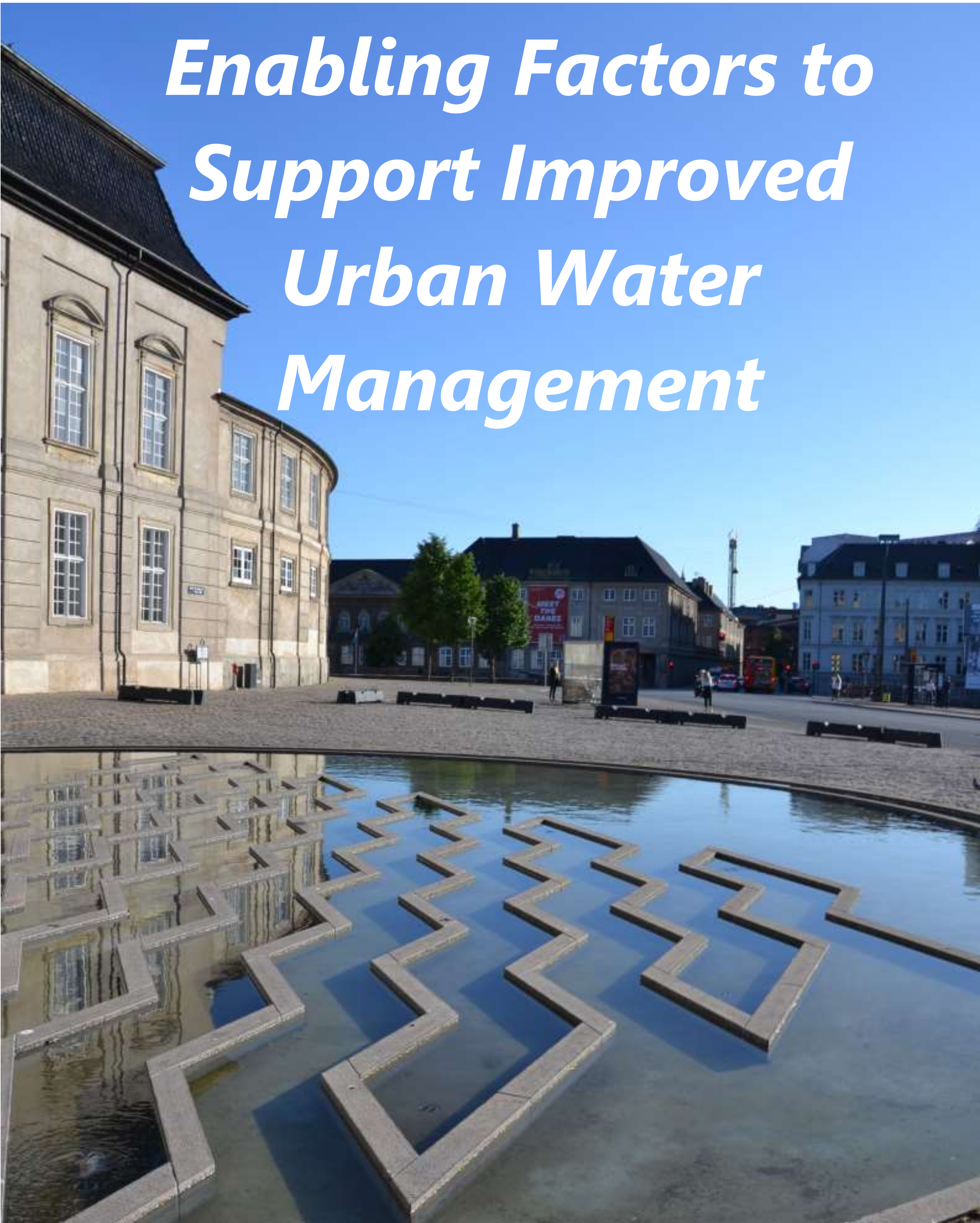
2018 Winston Churchill Fellowship

Stu Farrant

Enabling Factors to Support Improved Urban Water Management



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1.0 Introduction

1.1 New Zealand context and drivers for change

Increasing media coverage of the state of New Zealand's freshwater has recently heightened the public's awareness of the ongoing issues and enabled debate around the impacts of land development on the environment. With an initial focus on the degradation of waterways in the rural sector due to primary industry, there has recently been increasing focus on the impacts of urban land use. A realisation by communities that our towns and cities have significant impacts on waterways through stormwater runoff is prompting a rapidly changing attitude towards development and aspirations to manage stormwater in a way that mitigates impacts on urban environments. This change highlights the challenge that New Zealand towns and cities face as we endeavour to address ongoing housing pressures and urban population growth in balance with the need to protect our fragile and unique freshwater and coastal receiving environments.

The challenge of these potentially conflicting interests is encapsulated at a governance level by the National Policy Statements, in particular the NPS Freshwater Management (NPS-FM) and the NPS Urban Development (NPS-UD). These central government policy tools define clear obligations to resolve the ongoing issues around the provision of affordable high-quality urban development whilst at the same time ensuring that our freshwater resources are not further compromised. This includes requirements to maintain or improve water quality in waterways and to reflect the aspirations and values of communities and mana whenua in defining limits to the amount of urban contaminants such as nutrients, sediments and heavy metals which can be discharged to the environment. As the legislative requirements of the NPS-FM has prompted regional councils and unitary authorities to develop water quality targets and limits to be encapsulated in natural resources plans, increasing spotlight on urban water has also been prompted by a number of high-profile drinking water contamination events (such as Havelock North) and heightened public health concerns at high profile recreational areas from wastewater discharges into fresh and coastal waters. These have been the catalyst for a wide-reaching review of the provision of three waters infrastructure (stormwater, wastewater and drinking water) across New Zealand which is exploring a range of options for improving how these essential services are delivered.

For most urban centres in New Zealand, improvements to water management will require a paradigm shift in the way that urban stormwater has been managed with a need for transformative change in policy, infrastructure planning and uptake of innovation. This change provides an opportunity to deliver not only better protection for our freshwater, but also enhance the human landscape through embedding urban ecology into or cities, improving the amenity of cities through integrated green infrastructure and improving the health and wellbeing of citizens. In a time of change, with uncertainty around; climate change, natural disasters and social cohesion, the opportunity to embed resilience thinking into infrastructure planning and urban design is more important than ever. The management of urban stormwater must therefore deliver multiple benefits at a range of temporal and spatial scales to demonstrate long term value in terms of economic, social/cultural and environmental metrics.

Historically, New Zealand has been slow to embrace innovation in the management of urban stormwater. With a continued focus on conveyance of stormwater and a reliance on traditional piped infrastructure our cities have continued to grow and develop based on the same principles which have resulted in the numerous highly degraded waterways in the first instance. With the exception of a handful of local councils, the discharge of untreated stormwater directly to fresh and coastal waters has been permitted at a policy level and our communities have been severed from these once abundant and defining ecosystems. Internationally, many countries, regions and cities have recognised the need for change and invested heavily in applied research, innovative green infrastructure, multi-disciplined urban design and community education. In doing so, these progressive cities have followed a similar path of experimentation and learning in their trajectory towards being 'Water Sensitive Cities'. These learnings provide New Zealand with the opportunity to make well informed decisions based on real world experiences to ideally fast track a transition towards best practise urban stormwater management and environmental protection.

This research therefore aimed to connect and engage with leaders in cities which are proven exemplars of good urban water management to get an understanding of how they have successfully implemented change and how this can benefit cities across New Zealand in the coming years.

1.2 Research Intent

With the support of the Winston Churchill Trust, research was undertaken into the catalysts, policies, technical capacity and innovations which have supported the implementation of effective urban stormwater management in leading cities in Europe and North America. Through meeting and engaging with industry leaders, researches and government regulators in a selection of globally leading cities I gained a well-informed understanding of the critical success factors which may be transferable to the New Zealand context.

Specifically, my research travel focussed on;

1. The environmental, social and economic drivers which have motivated cities to improve urban water management.
2. How these motivations have been successfully translated into actions to address urban impacts on receiving environments.
3. How regulation and policy tools have been implemented to facilitate change.
4. How institutional and industry capacity has been enhanced to ensure motivations and policy are translated into good practice.
5. How different financial models have been developed and used to fund public and private investment in stormwater management infrastructure.
6. How relationships between governance and industry have created a willingness to invest in new technologies and pursue a paradigm shift in urban water management.
7. How innovation and a culture of applied research is fostered to drive change and continued improvements.
8. How environmental and engineering elements are successfully integrated with urban design, landscape amenity and other important considerations to deliver multiple benefits.
9. How social sciences and behaviour change programs are used to educate the community to increase awareness, of the issues relating to urban stormwater management and increase the uptake of change and private investment.

