Municipal Engineering Foundation - Victoria

Overseas study tour September 2011 to Canada, United States, United Kingdom and Singapore

Reuse of storm water - to supplement potable water system and aquifers, through roof water harvesting and aquifer storage and recharge




Peter Robertson - Director City Infrastructure, Warrnambool City Council
BE Civil, Gra Dip Municipal Engineering, MIE Aust CPEng

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1. Executive Summary

"Whisky is for drinking; Water is for fighting over" so it was alleged that Mark Twain made this remark many moons ago.

He also said, "I've seen a heap of trouble in my life and most of it never came to pass."

And so it might just be that the "water crisis" in Australia and globally is a preoccupation; something that has distracted and engaged us, rather than a real crisis.

After all, saving water, and saving rivers, makes for a good environmental campaign. And environmental campaigns can give meaning to the lives of those who would like to have something to save, or is it that we like to worry about water while sitting in our warm baths of drinking-quality water, sipping whisky!

Dorothea McKellar penned 'My Country' nearly 100 years ago, in 1904, when Australia was in drought and before most of our current water infrastructure had been developed. She wrote,

Core of my heart, my country!
Her pitiless blue sky,
When sick at heart, around us,
We see the cattle die
But then the grey clouds gather,
And we can bless again
The drumming of an army,
The steady, soaking rain.

We have, in Australia, been going through another very dry period. Prior to the drought breaking in late 2010, our newspapers were reporting that it was the nation's worst drought in more than a century.

And so began my quest to understand the implications of water use, its availability and the need for us to better manage this resource, into the future.

My topic in making the application for the fellowship though the Municipal Engineering Foundation of Victoria and its Study Tour for 2011 was based on the above[1].

Whilst the other two members[2] of the study touring party were pursuing slightly different topics, with the sites visited as part of the tour not coinciding with the topics that I was pursuing, a lot of my information was obtained prior to the trip commencing via telephone, email and contact through Australian affiliates in my topic area. Networking at the American Public Works Congress in Denver also brought further contact in this field. It should also be noted that my investigations into these relatively new topics is somewhat ground breaking in the sense that not much of this work is happening around the globe, in the context of what we are endeavoring to do around Warrnambool at the present time. It may be ground breaking in the sense of the approach to the problem but across the globe, our water management initiatives to solve the problems that it poses, is somewhat poor.

[1] Appendix A of this report contains the details of topics that were investigated as part of this study tour
[2] Katherine O'Connell - Stonington City Council and Christopher Lynn - Mornington Peninsula Shire Council

It should be also noted that the contents in this report should be taken into context of what is happening globally in terms of the financial crisis, its impact in local government across the United States of America, the United Kingdom and Canada, the Water Laws and Rights in the States, and the current reforms that are happening across the board in the UK as a result of the unprecedented floods that occurred in the midlands area in 2007.

Historically, both in the US and UK and to a lesser extent Canada, storm water and waste water (sewer) have been combined for discharge purposes. Here lies one of the challenges and an inherent difficult problem to overcome when talking about improved water quality and reuse for the portable water system.

We have very high standards' in our separation of sewer and storm water treatments throughout this country - is this high standard sustainable into the future? Treated waste water and storm water is discharged into water courses in one city / town and then extracted for portable water use by another the city /town, downstream. Whilst both these positions should be applauded, is this a more sustainable approach to manage our portable water system into the future? Will Australia accept treated effluent as part of its portable water system? Certainly this is an issue that we are facing here at Warrnambool with the Aquifer Storage and Recharge (ASR) trial currently underway, where the Environment Protection Authority of Victoria is requesting that the storm water discharged into the aquifer be of equal or greater quality than the water in the ground water system. What about the treatment that happens naturally in "mother earth"?

Climate change and a growing population, and increasing urbanisation, add to the stresses on Australia's water resources. To meet Australia's urban water requirements we need to both continue to conserve water and to diversify our sources of supply. Desalination of seawater, water recycling, increased use of groundwater, and stormwater and rainwater harvesting are being used in different Australian urban centres to augment water supply.

In Australia, as in the United States and to a lesser extent the United Kingdom, for over 40 years, there is evidence that public acceptance of water recycling via aquifer storage and recharge for drinking water supplies is strong, in marked contrast with water recycling without natural storage and treatment.

If 200GL of the Water Services Association of Australia[3] projected 800GL shortfall in water in Australian cities by 2030 were met from stormwater ASR, the cost savings in comparison with seawater desalination would be $400m per year in addition to significant environmental benefits. Seawater desalination, water treatment and water recycling plants are most efficient when operated at a constant rate. Aquifer storage may be used effectively in combination with these sources to reduce costs of meeting seasonal peak demands. Less than three per cent of urban stormwater runoff is currently harvested for use in Australian cities. In capital cities with annual rainfall in excess of 800mm, the volume of urban runoff exceeds the amount of water delivered by water mains. Water storage is the main impediment and ASR provides a solution to this where suitable aquifers are present. Currently all urban ASR is for immediate economic benefit, including by local government. No government or water utility has yet undertaken ASR to develop strategic reserves for drought and emergency supplies, even though this may be the cheapest form of augmenting urban water supplies. Recharging aquifers from mains water at times when reservoirs are approaching spill, subject to environmental flow considerations, is among the cheapest ways to build high quality drought and emergency supplies.

[3] Australian Government National Water Commission - Waterline Report 2010

There is much discussion in the 'urban planning space' of how to make our cities more sustainable; with lower energy, water and ecological footprints while maintaining the living standards we have grown accustomed to. In Warrnambool, the harvesting of rainwater from the roofs of our growing urban areas can meet **100 %** of the annual demand of these new houses. Taking this component of water away from the 10 fold increase in runoff reduces the adverse impact of development on the local rivers and streams.

Rural Australia utilises and relies on rainwater from roofs for their daily existence but larger towns and cities have a very low dependence on roof water. Backyard rain water tanks are slowly finding their way through suburbia, but to date this has had little bearing on the reticulated demand. Rainwater tanks are also limited by storage capacity, with much of the water overflowing from the tank and lost, even during small rainfall events, and there is reluctance in urban situations to use such water for potable purposes without some form of disinfection.

More recent developments have incorporated "Water Sensitive Urban Design" to reduce the peak flows and improve water quality but have not addressed the better use of this resource.

Warrnambool's regional roof water harvesting involves roof water being conveyed to untreated water storage via a dedicated pipe to mix with other untreated water. It is then treated through the existing water treatment plant to become part of Warrnambool's drinking water supply. It requires the construction of an independent roof water collection pipe network within the subdivision in addition to the surface water (stormwater) network. The collected roof water is then be mixed with other raw water supplies before treatment or be treated independently to meet drinking water standards. Either way it contributes to the drinking water supply of the city.

Numerous direct and indirect economic, environmental, and social benefits to the local area have been identified, making this project a "showcase" of sustainability for the rest of the nation through the better use of available water resources and water sensitive urban design.

Water quality improvements during aquifer storage of recycled waters are being documented at demonstration sites and operational projects in Australia and overseas. Warrnambool is one such trial that is now in operation for 6 months. The growing body of knowledge allows more confident reliance on aquifer treatment processes allowed for within the Australian Guidelines for aquifer storage. Urban stormwater stored in an aquifer for a year has been proven to meet all drinking water quality requirements and has been bottled as drinking water. Further research is needed to build confidence in the robustness and resilience of preventive measures to ensure that drinking water quality can be met reliably on an ongoing basis. Recycled water, if stored in an aquifer for a period before recovery as drinking water, provides an additional level of public health protection beyond direct reuse. Certainly this is the argument that was used in the City of Aurora's in Denver Colorado - Prairie Waters Project's case, to justify the need to meet the demand for water as part of Aurora Water's approximately $1.1 billion, 10-year capital improvement project budget, which was to strengthen the reliability of the existing water system while increasing supplies and expanding water conservation efforts.

The study tour across the board was an exciting venture; there are a lot of good things happening in Australia and it has been recognized as leading the world in some aspects and certainly in the topic that I was pursuing. It is also good to know that some of the work undertaken by Monash University is well recognized in the US, UK and Canada. In the same token, some method's used for flood management in particular the US, we could continue to learn from and to better understand their approaches in this area. The whole of life approach, the climate change scenarios are areas we could improve on. The Dutch in particular are looking at 1 to 1000 and 1 to 5000 flood return period impacts on the quality of life; the standard return intervals for design purposes in the US and UK are set at 1 in 200; we are only now considering if we should remove ourselves from the 1 in 100 criteria here in Australia.

I want to take this opportunity to thank the Municipal Engineering Foundation of Victoria and it's Trustees' for giving us the opportunity to partake on this tour. It was recognized in all places we visited, what an opportunity we as a group had in making this tour; this fact should not be lost in all its participants, both past and into the future.

Close to half the developing world is suffering from one or more diseases associated with the inadequate provision of water. These shortages are where there is real poverty in our world.

Some of the driest countries such as Saudi Arabia have enough water from desalinisation technologies. After all, we live on what has been described as the Blue Planet. Planet earth is 70 per cent covered by water.

In terms of available fresh water per capita, we have a lot of water in Australia; with most of it falling in northern Australia. According to the World Resource Institute, we have 51,000 litres of available water per capita per day. This is one of the highest levels in the world after Russia and Iceland, and well ahead of countries such as the USA at 24,000 and the UK at only 3,000 litres per capita per day. This doesn't mean we should pipe water south, but it does mean we have choices and we also happen to be living in the driest continent in the world.

2. Acknowledgments

Municipal Engineering Foundation Victoria and its Trustees

Warrnambool City Council

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Clearwater

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Essex and Suffolk Water, United Kingdom

Thames Water, united Kingdom

United Kingdom Environmental Agency

Singapore Public Utilities Board, Singapore

City of Stirling South Australia

City of Charles Stuart South Australia

Wannon Water, Warrnambool

Sinclair Knight Merz, Melbourne Australia

My Family!

3. Introduction

Climate change and population growth are reducing the reliability of traditional water supplies in Australian cities. Urban stormwater and recycled water are relatively untapped resources that could help us meet future demand.

Working with government and industry partners, the CSIRO and now a number of other Authorities' such as Monash University, has pioneered the research, development and implementation of managed aquifer recharge(MAR) and indirect potable reuse schemes in Australia. These schemes are utilising stormwater and reclaimed water to augment potable and non-potable water supplies. Recycling and Diversified Supply research has covered the technical feasibility, public health, environmental sustainability, allocation policy and economic viability of storage and reuse of water that would otherwise be discarded. This research and my study tour matters undertaken to date is focused around two distinct areas - stormwater and rainwater harvesting, and waste water recycling.

4. Stormwater harvesting

Stormwater harvesting (also known as rainwater harvesting) involves the collection and reuse of water from the stormwater drainage system. The process generally involves collection, storage, treatment to remove contaminants, and distribution. In Australia's major cities, stormwater harvesting has the potential to supply an average 265 kL of water/household/year, which could help protect against water constraints. Stormwater harvesting could also reduce impacts on urban waterways at potentially lower costs and with a reduced carbon footprint compared to high energy manufactured supplies, such as desalination.

However, stormwater harvesting has its own particular challenges due to variability of flows and water quality and a need to better understand potential contaminant inputs. Further research is needed to improve uptake and underpin investor, public and government confidence.

5. Wastewater recycling

Purifying wastewater for beneficial use is potentially one of the most secure water supplies. It involves taking wastewater and treating it to give water of a quality fit for its intended use, be that watering a golf course or as drinking water.

To ensure that recycled water schemes are safe, cost-effective and publicly acceptable, robust scientific evidence is needed to improve our understanding of potential health risks, adequacy and efficiency of current treatment processes, and community responses associated with its use.

Many communities also drink recycled wastewater in what is called "unplanned potable re-use". This happens where one community collects and treats its wastewater, the cleaned product of which is output to a river up-stream of another community using the same river as their main drinking water source.

5.1 United Kingdom Experience

There are many large towns on the River Thames upstream of London (Oxford, Reading, Swindon, Bracknell) that discharge their treated sewage into the river, which is used to supply London with water downstream. The same happens in the United States, where the Mississippi River and all its tributaries' serve as both the destination of sewage treatment plant effluent and the source of potable water.

5.2 Australian Experience

In Australia the Murray-Darling River System provides a number of examples of unplanned potable reuse. A number of farms, towns and cities draw a portion of their drinking water from and also discharge their wastewater into rivers and tributaries of the Murray-Darling System. Canberra, Albury and Wagga are examples of such cities. The Murray River is Adelaide's primary drinking water supply source.

The difference between planned and unplanned potable reuse is in how they are designed and regulated. More stringent water quality and environmental requirements are in place for the planned wastewater recycling schemes such as groundwater replenishment in order to protect public health. This is clearly the results that we are after in the trails that are being conducted here in Warrnambool.

