The future development of stormwater reuse infrastructure

This article summarises a report containing the findings of the Municipal Engineering Foundation Victoria Study Tour 2008, which visited municipalities in the USA, Sweden and the UK. The purpose of the report was to provide public works engineers with information on the infrastructure being implemented for the reuse of stormwater, and how stormwater management systems may have to be adapted to address the impacts of climate change.

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Stormwater is seen by an increasing number of public works engineers as an important resource and a solution for increasing demands on existing water supplies.

If we could capture and reuse stormwater for everyday functions, what infrastructure options are available?

This is the question which I sought to answer on the Municipal Engineering Foundation Victoria Study Tour 2008 to municipalities in the United Stated of America (USA), Sweden and the United Kingdom (UK) and summarised in the subsequent report.

The state of Victoria has been in drought conditions with below average rainfall for more than 10 years which has forced government departments to fund and implement measures to deliver water to expanding communities as well as impose water use restrictions throughout the state to accommodate low inflows to major water storage supplies.

Future climatic conditions are expected to become increasingly dry, with more hot days.

On the other side of this drier climate, storm intensities are expected to increase.

There will no doubt be some impacts from these predictions on stormwater infrastructure, existing or new, and stormwater management.

Figure 1. Low Impact Development, Sweden.

Green versus grey initiatives

Stormwater from buildings, roadways and parks, through conventional methods in stormwater systems, flows through concrete pipes and pits, and ends up at the outfall discharge location with limited quality treatment incorporated into the system.

These types of stormwater infrastructure are now being referred to as "grey" stormwater infrastructure due to the limited environmental benefits and ability to address long-term sustainability concerns.

The focus for public works engineers is now on transitioning to the implementation of "green" infrastructure for stormwater management to address how to treat, store and reuse stormwater.

This approach provides means of managing the stormwater locally, and aims to heal, maintain and provide improved amenity outcomes.

"Green" Best Management Practices (BMP) can reduce discharge volume and reduce local irrigation demand by improved stormwater management and reuse, and avoid the high cost of upgrading the "grey" infrastructure.

A complete move from "grey" to "green" infrastructure may not be justified, but a balance between both is more likely necessary for an adequate stormwater management system to deliver both sustainable stormwater catchment practices and service to the community through efficient water movement.

Observed throughout USA, Sweden and the UK, Low Impact Developments (LID) have been introduced as a holistic approach to sustainability in developments from buildings to roads.

LID is a land development strategy that includes stormwater management applied at the parcel and subdivision scale that emphasises conservation and use of on-site natural features integrated with engineered, small-scale hydrologic controls to more closely mimic predevelopment hydrologic functions.

A number of countries including the USA are looking to create legislation that requires new developments to incorporate

LID. However, these initiatives have met with strong opposition from developers concerned about the significant capital costs.

This did not appear to be as evident in Sweden and the UK, where schemes are in place for significant changes in favour of sustainability.

Reuse infrastructure

There are many components and methods in mitigation of stormwater through "green" infrastructure, some of which are summarised below.

Permeable Pavements: Permeable paving is best used in roadways, car parks and other pavement areas to increase the permeable area to sub-surface systems.

Types of permeable pavements include paving blocks with gaps between the blocks filled with permeable material, porous concrete and porous asphalt pavements.

Figure 2. Asphalt porous car park pavement, USA; insert: Porous concrete mix.

Unsealed crushed rock or gravel pavements are also able to provide infiltration functions, however are often overlooked in lieu of a finished surface treatment requiring less maintenance and higher amenity for users.

This type of pavement design and filtration allows for large volumes of storage within the pavement before collection, as well as providing limited removal of sediments and flow control.

However, it should be noted that this type of surface is not as structurally resilient as conventional pavement composites and is often prone to blockages.

Rain gardens/Swale Drains: A common application of "green" infrastructure observed during the study tour was the use of "rain gardens", and there appeared to be a simple arrangement to capture stormwater for natural use on vegetation areas, typically suitable for small drainage areas from buildings, roadsides and vegetation islands.

A project to reconstruct a residential street in the USA with "swale drains" was completed with a 98% reduction in stormwater volume through filtration to groundwater.

Figure 3. Reconstruction of a roadway, USA

Although the focus was not stormwater reuse, the function of infiltration and the change in both street beautification and community awareness and support were very successful.

