STORMWATER MANAGEMENT OPPORTUNITIES WITH URBAN RE-DEVELOPMENT

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ABSTRACT

To control a city's urban expansion and minimise the city's environmental effects it is becoming more critical to look within existing urban boundaries for development opportunities.

Urban redevelopment provides opportunity to not only maintain existing stormwater quantity and quality, but to improve the existing stormwater situation. By involving engineers, landscape architects, planners and the community, environmentally and economically viable solutions can be developed to reduce the strain on existing or ageing infrastructure and improve existing environmental conditions within a catchment.

Drawing on experience gained from various projects, from the UK, Australia and around New Zealand, this paper will discuss examples of how engineered solutions can be integrated throughout developments, providing environmentally beneficial and economically viable solutions to manage and improve stormwater conditions within existing urban areas.

KEYWORDS

Stormwater, Urban, Landscape, Economic, Low Impact Design

1 INTRODUCTION

Low impact design (LID) is a design approach with a range of natural and structural techniques which can be applied to urban development and stormwater management. The purpose of LID is to return a catchment towards a natural hydraulic condition, maximising ground water infiltration, and attenuating and treating surface water runoff to reduce impacts on the receiving environment. Traditionally brownfield or urban redevelopment is required to simply maintain the stormwater runoff status quo, or existing hydraulic condition post development. However, by integrating LID processes in brownfield or urban redevelopments, developments can achieve more attractive, multifunctional landscapes with positive social, environmental, ecological and cultural outcomes but also potentially return catchments to pre-development hydrological conditions.

In the past, urban developments in New Zealand and around the world were developed with little or no consideration to the natural hydrological conditions of the receiving environments. Over time the scale of development has modified stream flow characteristics and health, increasing risk of flooding, sediment deposition in estuaries and harbours, and habitat removal. D Rowe et al, (2008) identified that in the Auckland region alone 8 kilometres of stream continues to be lost each year. Various documents in New Zealand have been developed to reduce the effects of development including NZS4404, and the Auckland Council stormwater guidelines, to name two; however there is no formal policy to return brownfield or urbanised areas back towards a naturalised hydraulic state.

Various developments, both from the UK, Australia and around New Zealand, have demonstrated how, by integrating LID principles and conventional stormwater management practices, brownfield developments and urban redevelopments can provide an opportunity to improve a catchment's stormwater quantity and quality, and improve flood risk, with minimal additional cost to the developer and the regulatory authority.

2 PRINCIPLES, CHALLENGES AND OPPORTUNITIES

Auckland faces a number of infrastructure difficulties including traffic congestion and the costs of providing water services for ever-expanding suburbs; and while intensification can lead to more efficient land use, housing alone will not create an attractive place to live. As section sizes are reduced and dwelling sizes increased, private outdoor living space becomes increasingly compromised. This makes attractive, useable parks and reserves all the more important for residential amenity and to provide opportunities for active and passive recreation. By integrating stormwater management and treatment devices into available open spaces, developments can progressively improve a catchment's hydrological cycle while maintaining available open space for recreational and aesthetic uses.

Several challenges and benefits can result from incorporating low impact design into brownfield or urban redevelopment. Krausse (2010) recognised that brown fields and urban areas are already highly modified environments, with most catchment features such as streams heavily degraded by past development, sedimentation, loss of riparian cover, and change in the catchment's hydraulic conditions. In most cases it is not possible to restore these receiving environments to pre-development conditions. On some scale it may be appropriate to reduce existing negative impacts by enhancing various ecosystem processes while at the same time reducing the heat island effect, providing attenuation, filtering contaminants, and reintroducing some natural elements to urban environments; a view consistent with an LID approach. Integrating LID into the urban environment has the potential to improve the quality and quantity of surface water entering the environment, by providing onsite treatment and attenuation of surface water throughout the development. Collectively this will have a quantifiable hydraulic effect on the receiving environment whether it is a stream or networked system. These effects can include reducing pollutants, reducing flood risk and the risk of combined sewer network overflows, reducing risk of stream erosion and potentially increasing infiltration to groundwater, to name a few.