5.3 United State Experience

In various states of America, including California, Colorado, Florida, Northern Virginia, Texas and Washington, trials have been undertaken since the 1970s and have proven to be highly successful. These trials have resulted in a number of full schemes being developed. The Prairie Waters Project in the City of Aurora in Denver is the most recent project that has been implemented in the US at a cost of $754m. The Project is one of the most advanced environmentally sustainable water supply systems in the US. The City is committed to maximizing the efficient use of its water while providing the stewardship necessary to protect this resource. While planning for the Prairie Waters Project, Aurora first looked for ways to improve the city's commitment to water conservation. As a result the city has become a leader in water conservation with aggressive programs to help encourage xeric landscaping, providing rebates of water saving appliances, and enforcing reasonable limits in outdoor irrigation. Aurora Water customers have responded well to using water efficiently and have made significant strides in cutting their water use.
Other Australian states and cities including the ACT, South Australia, Western Australia and Queensland are investigating recycled water for drinking; however these proposals involve adding the water to their dams (their major drinking water source), rather than into groundwater.

In 2009 the Queensland Government completed a $9 billion Water Grid to treat and supply recycled water to southeast Queensland. This water is used for nearby power stations and will be added to Wivenhoe Dam, Brisbane and surrounds' major water source, when combined dam levels fall below 40%.

5.4 Singapore Experience

Singapore (NEWater) has been developing recycled water plants since the late 1990s. Approximately 11 megalitres a day of water is added to a reservoir then further treated as part of Singapore's normal drinking water treatment system. This water currently provides approximately 1% of Singapore's daily requirements, and the volume of recycled water has increased to 2.5% by 2011.

NEWater is highly treated recycled water that has been strongly endorsed as a safe and sustainable source of water exceeding the drinking water standards of the World Health Organisation (WHO). NEWater was subjected to 20,000 tests over two years before it was endorsed by the WHO.

A Singapore success story and the pillar of Singapore's water sustainability, NEWater is high-grade reclaimed water produced from treated used water that is further purified using advanced membrane technologies and ultra-violet disinfection, making it ultra-clean and safe to drink.

Singapore now has five NEWater plants which can meet 30% of the nation's water needs.

By 2060, Singapore plans to triple the current NEWater capacity so that NEWater can meet 50% of its future water demand.

5.5 United States Experience - ground water

Orange County, California has recycled water for drinking since early 1976. Currently approximately 57 megalitres per day of recycled water is blended with groundwater and then pumped it into the groundwater system to replenish drinking water supplies and prevent saltwater intrusion. In 2007 the scheme was expanded to pump 265 megalitres per day into aquifers which supply up to 50% of Orange County's water.

The process used today incorporates a higher level of treatment than the original water recycling scheme, known as Water Factory 21, which consisted of lime clarification, re-carbonation, granular-activated carbon, reverse osmosis and chlorine disinfection.

The Whittier Narrows Water Reclamation Plant in California is the source water for the longest running groundwater recharge project in the United States. It provides treatment for 170 ML of used water per day, making up 35 % of the total recharge to the groundwater basin. The plant serves a population of approximately 150,000 people and replenishes the basin with water for 3.7 million people. Virtually all of the purified water is reused as groundwater recharge into the Rio Hondo and San Gabriel Coastal Spreading Grounds or for irrigation at an adjacent nursery.

The Montebello Forebay Groundwater Recharge Project in California is important because of its long duration and many health studies which were completed. The health effect studies reported that there is no discernible difference between the health of people who have been drinking the water produced by the project and the health of those who have not.

Treated wastewater from the City of Aurora in Denver Colorado is disposed of to the Colorado River filters through the riverbank into groundwater. The water is then extracted and piped to infiltration basins where it seeps through layers of soil into the aquifer. The water is recovered 2-5 years later and treated before being distributed to customers. This project has just been completed; the Prairie Waters Project will increase Aurora's water supply by 20%; delivering up to 10 thousand acre-feet (about 3.3 billion gallons) of water per year. (Detailed information about this project is contained in **Appendix B** of this report as I attended a number of Forums and a site visit during the APWA Congress in Denver).

5.6 United Kingdom Experience - environmental flows in streams

The Longford Recycling Scheme, Essex London was the first water purification project of its kind in Europe and commenced operation in 1997. The Scheme was the culmination of a project originally started in 1964 when a drought order allowed treated wastewater to be discharged to the river Chelmer instead of going to the ocean. This flow augmented the river and helped fill a reservoir. Research was then carried out to look into the feasibility of giving the waste water tertiary treatment so it would be of good enough quality to be permanently discharged to river to augment freshwater flow.

Treated wastewater is put into the purpose-built recycling plant for further tertiary treatment. The plant treats the water, removing phosphates, nitrates, ammonia, oestrogen and pathogens. Sludge is thickened through a dewatering process and then composted with straw off site and used agricultural food production. Finally, the recycled water is then discharged to augment the flow of the river Chelmer upstream of the Essex & Suffolk Water intakes.

Strict water quality control was put in place, including monitoring of viruses and oestrogens, and numerous studies have been done on the impact of the scheme on the environment and public health.

Recycled water is mixed with the water from the River Chelmer, which is abstracted at Langford, near Maldon, for Hanningfield reservoir refill where it is treated again before being put into drinking water supply. The scheme is associated with a population of up to 100,000.

Thames Water draws water from the River Thames and pumps it to a variety of bank-side storage reservoirs. On arrival at Hampton, the stored water is fed into the Grand Junction Reservoir. This small reservoir is predominantly used to blend different source water and balance the flow into the works. The water is then filtered through primary rapid gravity filters. The water from the primary filters gravitates under the Grand Junction Reservoir and six pumps lift the water into the ozone plant, where it is subjected to ozone dosing before passing to slow sand filters. Ozone is the activated form of oxygen and the dosing helps to reduce pesticide concentrations. An added benefit of ozone is to reduce the concentration of dissolved organic compounds and thus decrease the amounts of chlorine needed for disinfection.

6. Green Infrastructure in the United States and United Kingdom

Many communities in the United States and United Kingdom, ranging in size, population and geographic location, are looking for ways to assure that the quality of their rivers, streams, lakes and estuaries is protected from the impacts of development and urbanization. The investigations undertaken as part of this tour describes a number of cities and counties that are using green infrastructure approaches to reduce imperviousness and preserve natural open space throughout a watershed and at the neighbourhood scale, as well as adding green infrastructure practices at the site level.

Traditional development practices cover large areas of the ground with impervious surfaces such as roads, driveways and buildings. Once such development occurs, rainwater cannot infiltrate into the ground, but rather runs offsite at levels that are much higher than would naturally occur. The collective force of such rainwater scours streams, erodes stream banks and thereby causes large quantities of sediment and other entrained pollutants to enter water bodies each time it rains.

In addition to the problems caused by stormwater and nonpoint source runoff, many older cities (including many of the largest cities in the US and UK), have combined sewage and stormwater pipes which periodically and in some cases frequently overflow due to precipitation events. In the late 20th century, most cities that attempted to reduce sewer overflows did so by separating combined sewers, expanding treatment capacity or storage within the sewer system, or by replacing broken or decaying pipes. However, these practices can be enormously expensive and take decades to implement. Moreover, piped stormwater and combined sewer overflows (CSOs) may also, in some cases, have the adverse effects of upsetting the hydrological balance by moving water out of the watershed, thus bypassing local streams and ground water. Many of these events also have adverse impacts and costs on source water for municipal drinking water utilities.

The term “Green infrastructure” is a comprehensive approach to water quality protection defined by a range of natural and built systems that can occur at the regional, community and site scales. Linkages between sites and between practices within one site ensure that stormwater is slowed, infiltrated where possible and managed with consideration for natural hydrologic processes.

At the larger regional or watershed scale, green infrastructure is the interconnected network of preserved or restored natural lands and waters that provide essential environmental functions. Large-scale green infrastructure may include habitat corridors and water resource protection. At the community and neighbourhood scale (see photos above), green infrastructure incorporates planning and design approaches such as compact, mixed-use development, parking reduction strategies and urban forestry that reduces impervious surfaces and creates walkable, attractive communities. At the site scale, green infrastructure mimics natural systems by absorbing stormwater back into the ground (infiltration), using trees and other natural vegetation to convert it to water vapour (evapotranspiration) and using rain barrels or cisterns to capture and reuse stormwater. These natural processes manage stormwater runoff in a way that maintains or restores the site’s natural hydrology. Site-level green infrastructure is also referred to as low-impact development or LID, and can include rain gardens, porous pavements, green roofs, infiltration planters, trees and tree boxes and rainwater harvesting for non-potable uses such as toilet flushing and landscape irrigation.

6.1 Victoria's approach

Victoria's approach to Water sensitive urban design principals have led this way for some time now and the continuing work undertaken by the Clearwater Program for their vision for the water sensitive future aiming to achieve a balance between the natural and built environment, is to be applauded. To know that it is only now in the UK that this issue is being undertaken seriously and to a lesser extent in the bigger cities in the US, is credit to Australia's ingenuity and foresight to have some of these systems in place almost 10 years ago.

These processes represent a new approach to stormwater management that is not only sustainable and environmentally friendly, but cost-effective as well. Municipalities are realising that green infrastructure can be a solution to the many and increasing water-related challenges facing municipalities, including flood control, combined sewer overflows, Clean Water Act and Environment Protection requirements and basic asset management of publicly owned treatment works. Communities need new solutions and strategies to ensure that they can continue to grow while maintaining and improving their water resources.

6.2 City Seattle's approach

The City of Seattle, located on the Puget Sound in Washington State, boasts many successful green infrastructure projects and policies, many of which started out as pilot programs and grew to have a much broader application and impact. Seattle's approach includes several internal policies to require green infrastructure in public property standards, such as for street designs and capital project plans. At the same time, Seattle leverages its control of local codes and development policies to encourage and require green infrastructure on private property.

Seattle Public Utilities (SPU) is the local agency responsible for meeting National Pollution Discharge Elimination System permit requirements and it coordinates the City's Natural Drainage System (NDS) approach, which supports the use of green infrastructure at the site level and in terms of larger development planning and design.

SPU has made strategic decisions about using demonstration projects, such as the original 2nd Avenue Street Edge Alternatives (SEA) Street or the Seattle Green Factor to introduce new policies or methods for implementing green infrastructure. Many of the lessons learned from these earlier and easier projects are now being transferred to the rest of the City, including more challenging and highly urbanized areas.

7. Sensitive Water Bodies and Community Assets

In Seattle, as with most communities around the Puget Sound, the primary motivation for new stormwater management methods lies in protecting aquatic biota and creek channels as well as improving overall water quality. Coho salmon still thrive in many creeks of the Pacific Northwest, but their future health is at risk and has become a high priority for both residents and regulators. SPU takes a demand management approach by investing public resources in areas of the City with the most sensitive sub-basins and creeks, using practices that infiltrate stormwater runoff into soils, which treats water for pollutants and recharges water bodies slowly through groundwater recharge.

Seattle also chooses to use green infrastructure systems, often in the public right-of-way, in areas where surface vegetation not only manages stormwater but also adds visible community amenities. The Seattle Green Factor was originally developed for commercial cores and requires that property owners achieve 30% parcel vegetation using a defined set of weighted practices including green roofs, permeable paving and green walls that are highly visible. This weighted system reflects Seattle's emphasis on a range of benefits for the environment and for the community.

8. Stormwater Code

In the past five years, SPU has revised the City's comprehensive Drainage Plan to address flooding and water quality needs through green infrastructure source controls and to establish a long term schedule of both capital improvement and operating programs. The City of Seattle's existing Stormwater, Grading and Drainage Control Code provides guidance for flow control and water quality treatment using green infrastructure practices. In the past, Seattle has enjoyed support from the development community because requirements were so strict that they wanted cheaper ways to meet standards and found that green infrastructure offered cost savings, often through avoided grey infrastructure investments. However, Washington State's Ecology Department has recently updated the state National Pollutant Discharge Elimination System (NPDES) permit to require the use of practices that manage stormwater on site and limit on-site imperviousness.

8.1 Redevelopment

Seattle is in the process of revising and updating the Stormwater Codes and Manuals that address new and redevelopments. This update coincides with the new NPDES Phase I permit and requirement by the Washington State Department of Ecology to comply with their state-wide manual for developers. The new code will require an analysis of green infrastructure as a first evaluation in site design for all new and redevelopment plans. A fee-in-lieu policy is incorporated into this code revision that will allow developers to pay a fee in place of using detention vaults / basins for flow control. The fee amount is determined through the normal cost evaluation methods for sizing vaults / basins. SPU intends to use income from these fees for specific basin restoration or for salmon bearing creeks, as well as for incorporating green infrastructure practices into major capital improvement programs. SPU has identified key steps to creating new policies and materials for the following areas of stormwater management responsibility

● Source Control Manual ● Stormwater, Grading and Drainage Control Code ● Flow Control Manual ● Rain wise Incentive Program ● NPDES Phase I imposed by Ecology such as flow control requirements for small site developments and accompanying flow control technical manual.

The High Point redevelopment provides guidelines for future construction of publicly and privately funded homes that encourage sustainable design approaches Using a performance based approach the design meets the needs of the client and infrastructure stakeholders, and serves an ecological function cost importantly, the High Point model challenges beliefs that dense urban design and ecological performance are mutually exclusive. The City stormwater code and the High Point redevelopment project confirm Seattle's environmental commitment for sustainable development to maintain a high quality of life.