Roof Gardens: Roof gardens, in small flows, are able to treat 100% of storm event. However, higher flows are not able to percolate through vegetated layers fast enough to be completely treated.

Roof gardens can take soluble pollutants out of stormwater through filtration, and also remove anywhere from 50-75% of the stormwater volume that would otherwise be reused.

Roof gardens are often used throughout Sweden as a means of reducing stormwater volume, but it also provides a treatment to roof stormwater before being captured and stored in tanks for reuse, or before entering stormwater system.

Basin, Wetlands & Sediment Ponds: Detention basins, retardation basins, wetlands and sediment ponds generally are large enough and hold significant amounts of stormwater, and reuse can be achieved through pump systems.

Large catchment areas are able to be accommodated for, but may have some volume losses through evaporation and seepage.

Basins are commonly used, perhaps due to their multiple uses, either as stormwater infrastructure or as an architectural "landscape" - features which may add to the amenity and aesthetics of an area.

The downside to this is the need for relatively large land parcels, which in treatment only provide limited removal of sediments and pollutants dependant on holding times.

Stormwater Treatment Plant: Where localised treatment and reuse of stormwater is not able to be achieved, a single outfall can be treated in the same way a wastewater treatment plant operates.

The Santa Monica Urban Runoff Recycling Facility (SMURRF) visited on the study tour is a state of the art, first of its kind water recycling plant that treats dry weather urban runoff by conventional and advanced treatment systems to remove pollutants such as sediment, oil, grease and pathogens.

Basically, the SMURRF recycles polluted runoff so it can be reused for municipal water purposes.

Figure 4. Subsurface stormwater storage for a sports field, USA.

Pre-fabricated Infrastructure: This type of infrastructure can be installed in series with drainage system and remove limited amounts of pollutants plus debris, oils and metals.

However, these do not provide for any biological treatment of stormwater and are ideal for small flows.

These types of structural treatments are generally used in road reserve areas, where above-ground measure and space are not available or can be easily retro-fitted to existing stormwater systems for improving quality.

Rainwater Tanks: Tanks are one of the easiest ways to capture stormwater, particularly from buildings.

Once stored, the stormwater can be used for most non-potable uses such as irrigation, toilet flushing and laundry.

The quality of water is generally of a good standard, especially in rural areas where airborne pollutants are generally lower than urban areas.

Stormwater collection is also not subject to the pollutants found in roadways and other hardstand areas.

The limitation with tanks is the space requirements for installation.

Underground Storage: The idea of module-type storage construction is to allow for flexible storage size and to rely more on impervious ground material or fabricated liners to hold stormwater within the storage.

There is significant work required in construction of these types of storages and may have high capital cost associated with the product.

Possibly for higher volumes of storage and more convenient construction methods, fully integrated pre-fabricated underground storage, much like large cisterns, is also available.

Climate Change Impacts and Future Adaptation

Victoria is expected to have an average temperature increase of two degrees by 2030 and six degrees by 2070.

This will no doubt put more pressure on water supply infrastructure and storages.

Any efforts to reduce the onset of Climate Change today will not have actual results for many decades.

This brings about some uncertainty as to the long term forecast to deliver and maintain infrastructure.

Projections for rainfall confirm current observed trends of longer dry spells interrupted by heavier precipitation events.

It is expected there will be increases in extreme daily rainfall with decreases in frequency.

It is possible the 100-year storm could be the new 10-year storm and the 20-year drought becomes a common situation.

If the past can no longer be relied upon to predict the future, using a design storm model with 50-year-old rainfall data is thrown into question. The next level of action is to improve our long-term management of infrastructure and adapt.

A concern of introducing stormwater harvesting systems is that the cost of implementation, both capital and operational, may not provide the benefits most would expect, as climate change effects result in less stormwater able to be harvested and therefore create an unreliable water resource.

In lieu of these circumstances, not harvesting stormwater because of its unreliability may have consequences regardless. As demand on water increases, alternative sources will become invaluable.

The *Stormwater Design Manual 1967* is the current design guideline for stormwater infrastructure in the USA, but is based on climate data from a relatively short-term un-industrial period that is expected not to be replicated in the next century.

A storm event of one in 50 ARI for North West United States is currently modelled to be an intensity increase of up to 50%.

This indicates that current stormwater infrastructure is likely to be undersize in the future, if it is not already affected.