2.1 ENVIRONMENTAL

Multiple environmental benefits can be achieved by utilising LID in urban redevelopment, including habitat creation, and returning a catchment's flow condition to a more naturalised state. By altering surface conditions or returning a catchment towards a naturalised hydrologic state, the risks and benefits associated with developments must be understood and managed.

Flood risk can result from various sources including a catchment's overland flow paths (pluvial), or open water courses (fluvial). LID has been used to address issues of pluvial flooding to not only the immediate development, but also to the greater catchment by reducing stormwater peak flow within a catchment. Vesely et al (2005) discussed how Glencourt Place successfully demonstrated how LID can alleviate pluvial flooding within a developed urban area. The development utilised a system of ditches, gravel trenches, contoured flow paths and minimal piping, and rainwater tanks retrofitted to existing properties as an alternative to upgrading the surrounding stormwater infrastructure. The development demonstrated that LID has similar costs compared to a conventional engineered drainage approach when life cycles were extended to 50 and 100 years. A proposed redevelopment of the Powerco site, New Plymouth, has demonstrated how by integrating LID into the proposed development, the site has reduced their stormwater effects on the receiving environment, and subsequent fluvial flood risk down-catchment. The existing catchment is approximately 95% impermeable with risk of pollutants from various activities including heavy traffic movement and hazardous substance handling. The catchment currently receives minimal treatment through features such as gross pollutant traps and oil separators, before discharging directly into the stream, which runs along the boundary. The development integrated the proposed infrastructure and LID by directing impermeable catchment to raingardens, providing both surface water treatment and attenuation. The proposed development also directed a portion of roof catchment to stormwater attenuation tanks, provided for irrigation or potential grey water use, and stormwater attenuation. A hydrological model of the proposed development estimated a 10% reduction of the 10 year event peak flows while treating for the first flush of surface flow.

Brownfield developments have an inherent risk of land contamination and contaminant remobilisation as a result of changed surface conditions. Lyne Hill Penkridge, UK, is a practical example of managing the risk associated with contaminated brownfield by clearly defining areas and land use associated with the development, while locating and designing appropriate stormwater treatment and storage to achieve stormwater treatment and attenuation. Lyne Hill is an existing 9.1 ha largely impermeable industrial site located alongside the River Penk which is proposed to change to a mixed use residential, commercial, and light industrial development. The development was seen as an opportunity by the UK's Environment Agency to reduce the stormwater peak flow discharging into the River Penk through LID principles, while reducing the effects of flooding, and potentially contaminated land. The design team identified the areas at risk of pluvial and fluvial flooding, modifying land use and the location of LID treatment devices accordingly. LID solutions were integrated into the landscape and open space to provide an appropriate level of treatment to the area, assessed on pollution risk, and appropriate attenuation derived from land contamination risk. By integrating risk-based treatment and attenuation devices throughout the proposed development, specific risks of contamination were minimised while providing water treatment and reducing the catchment's peak flow by 10%.

2.2 LANDSCAPE INTEGRATION

Whilst intensification can lead to more efficient land use, housing alone will not create an attractive place to live. As section sizes are reduced and dwelling sizes increased, private outdoor living space becomes ever compromised. Integrating stormwater treatment and attenuation into the landscape becomes all the more important to provide both and stormwater treatment and attenuation opportunities.

Urban redevelopment provides an opportunity to provide residential amenity and useable public space, but additionally stormwater treatment and attenuation. Amongst other development opportunities, Krausse (2010) identified street redevelopment as an opportunity for retrofitting an LID approach into redeveloped and densifying areas to achieve an improvement in the surface water quality and quantity. Specifically noted was that by taking advantage of the road reserve redesign, development could minimise the area of impervious surface and maximize the opportunity for filtration and infiltration of surfaces while providing potential for improving amenity. This has been practically achieved in various projects throughout New Zealand including the proposed development of Baring Square, Ashburton, where it is proposed to utilise a combination of LID integrated into the landscape, and encouragement of low risk pedestrian use and limited vehicle traffic to reduce the length of flow paths and risk of surface water contaminants. By integrating the proposed landscape areas with LID, the development was able to provide treatment for the first flush of the catchment's pollutants and provide attenuation for up to the 10 year event with minimal effect on the aesthetics or functionality of the development.