Additional photographs' of the site visit to High Point and other areas in Seattle is contained in **Appendix C** of this report

8.2 Roads

Recognizing the contribution that streets make to overall imperviousness, the City of Seattle focuses considerable staff and resources to its NDS Program. The central goals of an NDS as an innovative approach to street design is to protect aquatic organisms protect creek channels and improve water quality by slowing the flow and reducing the volume of stormwater runoff. By retrofitting and redeveloping public rights of way to mimic predevelopment hydrologic processes projects like SEA Streets and High Point collect runoff from nearby streets, roofs and other impervious surfaces to store and treat it through vegetated systems.




Various storm water treatments across Denver, Seattle in the US and Kent County in the UK, observed during the visit to these areas

8.3 Retrofits Rainwise Incentives Program

Much of Seattle's land area is privately owned properties that contribute to water quality, flow control and conveyance issues. Runoff from residences and businesses results in degraded watersheds or flooding problems downstream where SPU invests in capital project solutions. The Rain wise Incentive Program is a customer stewardship program to encourage private property owners to manage stormwater flows on site. Through educational materials and low cost incentives, such as guides workshops and discounted utility costs, SPU hopes to see customers using on-site management techniques, as listed below, to protect both public infrastructure and the environment:

●Rainwater cistern ●Downspout disconnect ●Rain garden ●Rock-filled trench ●Porous pavement

●Trees ●Compost and mulch

SPU is also investing in a Roadside Rain garden project and providing residential incentives for rain gardens and cisterns in the Ballard neighborhood.

8.4 Capital Improvement Program (CIP) Projects

The City of Seattle makes a clear connection between the use of green infrastructure for stormwater management and overall asset and demand management for all SPU sewer and drainage systems. Most major capital projects within the City, even managed by other agencies, include consideration for incorporating low-impact development (LID) and thereby gaining the multiple benefits afforded to SPU's assets, regional environmental quality and quality of life for Seattle residents.

SPU's specific asset management approach enables the utility to meet agreed-upon customer and environmental service levels at the lowest cost, considering full life-cycle costs, by investing in maintaining and replacing its multi-billion dollar infrastructure. Although conventional methods for managing stormwater can be readily calculated for costs, benefits and risks, natural drainage designs with vegetation are still being considered to relieve traditional systems, despite less predictability for cost-benefit analyses.

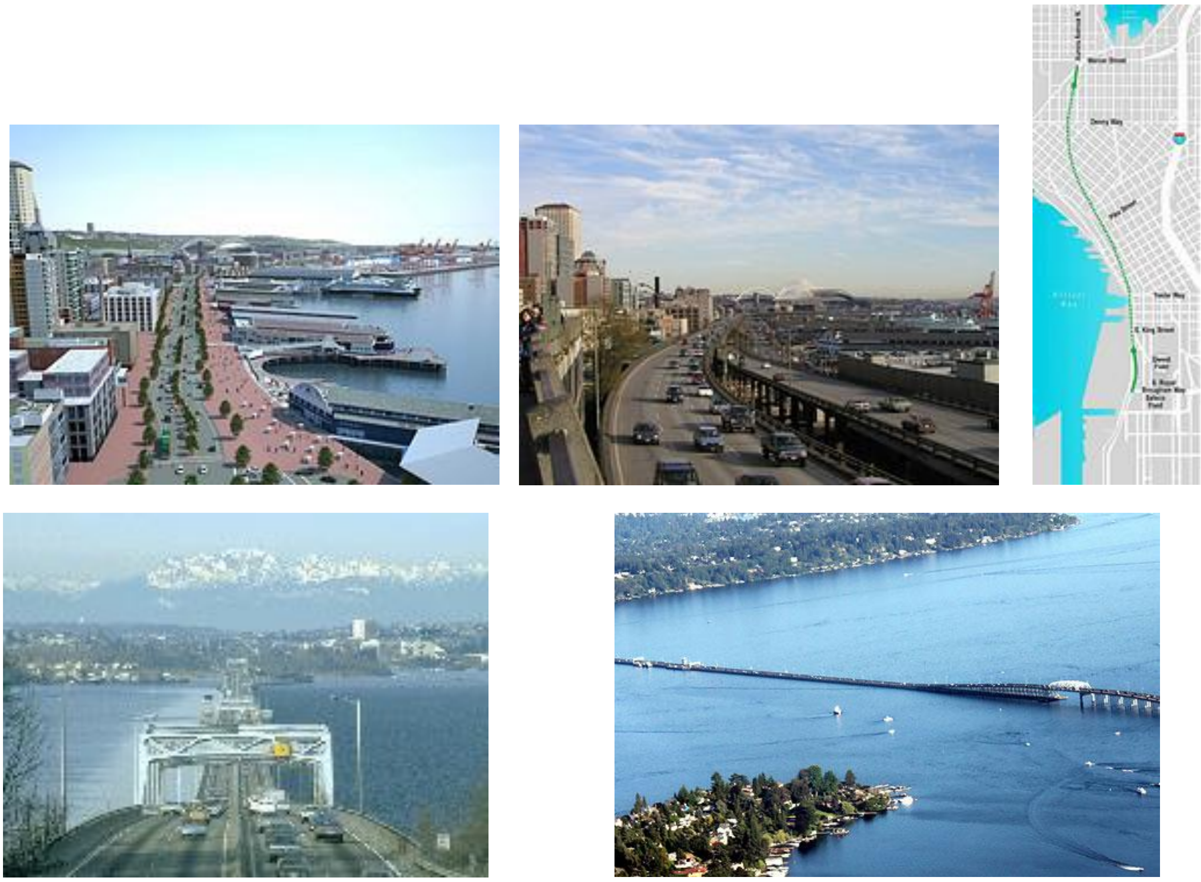
An example of LID in CIP projects is the Alaska Way Viaduct Project (see photographs below). The Viaduct is an elevated highway retrofit along the waterfront in downtown Seattle. The Washington Department of Transportation (WDOT) is responsible for a new plan to replace the existing highway structure. Despite no current plans for the Viaduct's retrofit, the Seattle Department of Planning and Development (DPD) will be working with WDOT to include low-impact development features as part of this multi-billion dollar capital improvement project. Another major project is the 520 Floating Bridge over Lake Washington, which costs more than $1 billion (see photographs below). Demand Management, which is a component of Asset Management approach, incorporates LID into all these other CIP Projects.

8.5 Implementation

As stated on SPU's Web site, "NDS cost about 10 to 20% less than traditional street redevelopment with kerb, gutter, catch basins, asphalt, and sidewalks," in large part because SPU was improving "chip and seal" streets that lacked underground infrastructure. For more developed parts of town within the combined sewer area, total costs are not as predictable.

NDS projects include SEA Streets, the Broadview Green Grid Project, 110th Cascade Project, Pinehurst Green Grid Project and High Point Project in West Seattle. The great achievement of these projects was finding a way to implement LID into street rights-of-way and reduce overall imperviousness of roadways. Most of these projects are located in the northern neighbourhoods of Seattle, which is much less dense than downtown portions of the City.

The next phase of demonstration and monitoring will be an extensive project to minimize downtown parking spaces and test the application of green infrastructure in an ultra-urban setting with a combination of green roofs, right-of-way application and methods to treat and release stormwater.



Alaska Way Viaduct Project and 520 Floating Bridge at Lake Washington

Roof garden developments in Seattle and Denver

9. Conclusion

Climate change and population growth are reducing the reliability of traditional water supplies in Australian cities. Urban stormwater and recycled water are relatively untapped resources that can and could help us meet future demand.

Working with government and industry partners, CSIRO has pioneered the research, development and implementation of managed aquifer recharge and indirect potable reuse schemes in Australia. These schemes are utilising stormwater and reclaimed water to augment potable and non-potable water supplies.

Recycling and Diversified Supply research covers the technical feasibility, public health, environmental sustainability, allocation policy and economic viability of storage and reuse of water that would otherwise be discarded.

9.1 Stormwater harvesting

Stormwater harvesting involves the collection and reuse of water from the stormwater drainage system. The process generally involves collection, storage, treatment to remove contaminants, and distribution.

In Australia's major cities, stormwater harvesting has the potential to supply an average 265 kL of water/household/year, which could help protect against water constraints.

Stormwater harvesting could also reduce impacts on urban waterways at potentially lower costs and with a reduced carbon footprint compared to high energy manufactured supplies, such as desalination.

However, stormwater harvesting has its own particular challenges due to variability of flows and water quality and a need to better understand potential contaminant inputs. Further research is needed to improve uptake and underpin investor, public and government confidence.

9.2 Wastewater recycling

Purifying wastewater for beneficial use is potentially one of the most secure water supplies. It involves taking wastewater and treating it to give water of a quality fit for its intended use, be that watering a golf course or as drinking water.

To ensure that recycled water schemes are safe, cost-effective and publicly acceptable, robust scientific evidence is needed to improve our understanding of potential health risks, adequacy and efficiency of current treatment processes, and community responses associated with its use.

9.3 Research to facilitate uptake

Across both these water supply options, there is considerable research required in:

- treatment requirements and efficacy of different treatment systems along with associated governance solutions
- improved methods for detecting pathogens (including potential real-time monitoring) and measuring the reduction of trace organics and pathogens in natural systems
- the applicability of natural treatment systems as part of a recycling scheme, including risk analysis and the application of engineered pre or post-treatment solutions to manage any residual risks

- social acceptability, trust and risk perceptions
- decision support tools that quantify economic and environmental attributes of alternative supplies
- passive sampler design for highly variable contaminant concentrations
- methods to assess impacts of water recycling on water infrastructure, aesthetics of drinking water and water ecosystems.

Here in Warrnambool, the simple process of collecting roof water and placing / storing it in the aquifer for future use has begun. Similarly, the collection of roof water and placing it in the raw water basin for portable water use has also been implemented. Little did we know the challenges that would come across us in implementing such process'.

9.4 Legislation and Regulation

Legislative responsibility for stormwater in Victoria rests with Municipal Councils meaning that without the support of the Council, no Water Authority could have pursued water a harvesting initiative.

Who assumes the responsibility for the roof water harvesting network?

Stormwater reuse is supported by Section 56.07 of the Victorian Planning Schemes - Integrated Water Management.

9.5 Who pays for this infrastructure - cost to Developers?

As part of a number of trails and initiatives with new development around Warrnambool, some developers have voluntarily installed the additional pipe network and detention tank within the subdivision at their full cost whilst some others have had part of all of their costs met by Federal and State grants as part of demonstration projects. The cost of installing the additional roof water collection network for the trials completed to date equated to $3,411/lot and $3,530/lot respectively.

It is intended that future subdividers would install the works as a requirement of subdivision. This has been in place now and we have the first VCAT challenge to this condition pending in March of 2012.

9.6 Landowner Reaction

The most common community reaction has been, "what a great idea, why hasn't it been done before now". There have been a few landowners who have asked why they should provide water free to the Water Authority and drawing parallels with the electricity "feed in tariff". The simple answer is that the roof water collection network simply collects water that would have otherwise gone to waste. Should anyone want to install a tank on their property and utilise this water then they are able to do so with the overflow from the tank directed to the roof water harvesting system.

9.7 Economic benefits

- In the majority of the cases water is pumped some distance form a suitable water source. Harvesting water locally results in reduced operating costs.
- It is a more consolidated and effective manner to harvest and use rainwater collectively than the adhoc and scattered approach of individual landowners installing individual tanks, pumps and pipework on their land.

- It is able to be implemented progressively as development (and consequential demand) proceeds in a growth corridor.
- It reduces the works required for stormwater management for Council and developers e.g. size of stormwater detention basins and treatment systems.

9.8 Environmental Benefits

- Our research in Warrnambool has indicated that it reduces the energy use and associated greenhouse emissions for transporting water for use.
- It diverts water to a beneficial use instead of running to waste and causing a downstream flooding and negative impact on local estuarine stream systems.
- It improves the environmental flows in the water courses that it is generated from.

9.9 Managed Aquifer recharge (MAR)

Australia's growing population, urbanisation and climate change will continue to drive water conservation measures and demand for alternate water supplies. MAR has the potential to reduce demand on current water supply systems and protect stressed groundwater resources. At the same time, it is generally acknowledged that the potential role for MAR has not been fully realised. In the mid-2000s, MAR schemes only existed in concentrated pockets across Australia including Adelaide, Perth and a couple of rural areas. The limited uptake and growth can be attributed to a number of key factors including

- high uncertainty of initial cost estimates compared to alternatives
- relatively high upfront costs to evaluate feasibility
- poor understanding of groundwater processes by water engineers and regulators
- regulatory barriers
- lack of demonstration sites.

The Brauerander Park project represents a strategic investment targeting a number of the above barriers to MAR. This project will support the growth of MAR schemes in Victoria, targeting knowledge gaps, providing educative resources and facilitating MAR in a wider geographic area. The project has built capacity in the skills required to design and construct MAR schemes. Regulators have also gained knowledge through this project to inform development of MAR policies and guidelines.

Importantly this scheme has demonstrated the role of MAR in a groundwater management area that is fully allocated. It shows that when MAR schemes are appropriately designed and implemented, including proper assessment and mitigation of risks, ASR schemes have a role in allowing groundwater development in areas otherwise locked to further groundwater extraction.

One of the key differences between this scheme and more common ASR schemes, such as those operating in Adelaide, is that the treatment process is relatively simple. Schemes that divert water through a wetland as part of the treatment process have additional capital and operational costs. By using only a gross pollutant trap and filter system the treatment costs of the scheme are lower. For Brauer College the harvested storm water is predominantly collected from the roof of the school, which makes it cleaner than water collected from a typical urban catchment.