Research was undertaken through connecting and engaging with key representatives from;

- Local/state governments.
- Utility companies vested with managing urban stormwater infrastructure.
- Leading research centres and universities.
- Industry (environmental engineers, urban designers and technology suppliers).
- Community advocacy groups.

2.0 Fellowship Outline

2.1 Research Itinerary

Funding through the Winston Churchill Trust provided an opportune chance to learn from cities which receive accolades as examples of how we can address environmental and social concerns regarding stormwater, wastewater and drinking water whilst still maintaining financial viability in the provision of public and private assets. Cities were selected based not only on accolades alone, but also based on scale (500,000 – 1,500,00 people), geography (mix of river and harbour settings) and climate (distinct seasons and variable rainfall). These cities have variable drivers, governance structures and social/cultural contexts which influence attitudes and actions relating to urban water. The selection of destinations for research excluded some of the recent standout work being implemented in Australia and Asia (China and Singapore) and responses to extreme climatic challenges (such as Masdar City in UAE). Through previous work and travel the lessons from these alternate destinations are already understood by e and inform my current project work and advocacy. Research travel as part of this fellowship is intended to provide examples which were relatable to New Zealand and could therefore provide tangible lessons. The travel itinerary was as follows;

- ***Hamburg,*** Germany — 10th - 12th June 2018
- ***Copenhagen,*** Denmark — 13th – 17th June 2018
- ***Malmo,*** Sweden — 18th June 2018
- ***Stockholm,*** Sweden — 19th – 21st June 2018
- ***Portland,*** Oregon (USA) — 25th – 29th June 2018
- ***Seattle,*** Washington State (USA) — 2nd – 4th July 2018
- ***San Francisco,*** California (USA) — 4th – 6th July 2018

Tanner Springs Park, Portland

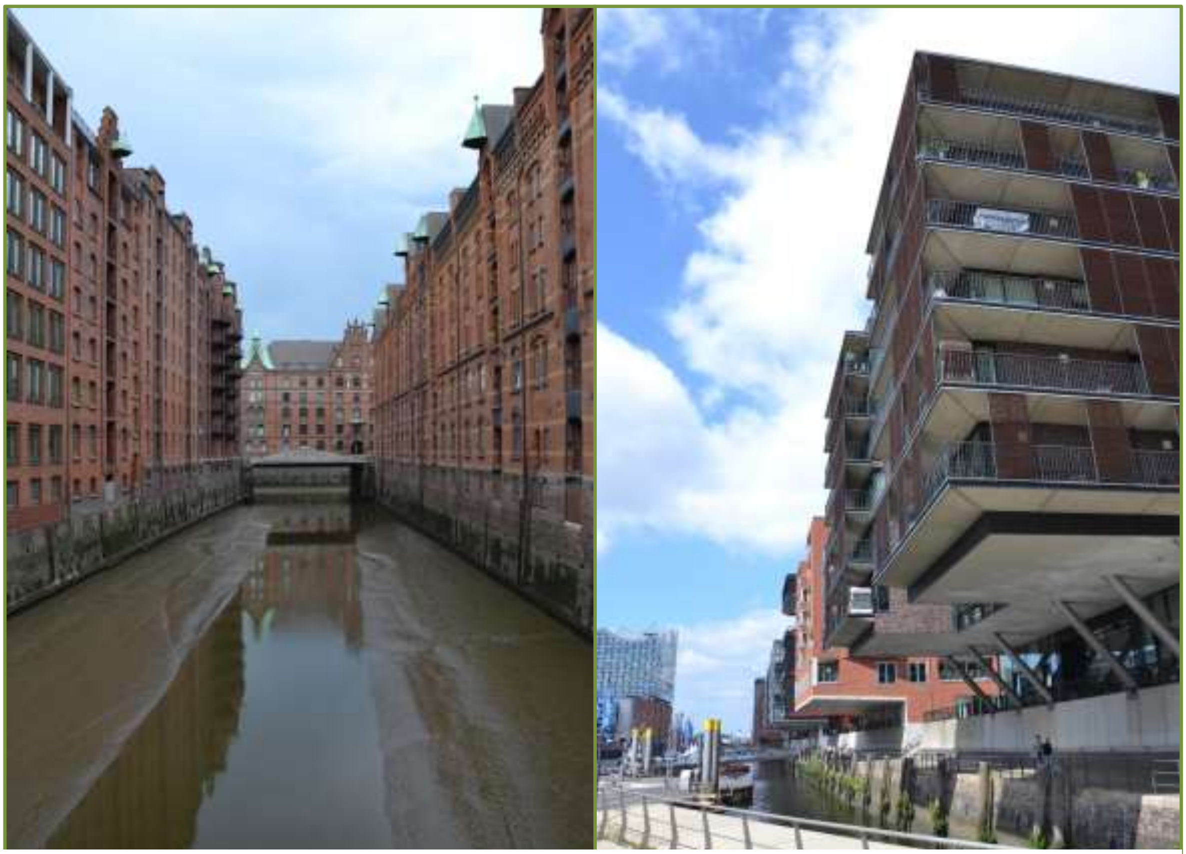
3.0 Fellowship Findings

3.1 City Summaries

Cities visited were all selected based on recent and ongoing activities relating to urban water management. These included management initiatives to address water quality, flooding and desires for a more integrated approach to urban water management. In each city, I undertook a mix of face to face meetings with available public officials, academics and private practitioners and visits to a wide range of on-ground sites which provided demonstrations of innovative and progressive urban water management. The following sections provide a brief summary of the visited cities as they relate to water management.

3.1.1 Hamburg – Germany

The city of Hamburg has maintained a long relationship with water, having first been settled in the 800's AD as a safe refuge between the rivers Elbe and Alster. As expected this prolonged history has shaped the modern city which is now the second largest in Germany and home to Europe's third largest port. The city is largely built around the River Elbe at its confluence with the Aster and Bille rivers, with the Alster River dammed at the main square to form a large artificial lake and control flow in the canals through the old parts of the city. The Elbe River is tidal at Hamburg, with several metres tidal range and vulnerability to significant storm surges and river flooding when they occur. This relationship with water is reflected in the Speicherstadt district (which is the historical warehousing area) as well as the extensive



Contrasting riverside development in Hamburg. Speicherstadt (left) and Hafen City (right)

canals which enabled direct connection to the thriving port and the North Sea. Hamburg is a city state meaning that governance has duel roles at both local and central government levels.