It has been noted by Scott K (2010) and Jones (2010), however, that there is a risk associated with integrating stormwater and landscape consisting of a lack of public awareness which can potentially undermine the ongoing operational effectiveness of an LID approach. A survey of Talbot Park residents, Auckland, found the participants appreciated the careful site design and landscaping of the development, noting it provides a sense of open space and high amenity value; however, it was found that very few of the residents surveyed recognised, or felt informed about, the purpose and operational requirements of low-impact devices, potentially undermining device performance and building of public acceptance of LID. This result emphasises the importance of an ongoing education programme for LID initiatives, both amongst the public and the maintaining authorities, to ensure their future success.

2.3 MAXIMISING RETURNS

In 2001 the office of the Parliamentary Commissioner for the Environment recognised the need to reduce stormwater generation through better site design, by way of reducing impervious surfaces, onsite collection use, and retention of natural streams and waterways. It recognised that by distributing LID storage and treatment devices throughout the catchment and utilising open space for storage and treatment, required surface water volumes for end of line attenuation and treatment are reduced, contributing to a hydrological improvement to the receiving catchment. One of the issue of urban intensification is that it can result in increased land values, with an associated reduction in the financial return for open space and, in the case of stormwater, infiltration and treatment opportunities.

To accurately determine the return of LID investment there must be a clear understanding of quantitative and qualitative costs and benefits. Chapman (2003) noted that when determining the costs associated with LID retrofit, it should be considered that brown field and urban redevelopment can provide a 'window of opportunity' for reassessing past practices and design philosophies in light of key future trends, utilising a costly exercise as an opportunity to change a traditional drainage philosophy and correct issues associated with the advanced age of existing infrastructure.

The opportunity provided by the Glencourt Place development was utilised by Vesely et al (2005) to compare the quantitative costs of integrating LID to mitigate flood effects, control the surface water, and reduce the strain on existing infrastructure. The North Shore City Council compared the costs associated with an LID approach and a conventional drainage system for managing the Glencourt Place stormwater issue. It was found that a conventional stormwater management approach of reticulating the area with SW pipes and/or overland flow paths – as opposed to a LID approach using a system of ditches, gravel trenches, contoured flow paths and minimal piping, backed up with properties rainwater tanks retrofitted – was only marginally less expensive; and that by projecting the life cycle costing time frame from 25 years to 50, and 100 years, there were some financial benefits of an LID approach.

Consideration of qualitative cost benefits of LID within greenfield and developed areas were discussed by Jones et al (2010) when a business case was outlined for water sensitive urban design (WSUD) in South East Queensland. It was discussed the quantitative and qualitative benefits of WSUD adoption as a means to not only stop the decline, but to restore the stream health within a catchment. The paper assessed six different development types, both greenfield and infill, and tested the practicality of WSUD practices for meeting the proposed stormwater management design objectives; identifying the quantitative costs of WSUD practices such as design, site acquisition, approval and regulatory costs, ongoing operation and maintenance costs, reduced pollutants loads discharged to waterways relative to unmitigated urban development, and the reduced need for rehabilitation and maintenance of downstream waterway environments. The financial benefits such as an increased premium on land values due to enhanced amenity values, and local and regional water quality as a result of the studied developments were also discussed. Interestingly, the paper recognised several unquantifiable cost benefits of WSUD such as the contribution towards aquatic ecosystem health and the services they provide, which assisted to preserve and enhance waterway-based recreation, and current commercial value of waterways such as tourism and commercial fishing. Additionally important non-market values such as the intrinsic value of aquatic ecosystems were considered. The outcome of the study determined that the costs of applying WSUD practices to achieve best practice stormwater management should not significantly impact on the profitability of residential, commercial and industrial developments, with the acquisition (capital and design) costs of WSUD to meet the stormwater management design objectives for residential developments being typically less than 1% of a new dwelling's cost; a similar magnitude of costs to the potential property premium attributable to improved water quality in local waterways. The report found that the impost on council budgets is likely to be negligible, with an annual growth in WSUD management costs in Brisbane requiring an increase in total revenue of approximately 0.005%.