Importantly, this ASR scheme is carbon friendly - the feasibility study demonstrated that the carbon footprint of the scheme is approximately five times lower than use of mains water, due to the energy in delivering (pumping) mains water to the site and the energy involved in treating the water.

10. Appendices

10.1 Appendix A - Study tour investigation topics

To understand how roof water harvesting is utilised overseas; the issues in relation to who does this water belong to, can the water be charged out to residential properties' or should a rebate be provided to the residents, and the design parameters', including water quality into the raw water basin of this collected water

- Water rights with regards to rain water harvesting
- The fundamental issues in not contaminating this water,
- a third pipe scenario are further challenges that we are facing in implementing such a scheme.
- Who pays for this pipe infrastructure and its ongoing maintenance are further issues we are challenged with.
- Understanding all aspects of integrated water management.
- Water management expertise for developed and developing countries.
- Understand the importance of integrated water management from a global to local scale.
- How integration and managerial skills are in place for planning, design and operation of water projects and facilities.
- The principles of managing water supply, wastewater treatment and urban infrastructure projects.
- Recognise the socio-economic factors affecting water solutions.
- Governance and institutional frameworks underpinning water management.

How aquifer storage and recovery in undertaken overseas, the implications to the ground water reserves; the treatment quality of the water before it's injected into the aquifer.

- Aquifer vulnerability to contamination
- Potential impairment of water rights
- Geotechnical impacts
- Aquifer boundaries and characteristics
- Recharge and recovery treatment requirements
- System operation
- Water rights and ownership of water stored for recovery
- Environmental impacts

What is in place for an operation to commence - what about:

- Operations plan

- Legal framework
- Environmental assessment
- Mitigation plan
- Monitoring plan

10.2 Appendix B - Aurora City Council, Denver - Prairie Waters Project

Like other cities in the arid West, Aurora needs drought protection. The Prairie Waters Project was the fastest, most cost-effective, and sustainable way to protect Aurora's citizens from drought.

During 2003, the city was months from needing to ration water to maintain a dwindling supply decimated by regional drought throughout Colorado.

• Innovative natural purification, environmentally smart water resource development and efficient water management has made this project *Environmentally Sustainable*.

• Colorado's volatile water market makes purchasing additional water resources time consuming and expensive. Not only is the project *Cost Effective* through developing already owned water resources, but other design and operation features work together to maximize the use of the city's funds.

• Aurora residents didn't have the luxury of time to wait for the city's water supply to hit critical levels before initiating a plan for more water resources. The Prairie Waters Project has delivered water to the city *Fast and on Time*.

The Prairie Waters Project is one of the most advanced environmentally sustainable water supply systems in the West. Aurora is committed to maximizing the efficient use of its water while providing the stewardship necessary to protect this resource.

10.2.1 Conservation

While planning for the Prairie Waters Project, Aurora first looked for ways to improve the city's commitment to water conservation. As a result the city has become a leader in water conservation with aggressive programs to help encourage xeric landscaping, providing rebates of water saving appliances, and enforcing reasonable limits in outdoor irrigation. Aurora Water customers have responded well to using water efficiently and have made significant strides in cutting their water use.

10.2.2 Planning Ahead

Drought and climate change mean water supplies in Colorado can vary a great deal. The Prairie Waters Project uses water from the South Platte River, which will be available even when other supplies are low.

10.2.3 Open Space and the Environment

The project naturally purifies its water underground. Because this process purifies the water naturally there is no waste that must be discharged back into the river.

Aurora Water works with a variety of regional watershed stakeholders, including members of the agriculture community, to share information and solicit input in order to make sure that the city's water resources are developed in an environmentally responsible way.

The Prairie Waters Project will capture water rights the city already owns, which means they will not need to acquire resources from other water rights holders, saving the city money.

At a total cost of $754 million, the project is funded through a combination of developer tap fees and rates paid by customers. The project is part of Aurora Water's approximately $1.1 billion, 10-year capital improvement project budget to strengthen the reliability of the existing water system while increasing supplies and expanding water conservation efforts.

Some water projects in Colorado can take decades to plan, permit and construct. The Prairie Waters Project was envisioned and selected because it can use water rights already owned by Aurora and can be completed very quickly. Additionally, the project meets water needs through 2020, something that maximizes city funds by investing in long-range water planning for residents.

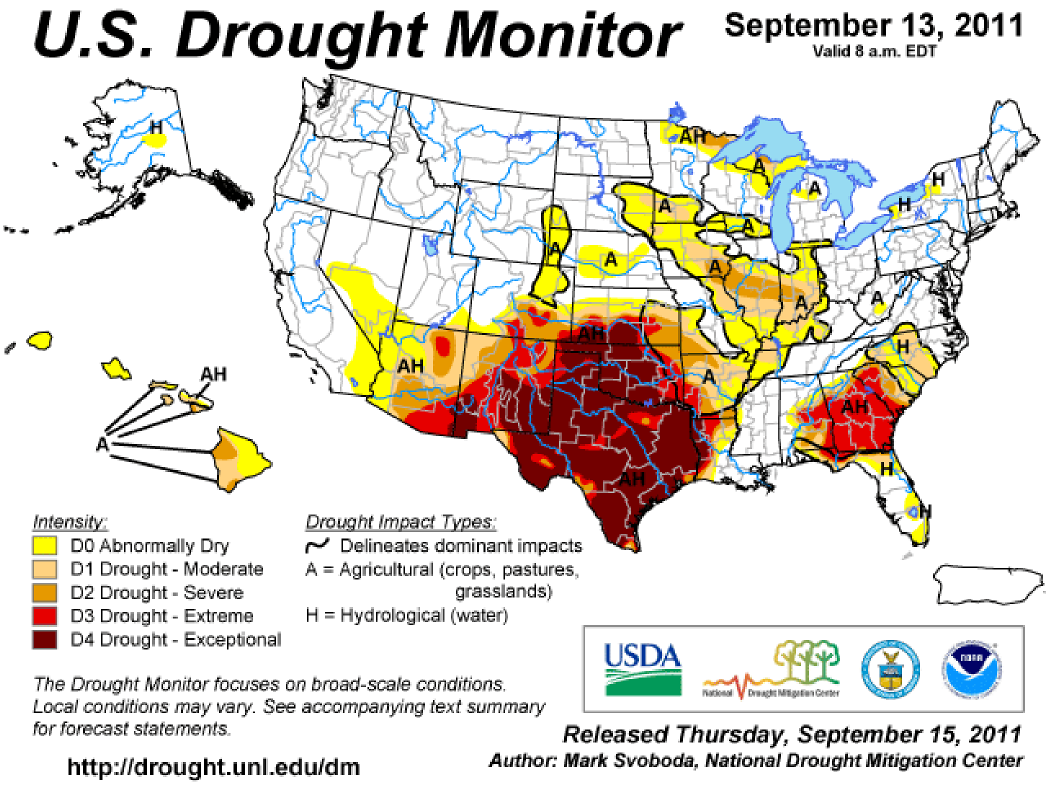
Drought impacts on regional water supplies have sent municipalities around the West searching for more supplies. Acquiring additional water has become difficult and expensive as more areas compete for resources. Aurora is ahead of the competition by investing in renewable water resources that the city already owns through developing the Prairie Waters Project.

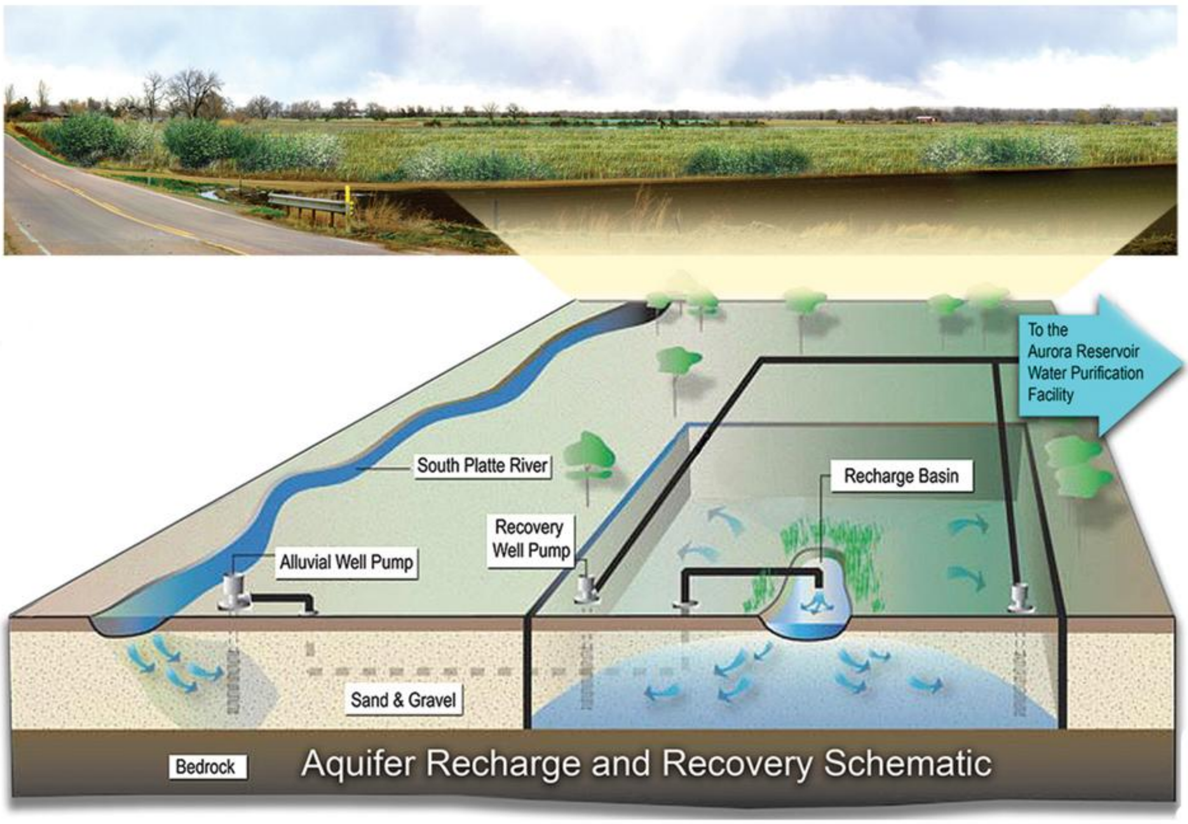
In 2002 and 2003 a historic drought significantly affected Aurora's water supplies and the city was faced with the prospect of rationing water to keep from running out of water.

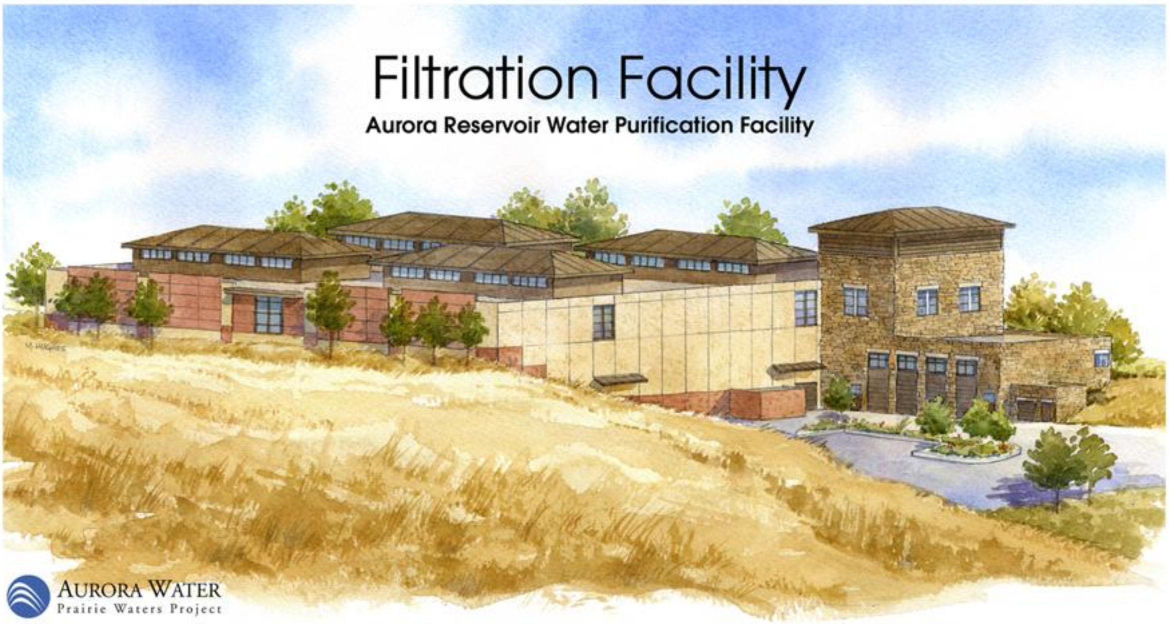
While Aurora's water system performs well in average and wet years, Aurora needs more water today to meet the needs of its businesses and families, and to protect the city from drought. Colorado's arid environment and cycles for drought makes this a challenge for all Colorado cities. Aurora's plan includes projects that will strengthen the reliability of the existing water system, expand Aurora's leading water conservation measures, increase the city's water supply, provide more water storage, and upgrade existing water infrastructure.