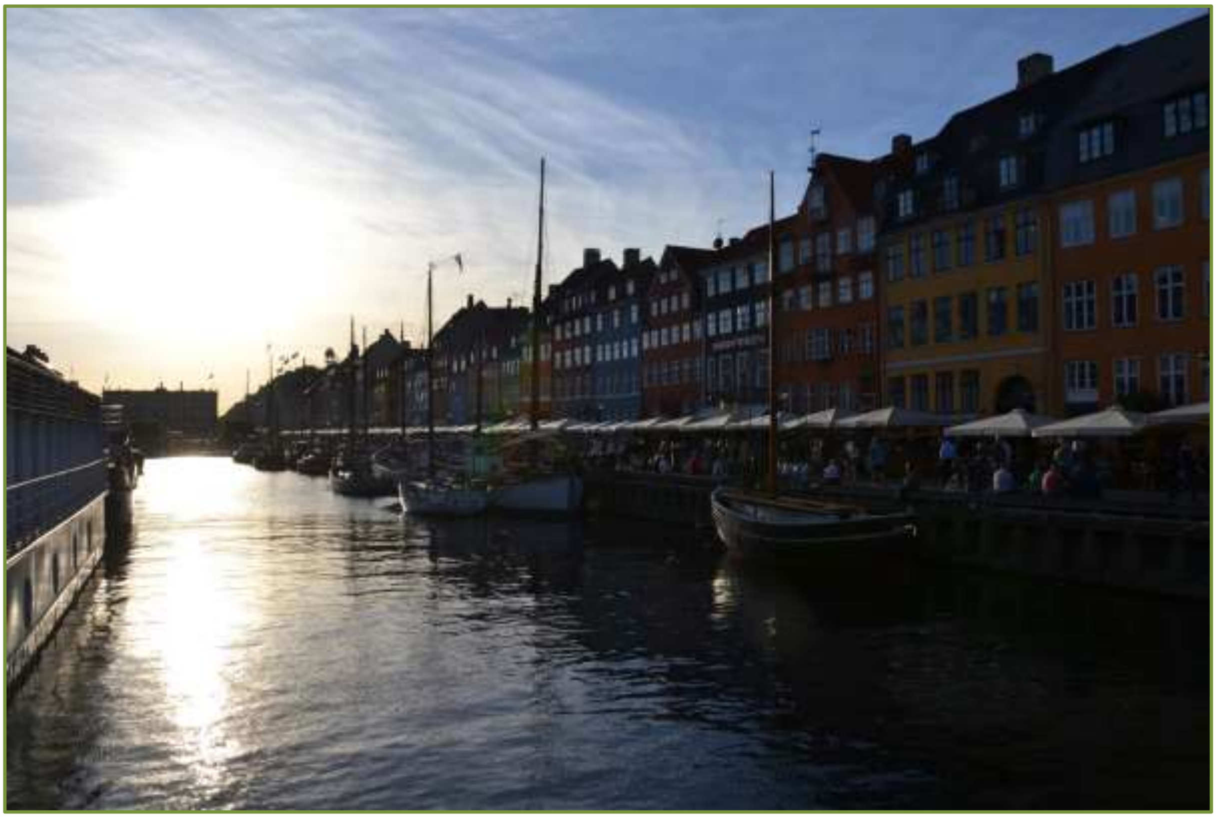
Hamburg's position on the Elbe has defined it since its establishment and continues to today. With the catchment of the Elbe extending across numerous state and national borders, Hamburg is vulnerable to flood events which typically occur with extended warning due to the large catchment scale. Whilst flooding has always been a challenge, the increasing frequency of storms, coupled with sea level rise, will increase the city's vulnerability. This has influenced the development of new brownfield development areas on the rivers edge.

Hafen City is a new inner-city growth area being built on former industrial land on the Elbe River. It is regarded as Europe's largest current urban development with plans to house 10,000 residents and 15,000 workers with a total area of approximately 220 ha. Being immediately adjacent to the river, the land is subject to infrequent flooding which needed to be factored into design. Rather than enforcing planning controls which limited any building activity on flood vulnerable land, Hafen City has been designed to integrate with the flooding. Low lying areas support extensive public open space (riverside promenade) with cafes, restaurants, shops and carparks included below the projected flood levels. Protection in the form of early warning systems, education and water tight flood exclusion doors has enabled this otherwise low value flood prone land to be developed in a manner which supports commerce and the amenity of the area. High specification architecturally designed buildings are then allowed to cantilever over the promenade in places effectively increasing the tenanted floor area without impacting on the flood protection.

Hafen City riverside promenade with flood doors designed into cafe to left

3.1.2 Copenhagen – Denmark

Copenhagen is positioned on the eastern coast of the island of Zealand. Having been the site of a Viking fishing village since the 10th century, Copenhagen became the capital of Denmark in the 15th century with rapid development from 17th to 19th centuries. Being very low lying, the city has always been defined by its relationship with water which is highly modified and managed. This includes three major constructed urban lakes (Sortedams Sø, Peblinge Sø and Sankt Jørgens Sø) and an extensive network of canals and boat harbours. All of these waterways are intimately linked to the urban architecture and extensive public parks of the city with an increasing aspiration for water based recreation and improved water quality.

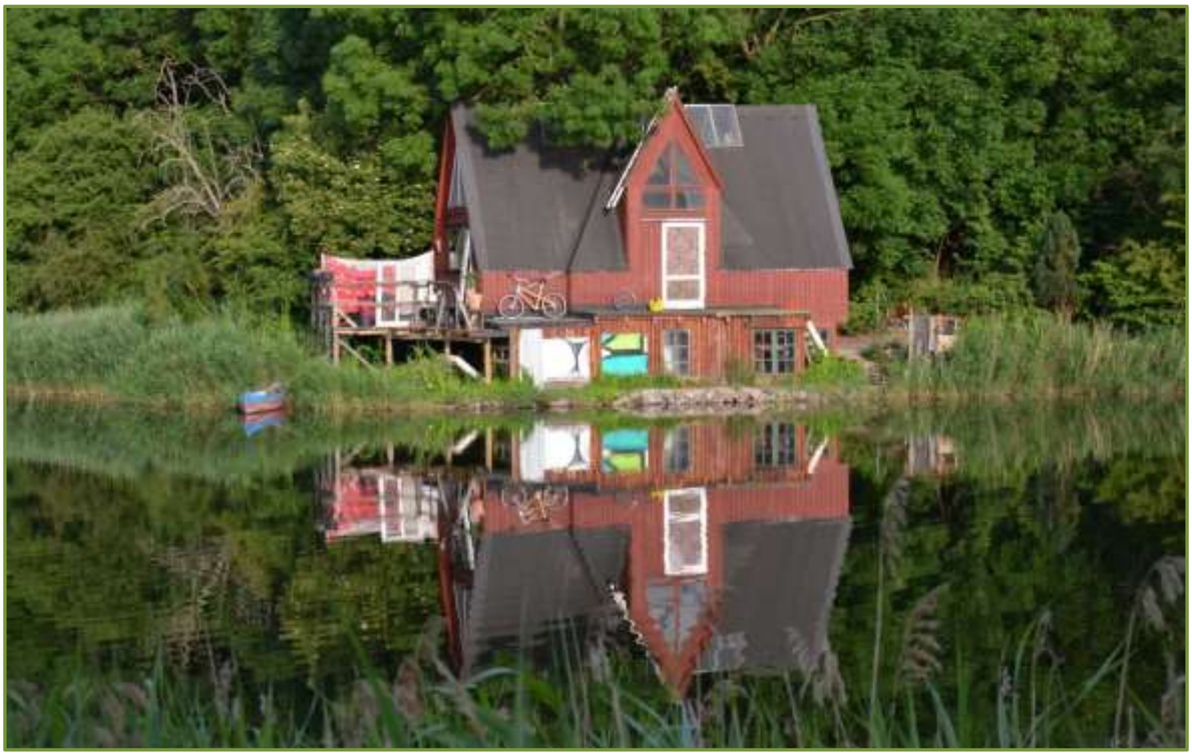


Inner city canal and nightlife, Copenhagen

The city has historically had a combined sewer system (where stormwater is drained into the wastewater piped network and conveyed to central wastewater treatment plants) with provision for wastewater overflows during large rainfall events. Due to the spread of urban water bodies through the city, much of the stormwater is also directly discharged into canals and/or lakes without any water quality treatment. In July 2011 the city was significantly impacted by a 'cloudburst' rainfall event which delivered over 150 mm of rain in less than 2 hours. This resulted in extensive flooding across the city resulting in over 90,000 insurance claims and over €1B damages. Recognition that such events are more likely under future climate scenarios, and that the current conventional approach to infrastructure will expose the city to unacceptable costs and ongoing damage, has driven the desire for alternatives to be found.

In response to this increasing threat of future extreme weather events, the council, utility and consultants developed the Copenhagen Cloudburst Management plan which was underpinned by a six-step formula as follows;

1. **Data and Investigation:** The city investigated, identified, and ranked areas according to their overall threat due to Cloudburst risk indicators, their potential to drive investment and influence property value, and the viability of implementation affecting adjacent developments.
2. **Modelling and Mapping:** Municipalities divided their regions into stormwater catchments, undertaking large-scale hydrological models (including GIS, surface water, sewage, landscape character, risk assessments) to map vulnerable areas. The conclusion was that traditional piped solutions alone were not enough with a need for public water utility companies to begin financing solutions that integrated Cloudburst events.
3. **Cost of Doing Nothing:** An analysis undertaken by the city and consultants calculated that the effect of climate change was so large, that the cost of doing nothing would amount to approximately €60-90 million a year from now to 2110.
4. **Design and Qualify:** Hotspots were identified, transferring strategic planning to human-scale experiences as a model for how other cities can mitigate Cloudbursts and daily rain events. The "Cloudburst Toolkit" was developed as a palette of universally applicable, multi-functional, flexible elements.
5. **Involvement and Iteration:** Future cloudbursts will impact all areas of Copenhagen and its population; an overall strategy for a public participation program was established to gauge the requirements of the citizens who would be affected.
6. **Cloudburst Economics:** A detailed socio-economic Cost-Benefit Analysis (CBA) tested two masterplan options. The option with the highest percentage of Blue-Green solutions (and also the least additional infrastructural pipe improvements) created a potential saving of 50% compared with conventional solutions alone. Additional qualitative social benefits, such as health, environmental, and urban spatial quality improvements resulting from the enhancements are considered likely to push this economic benefit even higher.