There is a challenge to quantify costs and returns on investment for LID developments and retrofits on a larger scale. As a result of the 2007 UK summer floods, 13 people lost their lives, while approximately 48,000 households and nearly 7,300 businesses were flooded resulting in billions of pounds of damage. As a reaction to the flooding and associated costs the crown commissioned an independent review. The Pitt Review (2008) found the floods were a combination of extreme weather, poor warnings, and pluvial and fluvial flooding. In total the Review made 92 recommendations to avoid such an event occurring in the future; amongst them was the encouragement of further application of Sustainable Urban Drainage (SuDS), the removal of automatic right to connection, and the removal of unrestricted right to pave over front gardens using impermeable materials. The Government / Environment Agency utilised the tragedy as an opportunity to implement the recommendations to encourage a change in culture towards stormwater and encourage the implementation of SuDS for both greenfield and brownfield developments. No further studies were noted to date comparing the cost benefits of retrofitting existing catchments with attenuation and treatment devices in the UK; however, it could be assumed that with a shift in culture to restrict flows entering rivers and streams, and attenuate flows on site much of the damage experienced as a result of the pluvial flooding could have been lessened or avoided completely.

2.4 CULTURAL PERSPECTIVES

Cultural wellbeing sits at the heart of sustainable management within the context of Aotearoa / New Zealand, alongside other Part II matters of the Resource Management Act which relate specifically to Māori. As our urban places continue to intensify, connections to the natural environment and natural processes can be lost as concrete and asphalt replace bush and grass, building and utilities replace trees, and water and waste appear and disappear with no apparent thought or consequence for the urban dweller. From a Māori perspective, this disconnection sits at odds with the holistic Māori understanding of Te Taiao, the environment.

Taking opportunities to retrofit existing hard engineered stormwater systems and catchments to embrace LID technologies as a means of managing urban stormwater aligns favourably with a Māori environmental philosophy. The attenuation and treatment of stormwater on site represents a way of improving the Mauri of the water captured, and importantly improving the Mauri of the downstream receiving environments.

By identifying opportunities to utilise native vegetation within stormwater treatment processes, LID developments can help improve the biodiversity of urban environments, providing additional habitat and nourishment for flora and fauna, and adding to the Mauri of the environment.

Early engagement with Tangata Whenua will provide guidance and assistance with design concepts and selection of appropriate plant species for inclusion in developments.

3 CONCLUSIONS

Multiple environmental benefits can be achieved by utilising LID in urban redevelopment, including habitat creation, and returning a catchment's flow condition to a more naturalised state. The discussed examples from throughout New Zealand and around the world have shown how urban redevelopment can provide an opportunity return a catchment towards a naturalised hydrologic state. Controlling stormwater peak flow close to source by integrating stormwater treatment and attenuation into the development we are providing the opportunity to address potential pluvial flooding issues within the immediate and greater catchment. The examples have shown that the discussed design philosophy can also be successfully integrated into areas of development with an inherent risk, such as contaminated land or brownfield.

As urban intensification increases, and open space becomes more limited we must become more creative in our stormwater management solutions, integrating residential amenity and useable public space, with stormwater treatment and attenuation. The integration of stormwater treatment and open space provides an opportunity to modify a traditional drainage philosophy and correct issues associated with potentially advanced age of any existing infrastructure.

This approach to stormwater management within urban development has the benefits of reducing the existing anthropogenic impacts on the receiving environment, enhancing the urban and natural environment while being sensitive to cultural needs. It also has the ability to reduce flood risk while limiting costs, to that of similar conventional drainage.

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