After implementing aggressive conservation efforts to help lessen drought impacts measures that today place the city as a conservation leader among Front Range communities Aurora evaluated more than 50 water resource alternatives and concluded that the Prairie Waters Project is the best solution for the city to obtain more water resources for today's customers.

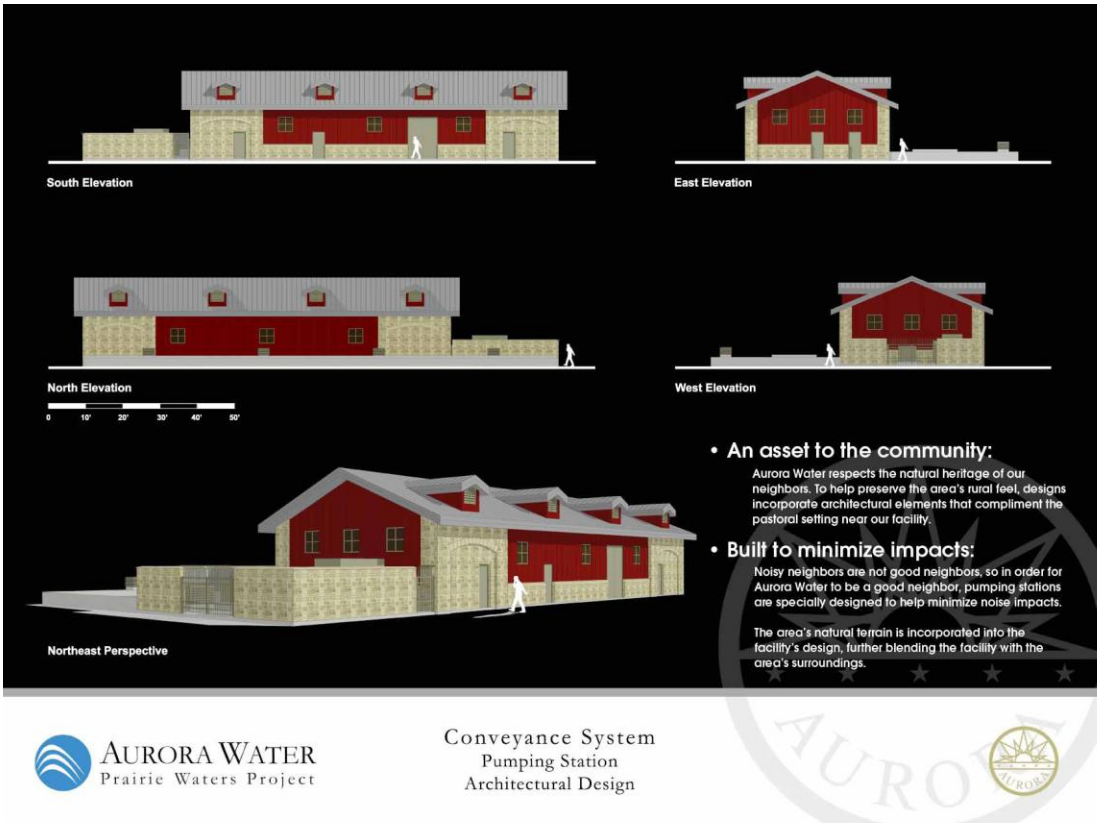
The Prairie Waters Project is the fastest, most cost-effective, and environmentally sustainable way to meet the city's immediate water needs and can be expanded in the future. Today's solutions to meet these needs require vision and cooperation with others, like farmers and ranchers, to meet the supply need for people while also protecting our environment.


U.S. Drought Monitor
September 13, 2011
Valid 8 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
A = Agricultural (crops, pastures, grasslands)
H = Hydrological (water)
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/dm
USDA
National Drought Mitigation Center
Released Thursday, September 15, 2011
Author: Mark Svoboda, National Drought Mitigation Center


To the Aurora Reservoir Water Purification Facility
South Platte River
Recharge Basin
Recovery Well Pump
Alluvial Well Pump
Sand & Gravel
Bedrock
Aquifer Recharge and Recovery Schematic

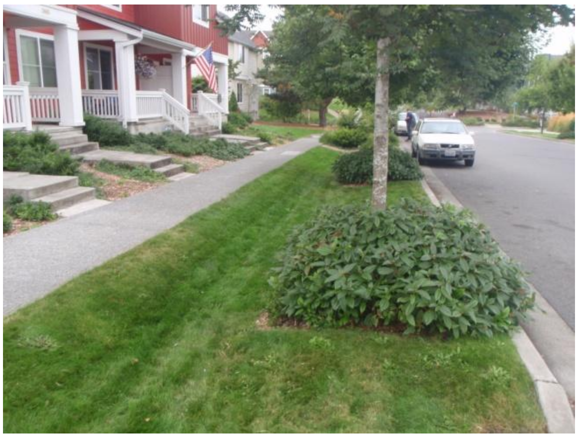


Filtration Facility
Aurora Reservoir Water Purification Facility
AURORA WATER
Prairie Waters Project



South Elevation
East Elevation
North Elevation
West Elevation
0 10' 20' 30' 40' 50'
Northeast Perspective
• An asset to the community:
Aurora Water respects the natural heritage of our neighbors. To help preserve the area's rural feel, designs incorporate architectural elements that compliment the pastoral setting near our facility.
• Built to minimize impacts:
Noisy neighbors are not good neighbors, so in order for Aurora Water to be a good neighbor, pumping stations are specially designed to help minimize noise impacts.
The area's natural terrain is incorporated into the facility's design, further blending the facility with the area's surroundings.
AURORA WATER
Prairie Waters Project
Conveyance System
Pumping Station
Architectural Design

10.3 Appendix C - Photographic journey through Seattle projects








10.4 Appendix D - Water Rights across the United States

10.4.1 Water Rights Law - Prior Appropriation

The scarcity of water in the Rocky Mountain and south-western states has led to the development of a system of water allocation very different from that which exists in regions graced with more abundant rainfall. Rights to water are established by actual use of the water, and maintained by continued use and need. Water rights are treated similarly to rights to real property, can be conveyed, mortgaged, and encumbered in the same manner, all independently of the land on which the water originates, or on which it is used. The following is a summary of the legal framework governing water rights in the arid areas of the country.

10.4.2 Doctrine of Prior Appropriation

The use of water in many of the states in the western U.S. is governed by the doctrine of prior appropriation, also known as the "Colorado Doctrine" of water law. The essence of the doctrine of prior appropriation is that, while no one may own the water in a stream, all persons, corporations, and municipalities have the right to use the water for beneficial purposes. The allocation of water rests upon the fundamental maxim "first in time, first in right." The first person to use water (called a "senior appropriator") acquires the right (called a "priority") to its future use as against later users (called "junior appropriators"). In order to assure protection of senior water right priorities and to maximize the use of this scarce and valuable resource, many states have adopted detailed schemes for the determination and administration of water rights. These state regimens define to a large extent just what a water right is.

10.4.3 Acquisition of Water Rights

To create a water right, one must make an appropriation. The essential elements of an appropriation are the diversion of water and its application to a beneficial use. A diversion is made simply by removing water from its natural course or location, or by controlling water that remains in its natural course. The requirement of application to beneficial use is satisfied by irrigation, mining and industrial application, stock watering, domestic and municipal use, and other non-wasteful economic activities.

The definition of beneficial use of water has expanded in recent years to include environmental dust control and snowmaking, among others. An appropriator may remove the water from its source and put it to beneficial use at any location. In contrast to riparian water rights, there is no geographical limitation as to place of use. Concomitantly, the ownership of land bordering a watercourse carries with it no right to the use of the water in the absence of an appropriation. To gain access to the water source and to transport it to the place of use, the appropriator must obtain an easement, either by contract or grant, or by prescription (continuous, adverse use of an existing ditch). Many state laws provide the appropriator with a private right of condemnation to secure an easement between the source of the water and the place of use.

Some western states recognize both absolute and conditional water rights. Where an appropriation has been completed by diversion and beneficial use of the water by the time the water right is adjudicated or a permit is issued, the water right is described as absolute, or completed. An appropriator may, however, obtain a conditional water right before the water has actually been used. This is useful primarily where large water projects are involved, the construction of which will take some time to complete. The appropriator may obtain a decree or permit to protect his priority before completing the appropriation in order to assure that water which was available in priority at the time the project was initiated will still be available after its completion. When a firm intent to appropriate certain water is established and certain acts in furtherance of the project are undertaken, a conditional water right may be recognized, with a priority date as of the date the first step in the project was initiated. If the project proceeds with reasonable diligence, an absolute water right can be obtained upon completion of the project, with a priority date which "relates back" to the date of the conditional right, that is, the date the project was launched.

Because the water right system is founded upon beneficial use of the resource, a lack of use can result in an "abandonment' or "forfeiture" of the right. Most western state laws provide for the loss of a water right if the water is not diverted and used for more than a specified period of time, sometimes as little as five years. Some states also require proof of an "intent to abandon" the water right. Such intent may be presumed if the non-use has occurred for an unreasonably lengthy period.

10.4.4 Types of Water Rights

Water rights are of two general types, direct flow and storage. A direct flow right is generally measured in terms of a rate of flow, not a total volume of water. For example, a direct flow right for "1.0 c.f.s." means that the appropriator is entitled to divert water from a stream or a well at a rate of not more than one cubic foot of water per second of time. He may continue to take water at this rate of flow for so long as it is physically available in priority and he needs the water for beneficial use. If a water right was initiated to irrigate a 40 acre tract, the need, or "duty" of that water right is measured as the amount of water necessary to irrigate properly that 40 acre tract.

The duty of water concept operates as a limit on the amount of water that may be diverted under a priority and is designed to prevent waste. In the example, the appropriator may divert 1.0 c.f.s. to the 40 acre tract only until it is fully irrigated. One c.f.s. of water flow is equivalent to 449 gallons per minute.

A storage water right is measured in terms of volume. For instance, the owner of a reservoir may have the right to store up to 1,000 acre feet of water each year, to be used at some later time for a beneficial use. An acre foot is that amount of water required to cover an acre of ground with one foot of water (43,560 cubic feet or 325,851 gallons). Sometimes a limit is placed on the rate at which water can be stored, such as a right which allows for storage of 1,000 acre feet, to be stored at a rate no greater than 5.0 c.f.s. Storage rights are usually only for one filling of the storage vessel per year.

10.4.5 Ground Water

Rights to water from underground vary in their treatment in the different western states. Some states treat tributary ground water-water that is hydrologically connected to surface flow - in the same manner as described above for surface water rights. Such ground water is integrated into the surface water rights priority system. Thus, a well withdrawing tributary ground water is treated in precisely the same manner as a surface diversion from a stream for the purposes of administration of water rights in accordance with the priority system. There may be a legal presumption that all ground water is tributary.

Some states recognize a completely different type of water right in non-tributary ground water, which water is coming from an underground aquifer which, because of its unique geology and/or depth below the ground surface, contains water that has no connection to any natural surface stream. Because there is no impact from the withdrawal of this water on the surface stream system, these water rights are not integrated into the water right priority system. Thus, water can be withdrawn from non-tributary wells regardless of whether senior surface water rights are receiving their full entitlement. In at least one of the western states, ownership of non-tributary ground water is tied to the ownership of the land overlying the water itself.

Many western states also have legislative schemes that allow for the designation of critical ground water areas. These are usually areas in which ground water withdrawals have been a primary source of water supply for municipal or agricultural water uses, and in which aquifer water levels are dropping. The purpose of the designation is to allow special rules to be established for protection of the aquifer resource, yet permitting some continued development, or mining, of the underground water. Priority systems may be put into place, or modified to require all water users to share the burdens pro rata. New wells may be permitted only if the proposed appropriation will not unreasonably impair existing rights from the same source.

10.4.6 Administration of Water Rights

A state agency or official is charged with the administration of all water rights within the state, usually an executive branch department of water resources or the state engineer. Additionally, there may be a "water commissioner" to administer the allocation of water on a particular stream or streams. Competition for water, as well as proper enforcement of the priority system, requires comprehensive administration. For instance, those persons with the oldest priority dates (senior water rights) can require that others stop taking water so that the water remaining in the stream system will reach the diversion works of the senior users. This type of demand by senior water rights is known as a "call." In times of shortage when senior water rights are calling for water, water users may be shut off in inverse order of priority by order of state administrators. The predicted administration of a water right must be considered in the evaluation of the yield that can be expected from that water right, or its value.

10.4.7 Replacement Plans

The laws of several of the western states provide for replacement plans which are schemes to balance new uses of water with the dedication of other existing water rights to the stream, so that the stream, as a whole, suffers no net decrease. A replacement plan is most often used to allow the out-of-priority diversion of water from the tributary stream system and the replacement of the depletion caused by that diversion from some other source. Sources of replacement water include senior direct flow water rights no longer used for their original purpose, non-tributary ground water, or water stored in a reservoir and available for later release. Approval of a replacement plan will permit the water user to continue diversions of water when curtailment would otherwise be required to meet a valid senior call for water.