Christiania home on waterway, Copenhagen

The masterplan identified over 300 specific projects to be implemented across the city over a 20-year period. Many projects related to a disconnection of stormwater from the combined sewer system to enable surface detention storage integrated with public open space. It was determined that an estimated 30% of existing connected stormwater would need to be de-coupled to account for future climate change. Under the European Union's 'Water Quality Framework' there is a conflict with taking stormwater which currently discharges to the municipal treatment facilities and instead discharging to fresh and coastal waters. Therefore, increased water quality treatment is also required to be integrated with retrofit projects and all new development areas must have fully separated systems and provide water quality treatment prior to discharge.

The master plan also identified conflicts with the use of roads as specific stormwater detention areas. In recognition of the multiple benefits of using roads as part of the stormwater solution, new national laws were drafted and passed in 2012 which enabled utilities to use roads as part of stormwater management strategies and to fund projects which required a change in the level of service for these roads. This also enabled co-funding for surface works whereby extensive works to redevelop public spaces to integrate stormwater treatment and flood detention could be paid for by both utilities and municipal urban design budgets. These changes were initially met with scepticism that municipalities would use funds on non-essential services but with the support of extensive modelling and collaboration between stormwater engineers, landscape architects and roading engineers the benefits were shown to justify the approach.

Funding for cloudburst projects therefore requires a mix of "urban space improvement" funding and "water tax funding". The water tax (which has been in place for many years) is applied to households and was initially increased by 15% (approximately $250/yr/dwelling). These costs will increase in initial years and then progressively reduce as the scale of required works reduces. The imposition of the water tax has explored link between capital expenditure and reduced long term insurance liability with active engagement with the insurance industry. Whilst not yet fully resolved it is hoped that the increased water tax will be offset by no increase in premiums due to improved resilience to climate change impacts.

Copenhagen urban development with extensive green roofs

3.1.3 Malmo – Sweden

Located across the Øresund straight from Copenhagen, the city of Malmo has long shared connections with its Danish neighbour. As another harbour city located on the coast, it too is exposed to the same climatic challenges and identified the need to improve the management of urban water for environmental and resilience reasons in the 1990's.

In 1997, redevelopment of the West Harbour precinct for high density residential apartments recognised the need to avoid stormwater discharge into the existing combined sewer and to protect the urban canals and coast from stormwater derived contaminants. The precinct was therefore designed with all surface runoff conveyed in surface channels (with no below ground pipes) with discharge to canals via pre-treatment in pocket wetlands and raingardens either at the edge of the canals or front of buildings. These features have been designed into the urban fabric to also add amenity to the streetscapes and to connect residents with water. Detention storage is also provided within the landscape to reduce flooding impacts.

Pocket wetlands out the front of convenience store in West Harbour, Malmo

At the same time, it was identified that efforts to retrofit precinct scale stormwater management into existing areas should be undertaken. As a result, the Augusten Eco Development was implemented which disconnected stormwater in a 1950's low socio economic, high density housing area and provided similar conveyance and treatment as the West Harbour area. Severe weather in 2014 which delivered 100 mm rain in 6 hours (100 year ARI) resulted in no flooding in either area, validating the approach.

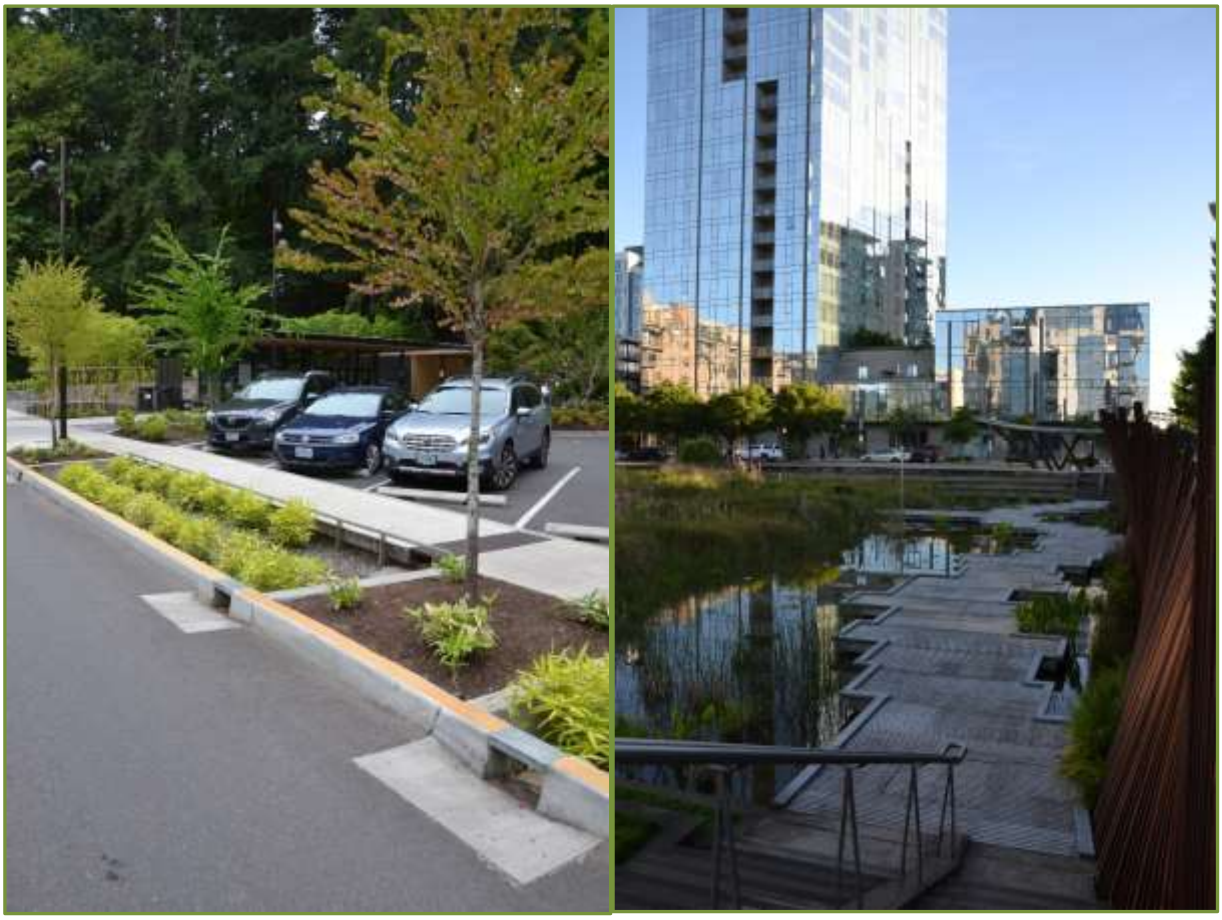
Malmo is also the location of the Scandinavian Green Roof research Institute. This was founded in 1997 also, to make use of a pre-existing municipal building (housing operations team) to test the effectiveness of green roofs. This has enabled long term testing of different proprietary systems, different growing mediums and different plants. Monitoring includes research into the lifecycle of green roofs and compares longevity against non-green roofs to test whether roof life is extended. This research has proved valuable understanding to green roof practitioners from across the globe with regular international delegations and student groups visiting the institute and/or participating in research. This facility also provides an opportunity to experiment with different visual outcomes including replicated meadows, productive gardens and habitats for lizards.