Some initial studies in 2001 for the USA have shown that approximately 20% of underground stormwater infrastructure is inadequate.

Therefore it is important to take into account the increased need in capacity of stormwater systems required for the future.

Conclusions

Predictions of higher intensity storm events lead to the conclusion that existing stormwater systems will become undersized and ineffective to control stormwater movement and possible further decrease stormwater quality.

The option to increase stormwater capacity for "grey" infrastructure is not an economical or practical solution in most cases and therefore leads to ideas such as stormwater management through harvesting and "green" infrastructure.

Although "green" infrastructure would ideally be introduced into present practices, the community will not always be ready for the change.

Education regarding the use of such infrastructure is required for the community and public works engineers to continue to successfully implement these initiatives.

Developing initiatives to capture, infiltration, storage and reuse provide for a more sustainable solution as well as reduce the need to renew "grey" infrastructure.

Initiatives currently being used in the USA such as permeable pavements, rain gardens, and underground retention/ reuse systems have been successful and cost-effective.

Recommendations

In order to make better use of stormwater, provision to implement "green" infrastructure should be made by municipalities as an alternative to potable water sources for uses where possible.

Sporting Fields: New and redeveloped sporting fields should have installed underground stormwater storage with field surface overlying the storage.

This will enable storm events and irrigation to filtrate and recycle back to underground storages for reuse with good-quality stormwater.

Parks & Gardens: Including roadway vegetation areas, smart use of stormwater infrastructure would see all stormwater catchment areas discharged over and infiltrated into vegetation areas, such as swale drains and other rain gardens, as a natural irrigation before entering any stormwater system or stormwater storage.

Buildings: Buildings should have both a potable water main connection and a reclaimed stormwater connection.

Reclaimed water is to be used for toilet flushing, garden irrigation, and car washing.

Depending on the location and quality of stormwater, it is possible to also connect these for laundry functions in a domestic environment.

Buildings in high air pollution areas, particularly metropolitan areas, should allow for roof gardens to treat stormwater before being collected in rainwater tanks for non-potable reuses.

Basins: It is recommended that use of open detention basins, where not required for public open space or stormwater treatment processes, be abandoned. Where detention is required as a function of the stormwater system, underground storage should be installed where both storage for local use and temporary detention can result.

Stormwater Treatment Plant: In high density areas where natural, non-structural stormwater treatment and collection infrastructure is not viable, treatment plants for stormwater reuse should be considered.

Pre-fabricated Products: There are many pre-fabricated products available that incorporate all of the reuse functions, capture, treatment, storage and distribution.

Where none of the above options are viable, pre-fabricated products can be installed into local stormwater systems for treatment and reuse.

Education: Municipalities should look at their existing stormwater management and water management plans and revise to include reference to stormwater reuse initiatives and use of stormwater as an alternative water source.

Guidelines: Government and industry have developed guidelines and concepts for stormwater reuse and provide a strong support base for municipalities wanting to evolve their own plans, policies, strategies, etc, into "green" infrastructure.

Municipalities are encouraged to seek out these supporting documents in review of stormwater management and water management plans.

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For further information visit the Municipal Engineering Foundation Victoria's website www.mefvic.org.au to access the full report.

Applications close for stormwater funding round

Australian councils had until February 10 to submit funding applications for stormwater harvesting and re-use projects under the second round of the National Urban Water and Desalination Program.

The program provides $1 billion over six years (commencing 2008/09) to help secure water supplies. It targets centres of at least 50,000 people and supports projects that use stormwater harvesting, recycling or desalination to improve the security of water supply.

The National Urban Water and Desalination Plan will provide a minimum of $200 million for stormwater harvesting and reuse projects. Grants or refundable tax offsets will be available for up to 50% of eligible capital costs.

The minimum project size is $4 million and funding is capped at $20 million per project.

Successful projects have to source 100% of their energy needs from renewable sources or fully offset the carbon impacts of the project's operations.

In November 2009 the Federal Government announced nearly $87 million for 13 projects from the first round of funding for stormwater harvesting and reuse projects.

The combined water saving generated by the projects in Victoria, Queensland and South Australia is estimated to be 4.6 gigalitres per annum.

The projects will also reduce stormwater pollution in local waterways and help maintain parks, gardens and sportsgrounds.

Federal Climate Change and Water Minister, Penny Wong, said new investment in stormwater represents progress towards securing Australia's long-term water supplies.