10.5 Appendix E - Sustainable Urban Drainage Systems in the United Kingdom - SuDS

The Construction Industry Research and Information Association (CIRIA), is an independent member based, not-for-profit association operating across market sectors and disciplines which delivers a programme of business improvement services and research activities for members and those engaged with the delivery and operation of the built environment, across the United Kingdom.

Drainage systems can be developed to contribute to sustainable development and improve urban design, by balancing the different issues that should be influencing the development of communities. Surface water drainage methods that take account of water quantity, water quality and amenity issues are collectively referred to as Sustainable Drainage Systems (SuDS). SuDS are a sequence of management practices, control structures and strategies designed to efficiently and sustainably drain surface water, while minimising pollution and managing the impact on water quality of local water bodies. These systems are more sustainable than conventional drainage methods because they:

- Manage runoff volumes and flowrates, reducing the impact of urbanisation on flooding
- Protect or enhance water quality
- Are sympathetic to the environmental setting and the needs of the local community
- Provide a habitat for wildlife in urban watercourses
- Encourage natural groundwater recharge (where appropriate).

Sustainable drainage is the practice of controlling surface water runoff as close to its origin as possible, before it is discharged to a watercourse or sewer. This involves moving away from traditional piped drainage systems towards softer engineering solutions which seeks to mimic natural drainage regimes. Sustainable drainage techniques have many benefits such as reducing flood risk, improving water quality, encouraging groundwater recharge and providing amenity and wildlife benefits. For a drainage scheme to be termed ‘sustainable’ it must meet the following three criteria advocated by Construction Industry Research and Information Association (CIRIA), ie Pollution Reduction, Landscape & Wildlife Benefit and Flood Reduction.

10.5.1 What SuDS techniques are available?

When designing a site’s drainage scheme the type(s) of SuDS techniques selected should aim to meet all three of the above criteria. The following table depicts a hierarchical approach to SuDS selection with the most sustainable techniques located at the top of the Table and the least sustainable at the bottom. It can be seen that the most sustainable techniques meet all three SuDS criteria. As part of a site investigation it should be explored which of these techniques could be applied to the development in question.

Before the building layout is decided it is important that land is first allocated to accommodate these SuDS requirements. A site’s drainage design can be made up of a range of SuDS techniques. SuDS systems need to be carefully designed to ensure that they provide habitat for flora and fauna as well as reducing flood risk and improving water quality.

10.5.2 The SuDS Hierarchy

Most Sustainable SuDS technique Flood Reduction Pollution Reduction Landscape & Wildlife Benefit

Living roofs Basins and ponds
- Constructed wetlands
- Balancing ponds
- Detention basins
- Retention ponds

Filter strips and Swales Infiltration devices
- soakaways
- infiltration trenches
and basins

Permeable surfaces and filter drains
- gravelled areas
- solid paving blocks
- porous paviors

Least Sustainable Tanked systems
- over-sized pipes/tanks
- storms cells

10.5.3 Flood Reduction

The Thames Region Catchment Flood Management Plan has shown us that over 215,000 properties in the Thames catchment are at risk of flooding during a 1% flood. Due to heavy urbanisation little room is left to build new flood defences, it is therefore vital that we place a greater emphasis on managing flood risk. Controlling the rate at which water runs off new developments is an important means of managing and reducing flood risk in this catchment.

10.5.3.1 Our position on sites greater than 1ha

Our position on sites greater than 1 hectare is that a drainage design strategy should be carried out at the outset to identify the options for the design of the surface water drainage system and how it will affect the site layout. This strategy should be submitted to us as part of a Surface Water Flood Risk Assessment for our approval prior to making a formal planning application. The following requirements apply to greenfield and brownfield sites alike and also sites which drain to surface water sewerage systems or combined sewers.

10.5.3.2 Applying the principles of SuDS

It must be demonstrated how the principles of Sustainable Drainage Systems have been applied to the development in line with the guidance contained in Annex F of PPS25 'Development and Flood Risk' (which supersedes Appendix E of PPG25). The hierarchical approach to SuDS selection depicted on the previous page should be used at the site investigation stage to help select the most sustainable drainage techniques for the site. At this stage land should be set aside specifically for SuDS. Traditional piped/tanked systems are not true SuDS techniques and should only be considered if it can be justified that all sustainable options in the hierarchy are not possible. We are unlikely to accept pumped drainage systems as they are not sustainable.

10.5.3.3 Drainage design criteria

It is our aspiration that the drainage proposals for a site would be designed to reduce runoff rates by achieving the following criteria:

• Seek greenfield discharge rates on greenfield sites, and on brownfield sites (where possible). We would invite the applicant to submit calculations using the methodology detailed in R&D Technical Report W5-074/A/TR1.
• Demonstrate that opportunities to implement sustainable drainage techniques at the site have been maximised.
• Demonstrate that the surface water drainage system can accommodate any storm event up to the critical duration 1 in 100 year storm event for the site without the flow balancing system being bypassed, whilst also taking into account PP25's climate change requirements. Sufficient information must be provided to demonstrate that the critical duration storm event has been used.
• Demonstrate that surface water discharges to watercourses do not exceed a velocity of 1m/s.
Health and safety is often cited as barrier to the use of ponds as SuDS. This reasoning is not justified and is not likely to be accepted by us because ponds need not be deep and can de designed so as not to be dangerous.

10.5.4 Pollution Reduction

Conventional surface-water drainage can lead to a deterioration in the water quality of rivers and streams. Pollutants are transported from impermeable areas to receiving waters either by surface flow and flow through pipes or via sub-surface paths where runoff is infiltrated reaching the groundwater table. Impermeable surfaces collect pollutants from many sources e.g. cleaning activities, wear from tyres, deposition from vehicle exhausts, oil leakage, illegal disposal of chemicals and oil. The Water Framework Directive (WFD) places an emphasis on member states to improve the whole water environment and promote the sustainable use of water for the benefit of people and wildlife alike. Designing SuDS systems can help to achieve the goals of the WFD as they can be used to trap and treat pollutants and reduce river pollution. Here are a few examples of SuDS techniques which treat water pollution:

10.5.5 Permeable surfaces and filter drains

Designed to allow water to drain through to a sub-base at a faster rate than rain falls. The sub-base stores water and either infiltrates into the ground or drains to a discharge point. Pollutants will be washed into the device and the sub-base will filter out any solid particles.

10.5.6 Filter strips and swales

These are sloping vegetated areas or broad shallow channels that water runs along when it has been raining but which remain dry when it is not raining. As runoff flows across the surface it is filtered and trapped by vegetation which traps silt and solid contaminants.

10.5.7 Basins, ponds and wetlands

These techniques are either dry most of the time (basins) or permanently wet (ponds and wetlands) and are used to attenuate water from a development. Runoff is held back long enough for solids to settle and plants such as reeds can be used to treat the pollutants.

10.5.8 Infiltration devices/soakaways

These devices make use of the ability of soil to absorb water and encourage infiltration by having a large surface area to drain water through. Soakaways are beneficial in that they recharge aquifers. Storage can either be in an underground chamber with holes in the sides and base or within the voids of a volume of coarse crushed rock. As runoff soaks into the ground it is filtered and biological action reduces organic pollutants. It is vital that any proposal to use soakaways is first agreed with our Groundwater and Contaminated Land Team in order to ensure that sensitive aquifers do not become polluted.

10.5.9 Additional Benefits of SuDS

10.5.9.1 Groundwater recharge

Ground contamination and Source Protection Zone issues need to be addressed as a key issue in the early appraisal of the drainage options especially if infiltration devices are proposed, this is to ensure that there are no barriers to their usage (e.g. ground contamination).

10.5.9.2 Combined sewerage areas

It should be noted that some areas (e.g. Central London) are drained by combined sewers where a single pipe conveys foul sewage and surface water runoff. These systems usually carry sewage to treatment works with an overspill mechanism which allows some sewage to flow into river during heavy rain. If your site falls in a combined sewerage area then opportunities should be sought to drain surface waters into surface water sewers or rivers. This is the most sustainable option as water does not have to travel long-distances nor does it have to go to a treatment plant. This will ensure that the amount of water entering these often overloaded systems is minimised.

10.5.10 Landscape and Wildlife benefit

SuDS techniques can be used to provide wildlife and ecology benefits as well as aesthetic benefits. Properly designed SuDS schemes can create habitats and increase biodiversity. Swales, ponds and filter strips can be colonised by a variety of wetland plant, fish, animals and invertebrates. They also provide a place for people to enjoy nature and relax. The key to the success of a SuDS scheme is designing them correctly.

10.5.10.1 Ponds, swales and filter strips

Ponds and wetlands are probably the most important SuDS technique in terms of providing amenity and wildlife habitat, however, it is very easy to get their design wrong. CIRIA document 609 provides useful guidance on pond design. Between 50-70% of a pond should have water 1-1.5m deep to encourage oxygenation, with deeper fish pools (2.5m deep) and 25% of pond surface should form a shallower bench. These varying water depths should be randomly distributed to provide a rich mosaic of habitats.

10.5.10.2 Suitable Native Plants

We can provide advice on what types of plant species would be suitable for different SuDS schemes and how to design the SuDS system for wildlife. The planting of SuDS should meet the following objectives:

- Create optimum habitat structure
- Use local provenance species and avoid alien species
- Provide erosion control
- Silt interception
- Treat pollutants
- Provide physical barrier to access
- Easy to maintain

10.5.10.3 Living Roofs

Living roofs (also called green roofs) are a great way to meet all of the three SuDS criteria and are ideal on most flat or gently sloping roofs. A living roof is a multi-layered system covering the tops of buildings with vegetation. These roofs can be designed to be extensive and covered with low-growing low-maintenance plants. Alternatively, intensive more landscaped roof systems can be designed. Extensive roof systems provide the greatest environmental benefit and should be planted with species which tolerate poor soils, acidic conditions, well drained systems and can colonise quickly.

10.5.10.4 Amenity / Recreation

Well-designed SuDS schemes can also provide recreational benefits and a sense of wellbeing to people as they promote outdoor exercise and the following activities such as: dog walking, education (e.g. pond dipping), board walks and visual/landscape enhancement. Research by CABE Space entitled 'Does money Grow on Trees' has demonstrated that access to green space can increase property prices by as much as 34%. This demonstrates the importance of green space to homebuyers and emphasises the economic benefits of SuDS.

10.6 Appendix F - Sir Michael Pitts recommendations in the 2007 floods in the United Kingdom

This is an edited version of a progress report that demonstrates the continued commitment to improve the way the agencies prepare for, and deal with, flooding following Sir Michael Pitt's review into the 2007 summer floods.

Based on the six themes identified by Sir Michael, some of the key set out below key points on progress made by the Government in the last six months and work which are expected to be delivered shortly.

10.6.1 Knowing when and where it will flood

The Government's response referred to the plans by the Environment Agency and Met Office to establish a joint centre to bring together weather forecasting and flood prediction.

With the help of £5 million funding from Defra, the new centre is already making a difference in terms of our ability to deliver flood alerts with longer lead times and more accurate, targeted information to emergency responders around the country.

The Environment Agency has also made significant progress in modelling and predicting river and surface water flooding. The Met Office is on track to deliver a body of work to improve its ability to forecast and predict weather, with a focus on improving warning lead times of localised intense rainfall events by 6-12 hours.

10.6.2 Reducing the risk of flooding and its impact

Since summer 2007 the Environment Agency has increased flood protection for an additional 57,950 properties in England, through 85 flood defence schemes.

The Government has published its draft Flood and Water Management Bill for consultation and Pre Legislative Scrutiny. This will, amongst other things, give county and unitary local authorities a leadership role in local flood risk management. Working with local partners, they will need to set out local strategies for flood risk management, establish asset registers and take the lead in investigating local flooding incidents.

The Government will also shortly publish proposals for restricting impermeable surfaces on commercial premises, and options for back gardens, with the aim of reducing surface water runoff. We are also exploring options, for consultation this summer, on how amended Building Regulations could be used to ensure that new or refurbished buildings in high flood risk areas are made flood resistant or resilient.

The Government has also extended eligibility for home improvement grants and loans to include resilience and resistance measures through establishment of a property level grant scheme.

10.6.3 Being rescued and cared for during an emergency

The Environment Agency has made good progress in determining improvements they will make to their flood warning systems. This includes changes to public flood warning messages as well as new advisory services to give more specialised information, and longer lead times to emergency response organisations. Through the new Flood Forecasting Centre, the Met Office and the Environment Agency are now issuing daily national Flood Guidance Statements to flood emergency responders, including local authorities, emergency services and key utility service providers; this service provides people with a five day forecast for potential flooding. Other services, including Extreme Rainfall Alerts are continuing to be provided to an increasing number of organisations. The Environment Agency is also working with infrastructure operators, trialling a tool that identifies their sites at risk when flood warnings are issued.

Good progress has been made in developing a national flood rescue asset register and the outline of a UK Flood Rescue Operations Framework. The Government is supporting this work through the Flood Rescue National Enhancement Project involving the various organisations across England, Wales and Scotland who provide flood rescue operations and services.

10.6.4 Maintaining power and water supplies and protecting essential services

The Government has made good progress in producing inundation maps for all 2092 large reservoirs in England and Wales. They are on course to complete this work by the end of this year and to provide Local Resilience Forums (LRFs) with a bundle of information, including: the inundation maps; guidance and templates for preparing off-site reservoir flood plans; a national protocol for sharing reservoir inundations maps; a prioritised list of sites showing highest to lowest risk reservoirs (based on consequence of failure); and guidance for warning and informing the public.