Research plots at Scandinavian Green Roof Research Institute, Malmo

3.1.4 Portland – Oregon, USA

The city of Portland is located approximately 100 kms inland from the Pacific coast at the confluence of Willamette and Columbia Rivers. The rivers initially provided valuable connections for the city and supported growth around a number of smaller tributaries (many of which were piped). The city developed with largely combined sewers resulting in ongoing problems with wastewater overflows during moderate rainfall events. In response to increased environmental awareness/advocacy in the 1980's (and federal requirements under Clean Water Act 1972) the city established a comprehensive work program costed at $1.4B to upgrade the wastewater system to reduce overflows. This was considered to be cost prohibitive at the time and state (Washington State) officials challenged Portland to find alternative solutions that were less centralised and more integrated. From the 1990's this was determined to be well served by a mix of traditional piped infrastructure with green infrastructure and distributed land use interventions which could save money whilst delivering better overall outcomes for the community and municipality. This provided the catalyst for wide range of stormwater management programs which have transformed city's three waters management. Programs implemented included;

- *Combined Sewer overflow program* (1991- 2011)
- *Downspout disconnection program* (1995 – 2011)
- *Private property retrofit program* (started after 2011)
- *Sump retrofit for infiltration program* (over 3,000 retrofitted to 2018)



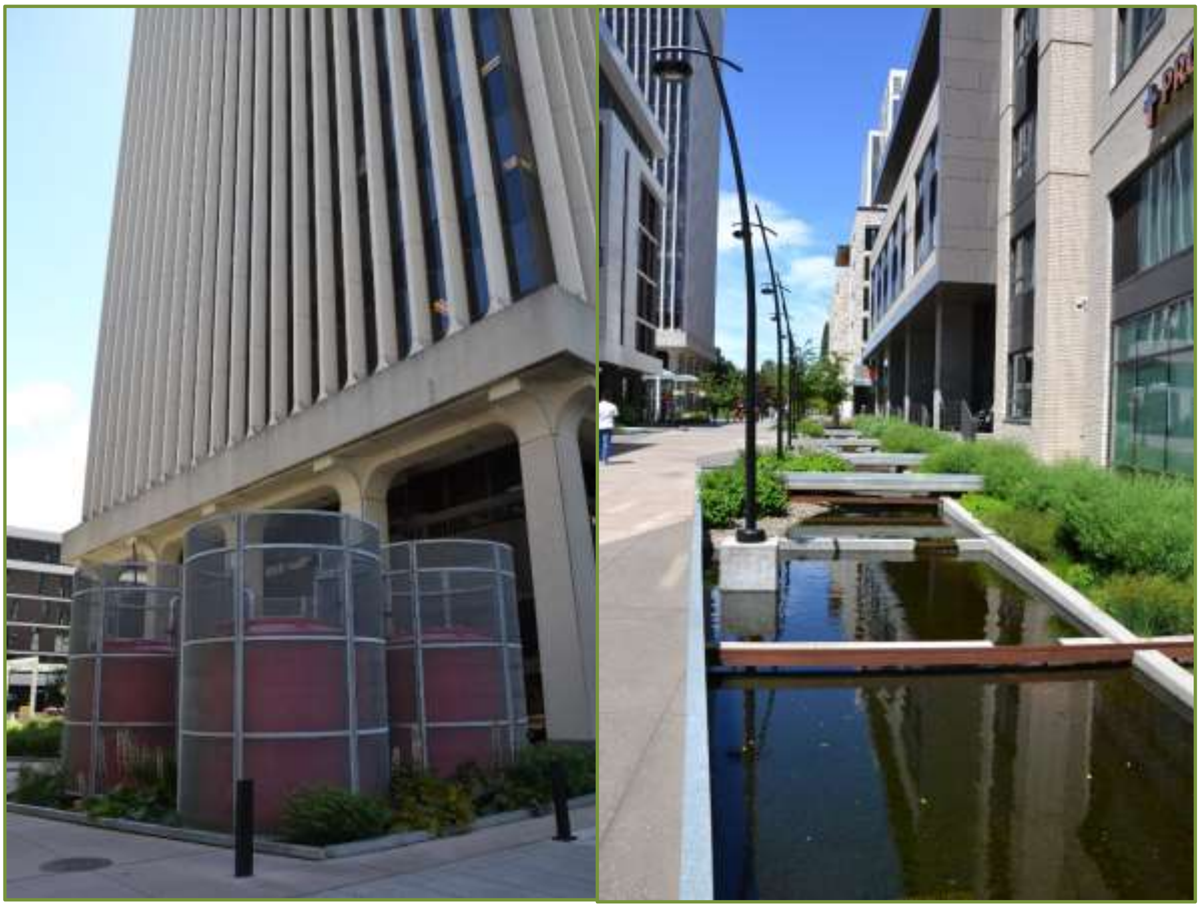
Stormwater treatment in Portland. Streetscape raingardens at Japanese gardens (left) and Tanner Springs Park (right)

Having learnt a number of lessons through this long transition process, the city now takes a proactive approach to incentivise voluntary action through different funding mechanisms. Stormwater is funded through targeted rates based on calculation of both offsite (receiving environment) and onsite (impervious area) considerations. This rate equates to approximately \$28/m^2/yr of impervious cover with single family residential properties charged a fixed fee. Multi-unit and commercial buildings are required to map impervious areas to calculate the onsite/offsite costs to be charged (imperviousness tax). This incentivises reduced impervious cover including incentive for green roofs.

Under the current private property retrofit program, residents can voluntarily opt in to get stormwater treatment devices retrofitted in their property for up to 35% reduction in targeted rates (Clean River Rewards). Under this program the city pays for the retrofit infrastructure, with the owner paying for ongoing maintenance with a deed restriction placed on the property to ensure lifecycle benefits are realised.

Use of green roofs is supported by the city and whilst previously promoted as a means of reducing impervious areas, as of June 2018, all new inner-city buildings must have green roofs installed to further drive implementation. This is intended to progressively use redevelopment to return current urban areas to a pre-development hydrology. It is noted that seismic risks are equivalent to New Zealand and that the continued implementation of green roofs has driven structural engineers and the construction industry to routinely deliver.

In terms of the design of retrofit and new public stormwater treatment devices (typically raingardens) the city has used experience and research to develop a range of standardised design elements which support certainty of performance and consistency. This includes standard details around inlets/outlets and clear design guidelines which reflect the city's intent for the delivery of quality assets. These have been implemented across the city with over 650 stormwater treatment devices now constructed in road verges, carparks and on private commercial properties.



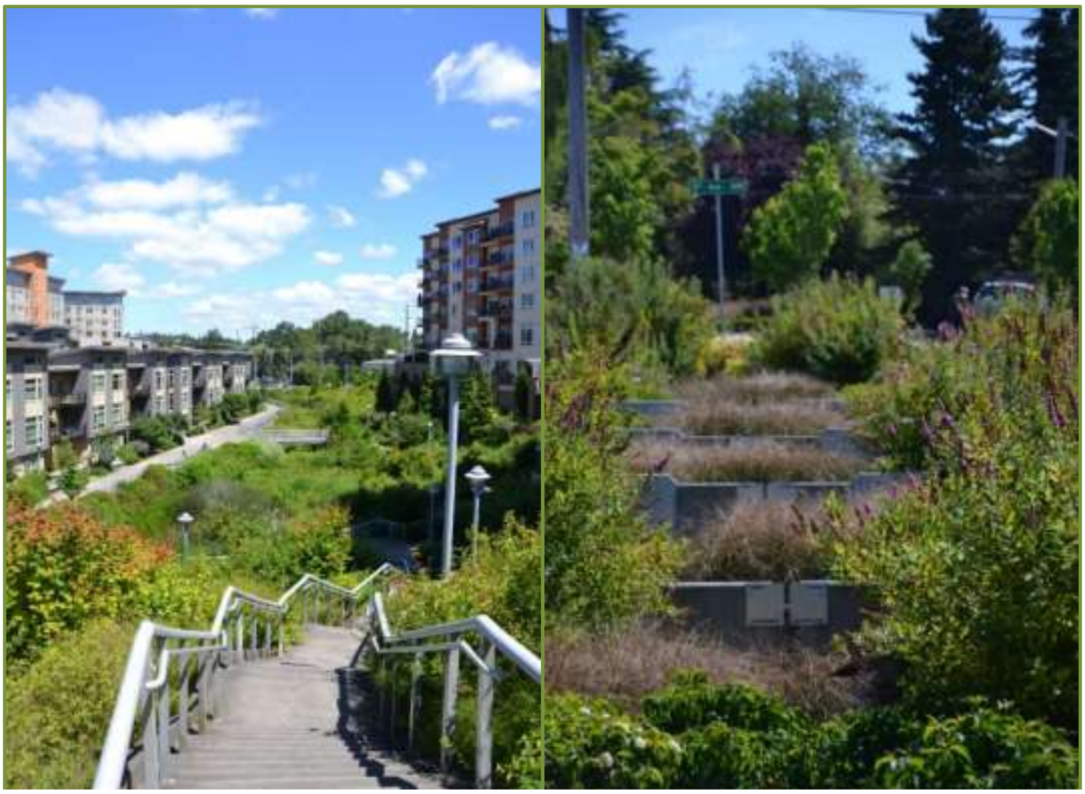
Integrated water management at Lloyd Eco District, Portland. Wastewater treatment units (left) and treated wastewater water feature (right)

