advocating the virtues of applying water sensitive urban design principles, or indeed the application of any new technology.

The Lynbrook Estate case study revealed that at the time of development there was a significant lack of awareness and understanding (knowledge) of emerging stormwater quality treatment systems amongst urban water professionals, in particular local government officers. To assist in replicating the application of WSUD principles in future greenfield developments, awareness raising and knowledge building are important features, particularly among local government planning and assessment approvals officers. Indeed, this industry-wide gap was recognised by key stakeholders (Melbourne Water in particular) and consequently, the Clearwater Program was created to address capacity deficits amongst urban water practitioners (www.clearwater.asn.au).

Another important aspect of this case study was the ongoing commitment and willingness of a range of stakeholders to explore the various challenges revealed by this demonstration project. The key driving agencies were open and flexible in design criteria, and the ongoing involvement of the same construction company introduced the opportunity for improvement in design elements in subsequent developments. Also, the leadership shown by two key stakeholders in underwriting the perceived risks was an important element in the successful development.

Overall, Lynbrook Estate successfully demonstrates the application of an innovative, stormwater treatment train in Melbourne. Despite encountering a number of challenges, the Lynbrook Estate project has played an essential role in the transition towards the institutionalisation of WSUD elements in some areas of policy and legislation in Victoria (Brown and Clarke, 2007). The success of the project, in terms of the collaborative process across industry, government and academic organisations, as well as the technical and commercial performance outcomes, contributed greatly to enhancing sectoral confidence in Urban Stormwater Quality Management, particularly amongst key champions (Brown and Clarke, 2007). Among other benefits, the project was able to provide a tangible example of how developers could meet the newly established objectives of the *Urban Stormwater Best Practice Environmental Management Guidelines*, and the need to meet nutrient reduction targets (Brown and Clarke, 2007). As a result of the project's achievements, similar WSUD practices have been approved and applied elsewhere across Melbourne in both greenfield and brownfield (retro-fit) areas, often without the same conditions being placed on the design teams (Lloyd *et al*., 2002a). The Lynbrook Estate is a well-known and respected project across Australia, and has been held up nationally as a leading example of WSUD.

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Summary

The purpose of reviewing four demonstration projects in detail was to reveal any similarities and/or key differences amongst the case studies in relation to the drivers for each project, the processes involved in designing, creating and implementing the on-ground innovation and to reveal the key implications arising from each case study. Furthermore, the case study outcomes were also designed to help verify the general interview dataset.

Collectively, the four projects demonstrated how a range of different water supply and treatment technologies can be successfully implemented at decentralised scales in both greenfield and brownfield (re)development sites across Melbourne. The drivers for establishing the projects varied amongst the case studies; however, all four projects featured key individuals who had a clear vision for incorporating sustainable urban water management practices and/or organisations with a strong commitment to the implementation of sustainability principles.

Importantly, however, each case study also revealed the key challenges to achieving successful implementation. For example, project proponents encountered difficulty in securing the necessary commitment from key organisations /stakeholders that were required to operate outside of their traditional boundaries. Other challenges faced included:

- A lack of supportive regulatory and policy contexts;
- Limited (early) stakeholder engagement;
- Extended timelines – delays; and,
- Issues with technology installation/operation.

Beyond the technological issues (most of which were resolved), the major challenges encountered related to critical ‘process’ lessons. Such lessons were often a result of deficiencies with current practices, which if not addressed, could act to inhibit replication of similar developments and on-going innovation. The highly interrelated process-oriented lessons identified from the case studies can be described as follows:

- *Engage with key stakeholders early in the project.*

  The 60L Green Building and Lynbrook Estate case studies both highlighted the benefits of early and ongoing stakeholder engagement. Conversely, Inkerman Oasis demonstrates the difficulties that can be encountered when failing to engage appropriate stakeholders.

- *Need to address the regulatory and policy context of the project.*

  Overcoming regulatory and policy gaps requires project proponents to actively engage with key regulators/policy advisors to assess any fundamental limitations in adopting new approaches (i.e. a decentralised, alternative water supply approach). Key regulatory and policy gaps were identified in each case study revealing the paucity of guidance and support for decentralised water systems from lot-scale (i.e. 60L Green Building) through to precinct/ regional scale (i.e. Aurora Estate).

- *Establish a common vision and guiding principles amongst key stakeholders*.

  For example, the 60L Green Building demonstrated the importance of having a common vision, established through key guiding principles that all key stakeholders were to meet throughout the life of the project (and beyond).

- *Sharing risk profile amongst stakeholders*.

  Often government departments are hesitant to incorporate new practices/technologies, concerned they may introduce greater risk profiles. However, projects such as the 60L Green Building and Lynbrook Estate highlight how key organisations which were willing to share the risk responsibilities were fundamental to securing project implementation.

- *Approach each demonstration project as a learning opportunity.*

  All interviewees involved in the case study projects reported a range of ‘lessons learned’ from their direct experience on the project. Projects need to allow for a broad investigation of options, support a process of ‘trial and error’, and provide a space to persist in overcoming barriers. The Aurora Estate case study in particular highlighted how one organisation fundamentally changed their business operations to incorporate sustainability principles.

- *Building socio-political capital.*

  Lynbrook Estate case study highlighted the benefit of erecting signage to improve awareness amongst construction workers regarding the existence, purpose and sensitivity of the bioretention systems in the development. Inkerman Oasis and the 60L Building have also used signage to raise awareness and understanding amongst community members regarding the alternative water treatment technologies, and to help ensure no unnecessary damage to the systems occurs.

Importantly, similar themes were also identified in the outcomes from other interviews with relevant urban water practitioners not directly involved in the projects covered in this report. Many interviewees highlighted similar challenges, barriers and opportunities they had experienced in their work and called for learning mechanisms to be implemented to leverage the insights gained from such projects so that they are disseminated across the sector more rapidly.

Broad sectoral learning implications

It is important to recognise the influence the case studies reviewed have had on changing key policy guidance documents in Melbourne. For example, Lynbrook and Aurora Estates have (directly/indirectly) influenced the development and subsequent changes to the Victorian Planning Provisions, in particular Clause 56, while the others have influenced revised EPA guidelines released in recent years (i.e. *Guidelines for Environmental Management: Dual-Pipe Recycling Schemes – Health and Environmental Risk Management*). Furthermore, key individuals involved in Aurora Estate have worked in association with the Plumbing Industry Commission to set guidelines for contract plumbers working on third-pipe systems.

Cumulatively, the outcomes of these projects have successfully challenged the traditional urban water management practices and encouraged key organisations and/or stakeholders to review their business and operational mandates. The relative success of the projects in creating and influencing change in current policy and practice suggests there is great opportunity for developing a coordinated learning approach to demonstration projects, which could contribute significantly in shifting the sector towards more sustainable urban water management practices. By capturing and disseminating the lessons learned from such projects on a broad scale throughout the sector, significant gains in sustainable urban water management could be made. For example, the lessons learned through experience at Lynbrook reached much further (in terms of the sector and policy changes) through the help of the Clearwater program, which worked to pass on the knowledge developed through the project and build greater capacity, awareness and acceptance throughout the sector (and government).

Overall, the review of these four demonstration projects reveals the importance of promoting a culture of "experimentation" to induce the learning necessary for supporting the transformative changes that will embed sustainable urban water management practices in Australian cities.

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