10.6.5 Better advice and help to protect families and homes

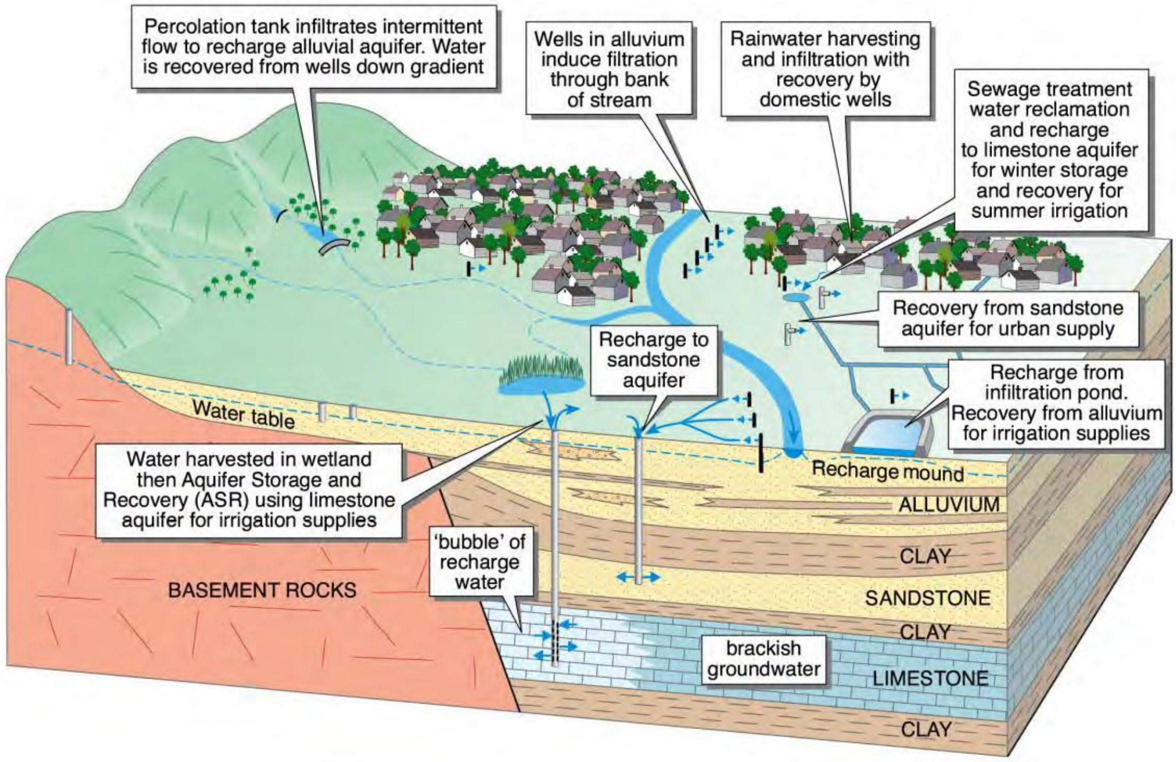
The Environment Agency has continued to improve advice to householders and businesses on flood prevention and mitigation. The Agency has also changed the way they will carry out their public information campaign, in the light of the Pitt report. For example, they have identified eight LRFs throughout England and Wales where they will work with partners and local communities to raise awareness of flooding and of measures to mitigate the impacts. Furthermore, the Government is establishing a programme to support and encourage individuals and communities to be better prepared and more self-reliant during emergencies.

10.6.6 Recovery

The Department of Health made available, in December 2008, a single set of health guidance for householders and businesses, drawing on advice from the Drinking Water Inspectorate, Food Standards Agency, Environment Agency and Health and Safety Executive. In addition, the Government has made significant progress in producing (for publication later this summer) updated Emergency Response and Recovery Guidance. This will set out:

- the principle of establishing Recovery Co-ordinating Groups, with agreed aims and objectives, from the outset of a flooding incident;
- clarification on which bodies should take the lead in multi-agency planning and response for severe weather emergencies;
- how Government Offices can best provide advice to areas dealing with severe flooding and secure support from experienced organisations;
- new arrangements for recovery and how LRFs can plan, train and exercise on that basis;
- an agreed framework for reporting on local recovery to the centre;
- guidance on producing monthly summaries of recovery progress including, where possible, the numbers of households still displaced from all or parts of their homes; and
- new funding principles.

10.7 Appendix G - Managed Aquifer Recharge



Managed aquifer recharge (MAR) is adapted to the local situation, and is usually governed by the type of aquifer, topography, land use and intended uses of the recovered water. This diagram shows a variety of recharge methods and water sources making use of several different aquifers for storage and treatment with recovery for a variety of uses. An understanding of the hydrogeology of the locale is fundamental to determining options available and the technical feasibility of MAR projects. Recharge shown here occurs via wells, percolation tanks and infiltration basins. (*Adapted from Gale, 2005, with permission)* There are a large number and growing variety of methods used for MAR internationally. Those currently in use in Australia are:

Aquifer storage and recovery (ASR): injection of water into a well for storage and recovery from the same well. This is useful in brackish aquifers, where storage is the primary goal and water treatment is a smaller consideration (for example Grange golf course, South Australia).

Aquifer storage, transfer and recovery (ASTR): involves injecting water into a well for storage, and recovery from a different well. This is used to achieve additional water treatment in the aquifer by extending residence time in the aquifer beyond that of a single well (for example Parafield Gardens, SA). **I**

infiltration ponds: involve diverting surface water into off-stream basins and channels that allow water to soak through an unsaturated zone to the underlying unconfined aquifer (for example Burdekin Delta, Qld).

10.8 Appendix H - Flood and Water Management Act - United Kingdom

10.8.1 Groundwater Issues

10.8.1.1 Groundwater flooding and the Flood & Water Management Act

In April 2010, the Flood & Water Management Act became law. The Act, which applies to England & Wales, aims to create a simpler and more effective means of managing the risk of flood and coastal erosion. The Act also aims to help improve the sustainability of our water resources and protect against potential droughts. This article addresses the flooding aspect of the Act, highlighting those provisions that relate to the management of the risk of groundwater flooding. The article also explains how the requirements of the EU Floods Directive are being implemented across the UK

10.8.1.2 Aims and drivers for the Act

Flooding in Oxford, January 2007. David Macdonald, BGS © NERC 2007

The Flood & Water Management Act aims to provide better, more sustainable management of flood risk for people, homes and businesses, help safeguard community groups from unaffordable rises in surface water drainage charges and protect water supplies to the consumer.

The Act had several drivers. It was recognised that the flood and coastal erosion risk management and reservoir safety legislation reflected outmoded approaches and organisational structures, with their roots in the 1930s and 1940s. Sir Michael Pitt's Review of the summer 2007 floods identified clear gaps in the way that flood risk is managed, particularly in relation to surface water and groundwater flooding and on the need for a more risk-based approach to reservoir safety. There is also a need to adapt to climate change which is predicted to increase flood and coastal erosion risks through rising sea levels, changing patterns of rainfall, flood flows in rivers and groundwater levels. The Act was meant to address the requirement to transpose the EU Floods Directive in to law in England & Wales. However, as the deadline for transposition was not going to be met, this was achieved through The Flood Risk Regulations 2009. It is proposed to consolidate these regulations with the relevant provisions from the Flood and Water Management Act and appropriate existing legislation as soon as possible to create a single coherent set of provisions dealing with flood risk assessment and management. Note, significant changes were made to the Flood and Water Management Act as a result of the consultation exercise which was undertaken earlier in 2009.

10.8.1.3 Roles proposed under the Act

The Act clearly sets out which bodies are responsible for managing flood risk. The Environment Agency (EA) has a strategic overview role while local authorities have a new leadership role in local flood risk management. As trailed in Making Space for Water and reiterated in Sir Michael Pitt's Review, the EA's strategic overview role applies in relation to all sources of flooding – that is river (main river and ordinary watercourse), sea water, surface run-off and groundwater, as well as coastal erosion and flood risk from reservoirs. Under this strategic role, the duties and powers of the EA, the lead Competent Authority under the EU Floods Directive, includes:

- setting out of a national strategy for flood and coastal erosion risk management;
- developing the methods, framework and tools to understand and manage flooding from all sources;
- supporting the roles of local authorities and others in flood and coastal erosion risk management (FCERM), by providing them with information and guidance;
- assessing flood and coastal erosion risk on a national basis and determine spending priorities to manage those risks as well as allocating relevant funding in accordance with the priorities;
- consenting and enforcement powers in relation to any works or activities by any person which may directly impact on flooding from main rivers and the sea;
- responsibility for flood warning for all forms of flood risk.

There are significant challenges here in relation to groundwater flood risk management, including building the understanding of flooding mechanisms, developing the management tools and addressing flood warning.

Groundwater flooding, Compton, Berkshire, January 2001
Jude Cobbing, BGS © NERC 2001

The Act ensures that, for the first time, one body is accountable for the delivery of coordinated local flood risk management so as to minimise the risk of a repeat of the floods in Summer 2007. Local flood risk covers flooding from an ordinary watercourse, surface runoff and groundwater. This local management role is given to County and unitary local authorities (LAs) which lead and are accountable for ensuring effective management of these local flood risks. The LAs in turn rely on information from other public and private bodies, such as Internal Drainage Boards, water companies and emergency services, which have a duty to co-operate and share information. The LAs have powers to do works for surface run-off and groundwater flood risk and also to maintain or restore natural processes and manage water levels in relation to these sources of flood risk. These are identified and managed as part of locally agreed work programmes. The Act creates new Regional Flood and Coastal Committees which provide democratic input into local decisions and help coordinate flood and coastal erosion risk management.

10.8.2 Transposing the EU Floods Directive

The EU Floods Directive came into force in November 2008. It followed major flooding across Europe in recent years. Member States were required to transpose the requirements of the Directive into UK law by November 2009. As explained above, as the provisions of the Flood and Water Management Act did not meet the deadline for transposition, the requirements of the Directive were met by the Flood Risk Regulations 2009. The EC Floods Directive was brought into force in Scotland through the Flood Risk Management (Scotland) Act 2009 and in Northern Ireland through The Water Environment (Floods Directive) Regulations (Northern Ireland) 2009.

The Directive requires member states to develop and update a series of tools for managing all sources of flood risk, in particular (further detail of the purpose and timing in Figure 2):

- preliminary flood risk assessments (PFRAs);
- flood risk and flood hazard maps;
- flood risk management plans;
- co-ordination of flood risk management at a strategic level;
- improved public participation in flood risk management; and
- co-ordination of flood risk management with the Water Framework Directive.

Output	Purpose	By
PFRA - Preliminary Flood Risk Assessment	To review historic flooding and its potential future impact drawing on available or readily derivable information	22 December 2011
PFRA - Significant risk areas	To identify areas that are at potentially significant flood risk	No formal deadline, but need to allow sufficient time for mapping
FHM – Flood hazard maps	To show the possible extent of flooding under different scenarios in significant risk areas	22 December 2013
FRM - Flood risk maps	To show the potential impact in significant risk areas	22 December 2013
FRMP – Flood Risk Management Plan	Defining objectives and measures to decrease the likelihood or impact of future flooding	22 December 2015
PFRA/FRM/FHM/FRMP	Updates including impact of climate change	Every 6* years thereafter

*The first review of the PFRA is due in 2018, but then every 6 years after that.

10.8.3 Outputs and deadlines for implementing the EU Floods Directive

In England & Wales, LAs are responsible for preparing PFRAs for ordinary watercourses, surface run-off and groundwater flood risk. Areas of significant risk should also be identified by the LAs, with EA support, however, to ensure consistency, prioritise investment and minimise the impact of a dispute, there should be external involvement in the final selection of significant risk areas. The Floods Directive provides some flexibility in determining which flooding scenarios need to be mapped. For example, it states that where groundwater flooding is the only risk, mapping may be limited to low probability scenarios. There are several types of flood risk management plan already produced or in development, which would meet the purposes of the Directive to decrease the likelihood or impact of future flooding. These will need to be co-ordinated to ensure that measures and objectives set are consistent; the EA in its strategic overview role should perform this task. LAs will be required to develop strategies for local flood risk management.

10.8.4 Groundwater flooding and the Act

The need to improve the management of groundwater flood risk in the UK was identified through Defra's Making Space for Water strategy. The review of the July 2007 floods undertaken by Sir Michael Pitt also highlighted that at the time no organisation had responsibility for groundwater flooding. These drivers, and the inclusion of groundwater flood risk management within the EU Floods Directive, have meant that the Act has a significant component which addresses groundwater flooding.