Portland has also adopted an innovative approach to precinct scale de-centralised governance to drive step change in sustainability. Initially five inner urban districts were identified (referred to as Business Improvement Districts) which could establish their own funding mechanisms and delivery pathways to upscale sustainability as public/private partnership. These were a subset of 11 identified urban renewal districts which are areas of the city where infill and redevelopment expected to occur in the coming years. Whilst this program initially struggled in a challenging political climate and difficulties engaging effectively with the public sector, it laid the groundwork for further development of the model. Prosper Portland (formally Portland Development Commission) supported a continued focus on 'Business Improvement Districts' and supported business/property owners to implement voluntary innovations to support transformative change. This program has ultimately enabled the establishment of decentralised private utilities to manage and operate three waters infrastructure at a scale which works economically.

Lloyd Eco District is an inner urban area in suburb of Lloyd where this program has been adopted. Redevelopment of former carparks and low value buildings into approximately 90 ha (with 1,000,000 m^2 lettable floor area) which is focussed on upscaled sustainability and innovation with an overall plan to increase floor area to 3,000,000 m^2. This includes fully private utility providing integrated three waters infrastructure to service the mixed use residential and commercial buildings. Developer contributions are waived by council, and the private utility is able to charge water/wastewater rates similarly to a traditional public utility. The result is an off grid solution with onsite wastewater treatment (biological treatment train), stormwater capture and treatment and reuse of harvested treated wastewater for non-potable use throughout buildings (toilets). Buildings maintain 95% occupancy and tenants/owners benefit from reduced annual costs whilst contributing to improved environmental outcomes.

3.1.5 Seattle – Washington State, USA

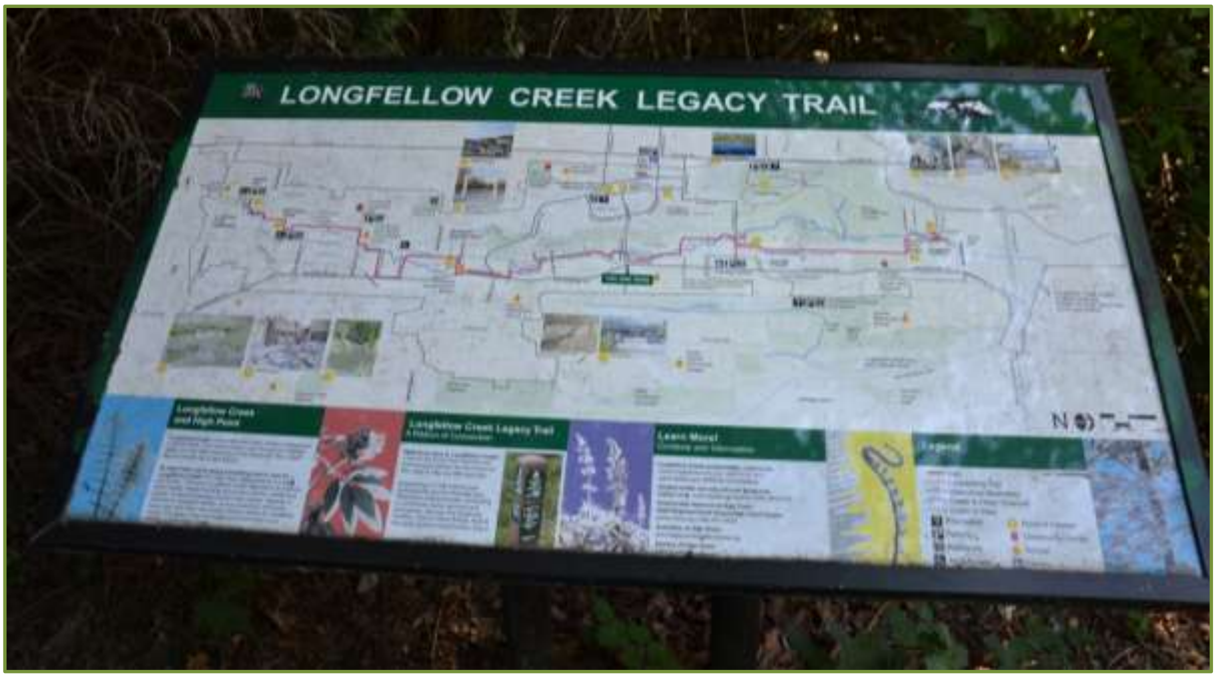
Seattle is located on the flanks of Puget Sound which is an inlet on the Pacific Coast. The sound supports an abundance of iconic species including whales (in particular Orca), river otters, seals and salmon. The



Stormwater management in Seattle. Daylighted Thornton Creek through development (left) and retrofitted raingardens at 101 Cascades (right)

cities connection with this natural environment has shaped its character and community with a heightened interest in the outdoors and value of nature within the urban environment. There is also an active cohort of environmental advocacy groups who have traditionally maintained a vocal dialogue on a wide range of issues relating to water quality and degradation of fresh and coastal waters. At a state level, environmental regulation is enforced through Water Pollution Control Act and Surface Water Quality Standards which are both administered by the Washington State Department of Ecology. This regulation, along with provision of clear guidance material and support, has driven Washington State and Seattle to take a progressive approach to the implementation of stormwater management across the municipal area. This includes efforts to significantly reducing direct connections of stormwater in new subdivisions through widespread use of swales as conveyance to centralised wetlands (Highpoint development), retrofit of stormwater treatment into inner urban street and catchment scale programs that engage with the local communities to garner support for ambitious retrofit projects.

These catchment scale projects include signage and supporting education material which clearly articulate the connection between activities and landuse on receiving environments and enable testing of targeted treatment and projects at a scale which represents the scale of the remaining or downstream freshwater streams.



Longfellow Creek information panel, Seattle

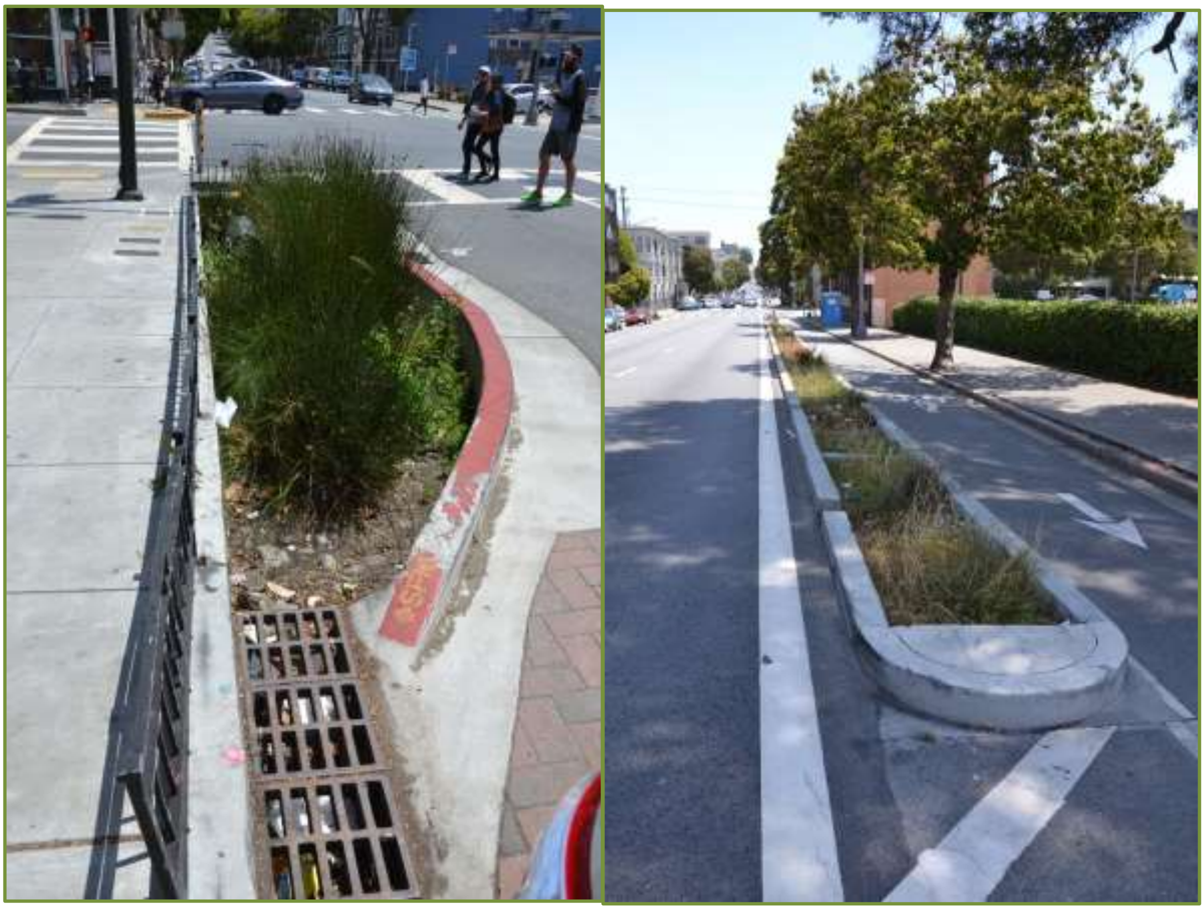
3.1.6 San Francisco – California, USA

The city of San Francisco shares the San Francisco Bay receiving environment with a number of other major population centres with a total population of close to 8 million. The bay comprises three estuaries (San Francisco, San Pablo, and Suisun estuaries) with major rivers including the Napa River, the Petaluma River and the Guadalupe River as well as numerous smaller creeks. San Francisco itself is positioned on the southern head of the bay entrance and retains almost no streams having been extensively urbanised from the mid 1800's. As a result of this, the city has invested less in urban water management in terms of water quality in recent decades.

From around 2003 the State of California picked up on federal policy related to Clean Water Act and required large cities to develop plans with Phase 1 cities being those without combined sewers (on the premise that untreated stormwater was being discharged) and Phase 2 being those with combined sewers (which includes San Francisco). State regulators required that by 2011 Phase 1 cities had to have implemented programs and Phase 2 had to have commenced planning. This identified a hierarchy of; Reuse, Infiltration and then Treatment.

In response to this, San Francisco invested approximately $57M on 8 early implementation projects which were largely politically motivated and had variable success. Current estimates are for a further $600 M to be spent in San Francisco over next 6 years on sites across the city funded through targeted rates. This funding will enable implementation of a wide range of prioritised projects across the city triggered by redevelopment, infrastructure renewal and roading upgrades.

Policy implemented in 2016 amended earlier policy requiring at least 15% coverage in solar panels on new inner city buildings to allow substitution with all or partial green roofs at a ratio of two to one. Therefore, where only green roofs were being proposed, 30 % minimum coverage is required on buildings up to 10 storeys high.



Streetscape raingardens implemented in early San Francisco projects. Raingardens are considered to be in poor condition

3.2 Identified Enabling factors

Following meetings with administrators, regulators, council officers, academics and consultants a number of enabling factors have been identified. These are considered to be key contributors to the respective city's progression in urban water management and are considered to be transferable to New Zealand context. These are listed below under city sections. Overarching general enabling factors which were consistent across all locations are presented separately in Section 4.

3.2.1 Hamburg – Enabling Factors

Investigations in Hamburg were limited to the Hafen City redevelopment on the Elbe River. Enabling factors which have supported this include:

1. Recognition that through appropriate design, flood encumbered land does not exclude high value economic activity.
2. Enabling economic activity within flood prone land (with appropriate protection) can increase the viability of development and improve long term social outcomes.

3.2.2 Copenhagen – Enabling Factors

Based on the experience and activities implemented as part of the Copenhagen cloudburst response, the following relevant enabling factors were identified;

1. Taking a whole of city strategic approach to identify issues and then test possible alternative pathways.
2. Clear recognition and quantification of the business as usual approach which is able to be evaluated against an alternative water sensitive approach at a whole of city scale.
3. Undertaking detailed socio-economic cost benefit analysis to demonstrate long term benefits and garner political and community support.
4. Recognition of the importance of co-managing roading networks as a fundamental component of the stormwater network. Pre-existing legislation that placed limitations on stormwater spending in road projects not seen as barrier but rather recognised that legislation needed updating.
5. Early recognition that traditional drainage solutions such as underground reservoirs are becoming less viable due to cost and limited underground space and that extreme weather events cannot be managed by conventional pipe systems alone given dramatically increasing intensities.
6. Recognition of the value of low-tech surface interventions which can be integrated with high quality contemporary landscapes to support climate adaptation solutions and environmental protection within the limited confines of urban space.
7. Establishing strong interdisciplinary collaborative approach with architects, engineers and planners to ensure that cloudburst projects preserve the identity of areas and are not just delivered *as* large engineered detention ponds.
8. Responding to climate change through determining extent of stormwater de-coupling required and then factoring in water quality to ensure that perverse environmental/social outcomes do not result.
9. Willingness to challenge well established national regulation based on need to change and implement innovative funding to allow co-funded public infrastructure.
10. Establishing link between increased household water tax and opportunity for reduced future insurance liability. Establish clear link between investment now and future resilience to improve overall economic equity.

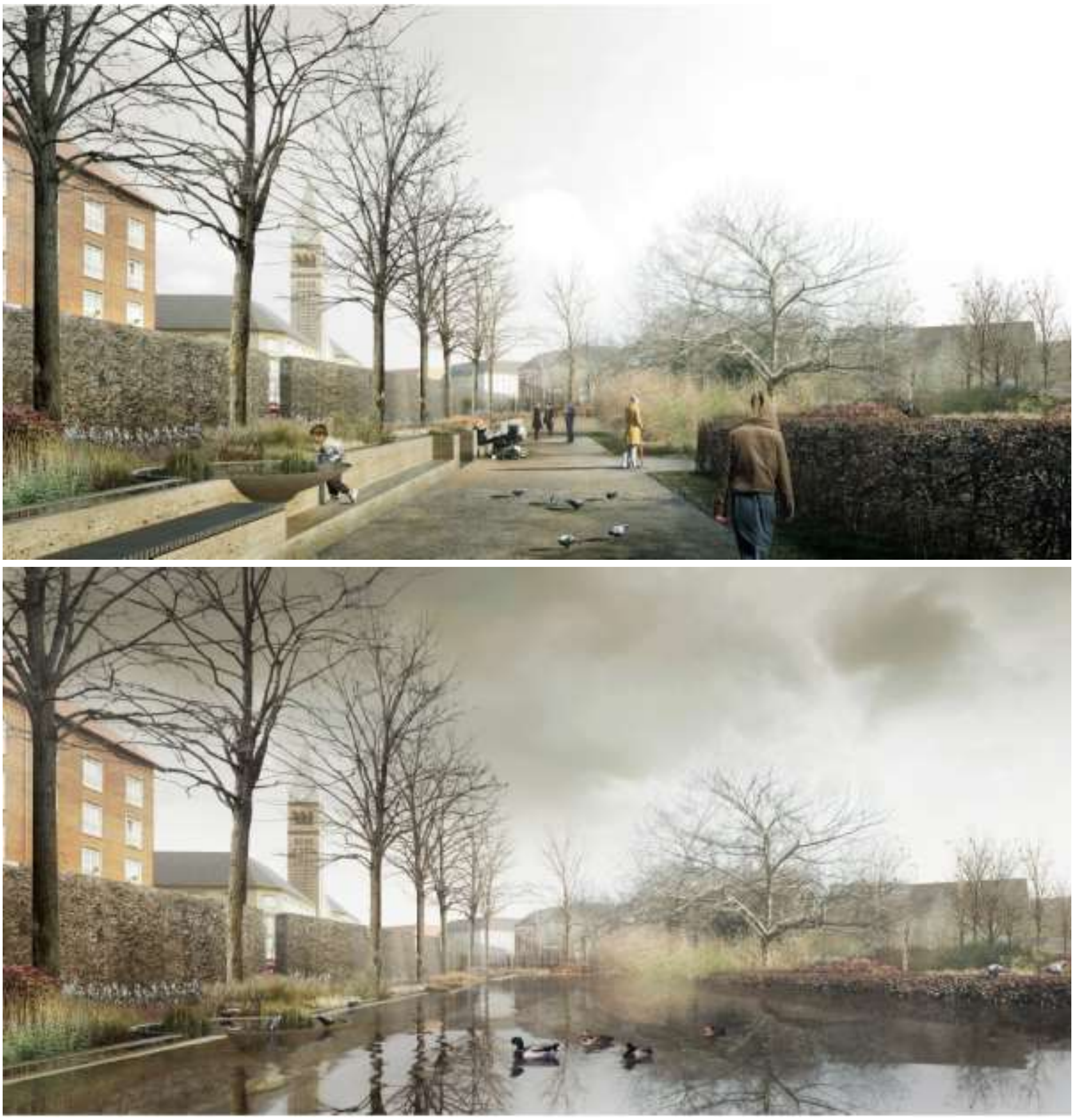


Figure 1: Enghaveparken water park showing flood detention in lower image. Image provided by Municipality of Copenhagen

Malmo – Enabling Factors

1. Investment in research into green roofs used to inform decision making and justify implementation at a policy level.
2. Recognition (through research) that the use of conventional green roofs will substantially reduce the volume of urban runoff in addition to providing improved water quality, insulation and urban ecology.