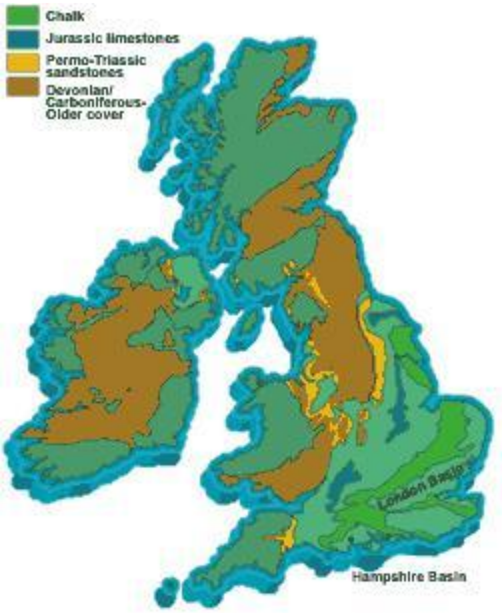
The means by which groundwater flooding risk is to be addressed by the Act has already been covered above but to summarise the key aspects are:

- the strategic role in flood and coastal erosion risk management given to the EA includes groundwater flooding;
- the EA's duties include the development of methods, framework and tools to understand and manage flooding from all sources, including groundwater;
- the EA is responsible for flood warning, so where it is identified that there is a requirement for groundwater flood warning, the EA will take the lead;
- the County and unitary local authorities (LAs) have responsibility for addressing groundwater flooding risk locally. They will be responsible for undertaking preliminary local flood risk assessments including groundwater, for assessing where these risks are significant, for mapping the associated risk where relevant and for developing local flood risk management plans, as required by the EU Floods Directive.
- the EA will support the LAs in their responsibilities relating to local flood risk management.

10.8.5 Further reading

Defra's pages on the Flood & Water Management Act
Water UK's web pages on the Flood and Water Management Act
Making Space for Water Strategy
Pitt Review: Lessons Learnt from the floods of summer 2007
EU Floods Directive

10.8.6 Groundwater Issues



10.8.6.1 Implications of the Water Act 2003

Background

The Environment Agency of England & Wales issues abstraction licences to individuals and organisations, which authorise the abstraction of a given volume of water, with conditions aimed at protecting the environment and other abstractors' needs. This legislative framework dates back to the 1960s.

Drought during the mid-nineties resulted in the 1997 Water Summit, producing a 10-point plan on improving water management. The review led to the publication in 1999 of 'Taking Water Responsibly'. This signalled important changes including:

- The Environment Agency's National Water Resources Strategy – 'Water Resources for the Future – A Strategy for England and Wales'
- Water Company Drought Plans
- All new licences to be time-limited
- Catchment Abstraction Management Strategies

The Water Act is the final element of the Government's strategy to modernise the regulatory framework in England & Wales. The Act heralds a new era in the management and regulation of water resources. It aims to provide a modern, efficient and robust legislative framework to facilitate both sustainable water resources management and economic growth through the new provisions it contains.

The Environment Agency is the leading public agency for protection and improvement of the air, land and water environment in England and Wales. Within this broad remit they are responsible for strategic water resources planning and the management of water resources through the abstraction licensing system. The Agency will be responsible for implementing many of the provisions of the Act.

10.8.6.2 Key Features of the Water Act affecting Groundwater

- All small abstractions, generally under 20 cubic metres per day (m^3/d), will not need a licence.
- Dewatering of mines, quarries and engineering works, use of water for trickle irrigation and abstractions in areas currently exempt will need a licence. The transfer of water for navigation will also need a licence.
- Three licence categories - full, transfer and temporary - replace the single licence used at present.
- The licence application process will be simplified, with the Environment Agency taking on much of the responsibility
- All abstractors now have responsibility not to let their abstraction cause damage to others. Damaging licences can be amended or revoked without compensation after 2012. Unused licences may be revoked without compensation.
- Water companies and the public sector have a new duty to promote water conservation. The Government will monitor performance.
- Water Companies will be required by law to develop, consult upon and publish water resource management and drought plans.
- The Act opens up the market for supplying water to industrial/commercial customers with water supplies of greater than 50 Ml/a.
- The Act places the pollution control function of The Coal Authority on a statutory basis and provides them with a number of statutory powers in pursuing these functions

The Act introduces many varied and complex provisions. As with most modern statutes, these provisions do not all come into effect immediately. Commencement Orders are required, which will be promoted by the Department for Environment Food and Rural Affairs (DEFRA) at an appropriate time to ensure an orderly introduction of the new measures. Different commencement dates can apply to different provisions.

For more detailed information or interpretation, please refer to the Environment Agency's booklet 'The Water Act 2003 – Modernising the Regulation of Water Resources'.

Links

- Water Act 2003
- DEFRA Water Act page
- Environment Agency's Water Resources pages

10.9 Appendix I - Warrnambool Aquifer Storage and Recharge (ASR) and Roof Water Harvesting projects

10.9.1 Roof Water Harvesting

Aims and Objectives

The project aims to develop and communicate an innovative working model of the use of the roof area in new subdivisions as a dispersed catchment supplying centralised storage, treatment and reticulated water supply systems. The project is a water supply augmentation project that combines the strengths of the corporation's water management capabilities with a 'new take' on rainwater collection through a devolved collection system which will maintain high standards with cost effective delivery.

Primary objectives are:

- Construction of the necessary infrastructure to capture and transfer rain water collected on new household roofs to existing centralised storage and treatment facilities, avoiding the need to transport this water from a river system over 100 km away.
- Identification of other cities with high potential to adopt this concept (primarily in coastal eastern Australia) and the provision of a tool kit to help identify its application in specific localities.
- Identification of any other regulatory or other barriers to the widespread adoption and uptake of this "alternative source of supply".
- Reporting of yield, quality and cost information to support adoption under HACCP-based risk systems for water supply.

Economic:

- Is a more consolidated and effective manner to harvest and use rainwater than the adhoc and scattered approach of individual landowners installing individual tanks, pumps and pipework on their land.
- Is able to be implemented progressively as development (and consequential demand) proceeds in the growth corridor.
- Reduces operational costs of transporting water over long distances.
- Defers the need to augment the existing raw water delivery system and to develop and harvest water from new groundwater resources. If this principle were adopted in other growth corridors with new development being close to "water demand neutral", the time period of deferring augmentation would be very long.
- Reduces the works required for stormwater management for council and developers, e.g. size of stormwater detention basins and treatment systems.

Environmental:

- Reduces the energy use and associated greenhouse emissions for transporting water for use in Warrnambool.
- Diverts water to a beneficial use instead of running to waste and causing downstream flooding and negative impact on local estuarine stream systems.
- Improves the environmental flows in the Gellibrand River.

Social:

- Reduces public health risks implicit in alternative recycled water or decentralised individual rainwater tank systems.
- Landowners will not be burdened with ongoing maintenance of an on-site harvesting and reuse system.
- Is innovative in approach to sustainable use of water resources, and promotes community consciousness of innovative outcomes that can be achieved in the water cycle.

Indirect benefits:

The design and construction of a working example of how such a rain water harvesting system would work will provide the following indirect benefits:

- Demonstrate to developers that such a system is workable and does not impose unreasonable requirements on their development.
- Demonstrate to other developers of new urban estates, water corporations, councils, catchment management authorities and the community that roof water harvesting is a sustainable, cost effective, environmentally friendly solution to reduce the reliance on other sources of water

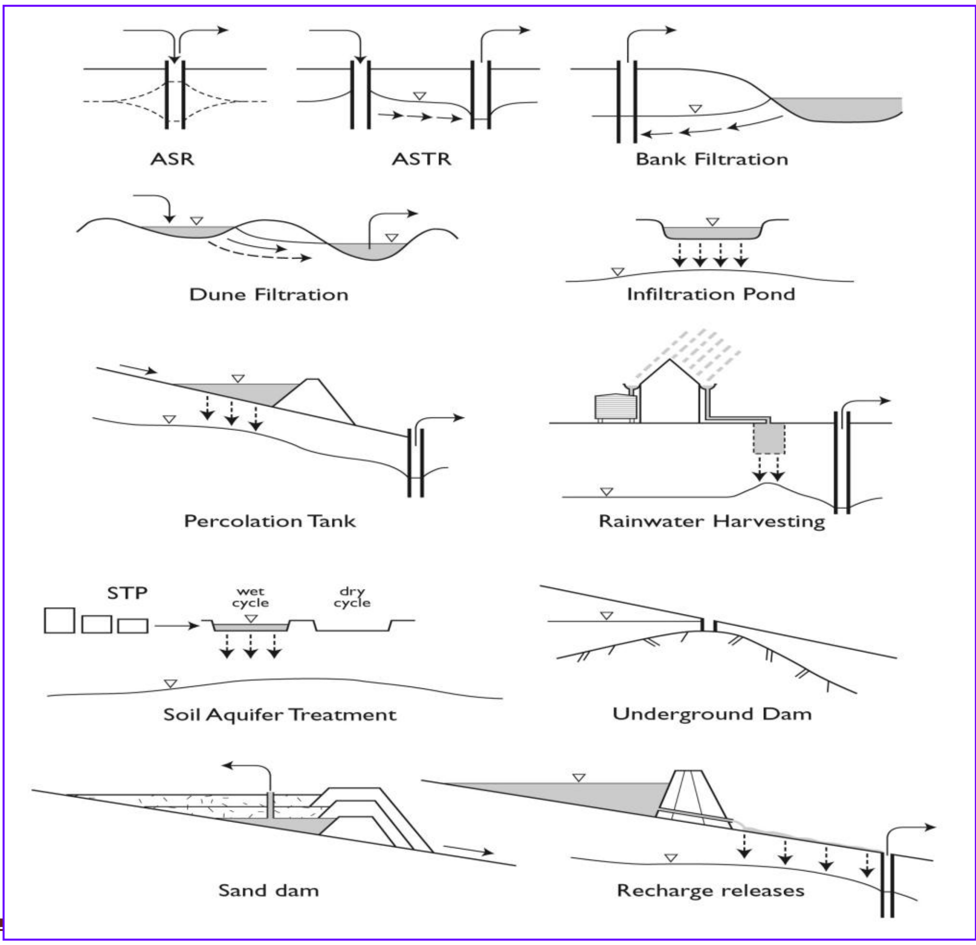
Roof water harvesting main trunk pipe being installed

10.9.2 Aquifer Storage and Recharge

Increased awareness about the need for water savings has led Warrnambool City Council to investigate more sustainable approaches to water supply for irrigation of sporting facilities. The current drought has acted as a strong catalyst for instigating the use of stormwater for irrigation purposes. Subsequently, the Council in partnership with the Brauerander Park Trust, has initiated a feasibility assessment to determine if Aquifer Storage and Recovery (ASR) is a feasible means of temporarily storing stormwater for later recovery and irrigation of Brauerander Park. Brauerander Park is a dedicated sports and athletics facility occupying 32 acres situated in West Warrnambool.

The storage of water in an aquifer system during periods of excess water supply and its recovery using the same bore during times of deficit is called Aquifer Storage and Recovery (ASR). Recharge of the aquifer can occur seasonally, or over a period of years before the water is recovered. The operation of the scheme at Brauerander Park would largely be seasonally based, with the majority of injection occurring during winter and spring, and recovery during summer and autumn (although in practice storage of available runoff will occur throughout the year).

- There are many different types of Managed Aquifer Recharge (MAR)
- Aquifer Storage and Recovery (ASR) is the storage of water in a suitable aquifer through a well during times when water is available and recovery of the water from the same well during times when it is needed.
- And many different potential source waters



A number of stages of the project have been undertaken to date. They include:

- Field Investigation at Brauer College (Drilling Program, Pumping Test, Groundwater Chemistry Sampling, Stormwater Sampling)
- Field Investigation at Brauerander Park (Drilling Program, Pumping Test, Groundwater Chemistry Sampling)
- Stormwater Quantity Assessment / Water Supply and Demand Analysis
- Stormwater Quality Assessment
- Modelling and Impact Assessment (Estimated Rates of Injection, Impact Assessment, Other gw users, Merri River, Impact on GDEs, Surface Discharge or Water Logging)
- Pre-Treatment Requirements (Clogging Prevention, Groundwater Quality Protection)
- Conceptual Design and Costing of Preferred Option
- TBL Assessment
- Regulatory Requirements
- Drilling and construction occurred 7-11 Dec 2009
- 2 Observation bores, 1 production bore
- Bore depth ~60 m
- Watertable depth ~27 m
- Cased to ~25 m then open hole
- All bores developed

Drilling and installation of electronic sensing equipment being installed in the ASR scheme in Warrnambool

- GPT in the 450mm drain, divert up to 54 L/s to 2 x 10kL underground storage tanks
- Fixed speed submersible pump in tank operates when triggered at approx. 10 L/s
- Water pumped 150m along 150mm PVC pipe via secondary treatment filter & actuated valve before gravity feeding into bore (provision for UV disinfection if required)
- Water level sensor in bore (~3m bgl) will relay information back to valve to control levels in bore
- Down hole submersible pump will lift to header tank as required

The overall project was divided into three stages. The status of each of these stages is described below:

- **Stage 1** - Detailed feasibility assessment of ASR - completed during 2006 and 2007, reported in SKM (2008).
- **Stage 2** - Design, construct and trial an ASR scheme at Brauerander Park - Construction 95% complete by December 2010 but final completion was delayed until June 2011. Injection trial commenced July 2011. Trial scheduled for completion approximately February 2012.
- **Stage 3** - Package and communicate project outcomes to the community and Local and State decision makers. Commenced with official opening of the trial project to occur on the 24 February 2012.

Completed project in readiness for the official openng on the 24 February 2012