3. Recognition that small scale 'at lot' stormwater treatment can work in both new and existing (re development) high density urban developments providing disconnection of stormwater and management within the landscape.
4. Recognition that the management of stormwater via small surface channels and discreet depression storage can provide resilience to flood events in low lying areas.

3.2.3 Portland – Enabling Factors

Based on the experience and activities undertaken by public and private sector in Portland, the following relevant enabling factors were identified;

1. Actions and strategies to improve urban water supported by clear federal government regulation. Clean Water Act (1972) and Endangered Species Act (1973) are both overarching frameworks which have direct translation to urban water issues resulting from urban modifications. These Acts were the catalyst for state and local government rules and policy to drive change in practice.
2. Foster strong voice of environmental advocacy groups to engage community in issues and garner political will.
3. Initial investment in determining cause and effect of stormwater related impacts used as the basis for change in practice. Evidence based approach (at a time when the link between urbanisation and water quality was less understood) used to get political buy in and to communicate obligations to respond to Clean Water Act and Endangered Species Act.
4. City officials were early adopters of research into effectiveness of green infrastructure including raingardens (bioretention), green roofs and urban trees. Research was intentionally undertaken in-house by city officials to enable flexibility and adaptation as understanding increased and to enable long term monitoring to be realised in a cost-effective manner. This enabled the city to learn from early implementation and adopt an approach of continuous improvement in design details and effectiveness to inform rules and policy.
5. Adopting a multi-disciplined approach within council where parks personnel (landscape architects), roading engineers and stormwater engineers work collaboratively to ensure that multiple benefits are understood and optimised.
6. Developed clear and unambiguous rules to drive improvements. For example, all development over 500 ft^2 (46 m^2) must have stormwater management with implementation of green roofs excluded from these areas. This recognition of green roofs as fundamental component of urban water management used to incentivise uptake.
7. Use redevelopment of CBD as catalyst to change urban water outcomes by mandating green roofs on all new buildings.
8. Recognise the role of street trees (canopy) for interception of small rainfall events to drive urban greening.
9. Established a regime where decentralised governance for three water services at a precinct or business district scale can occur. This includes allowing standalone private utilities to establish decentralised integrated water schemes with reduced public costs and rates enabling private operators to fund infrastructure through user charges etc.
10. Willingness to use large costs for required 'traditional' infrastructure upgrades as motivation to look at alternatives such as green infrastructure. Develop investment strategy based on integrated solutions which encapsulate both traditional hard infrastructure (pipes, pumps etc) and other green initiatives and intangible programs such as education.
11. Clear pricing structures where rate payers are charged for stormwater impacts with linkages to imperviousness for multi-unit and commercial developments. Pricing is based on onsite and

offsite impacts and enables residents to understand their role in water cycle and contaminant generation.

12. Utilise strong incentive programs to encourage voluntary uptake of programs involving retrofit at lot scale. Reductions in ongoing stormwater rates reflect change in land use and capital cost is borne by council with homeowners only responsible for maintenance. This use of public money in private property enables progressive improvements in space constrained areas.

3.2.4 Seattle – Enabling Factors

1. Actions and strategies to improve urban water motivated by federal government regulation. Clean Water Act (1972) and Endangered Species Act (1973) are both overarching frameworks which have direct translation to urban water issues resulting from urban modifications. These Acts were the catalyst for State and Local government rules and policy to drive change in practice.
2. Recognition that stream restoration and protection will only be effective if catchment wide stormwater management is also implemented. Use this to couple catchment programs with steam restoration aspirations.
3. Connecting communities with catchments and developing programs branded with receiving stream names to maintain community interest.
4. Working with developers to promote development scale stormwater strategies which reduce imperviousness and promote infiltration to manage hydrology as well as water quality.
5. Identify opportunities to daylight piped streams and use as focal points to brownfield redevelopment
6. Invest in extensive signage and branding to increase community education and provide profile.

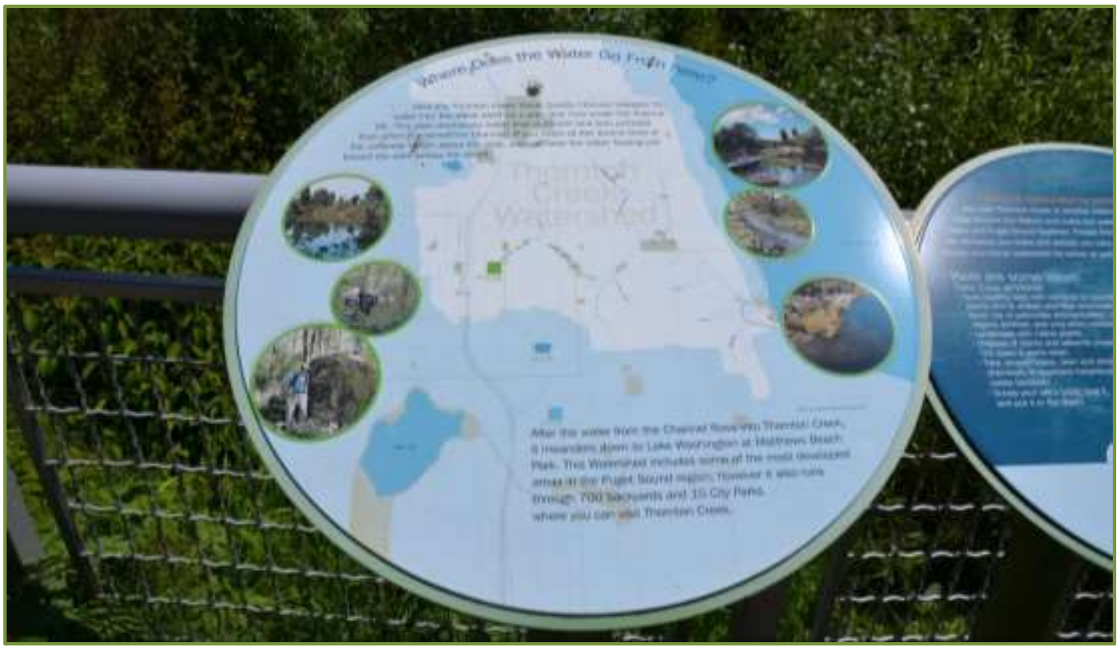


Figure 2; Thornton Creek catchment information, Seattle

3.2.5 San Francisco – Enabling Factors

1. Incentivising green roofs in medium rise (up to 10 stories) buildings through amendment to solar panel regulations to allow homeowner choice between panels or greenroof

4.0 Conclusions and Recommendations

In travelling to such a diverse range of cities I observed enabling factors which transcend the differences and are largely independent of place. These factors were replicated across these leading cities and encapsulated by public officials, utility operators, consultants, academics and community advocates alike. Key enabling factors included;

- Political will to take action and be proactive rather than reactive.
- Confidence to move from problem definition to problem solution without using residual uncertainty as justification to defer.
- Use of financial incentives and alternative funding models as catalysts to drive change in practice.
- Learn from experiences (both good and bad) to develop consistent approach which reflects local climate, topography and urban form.
- Foster innovation through taking an open mind to changing the status quo and not being constrained by the business as usual mentality.
- Willingness to involve community in decision making.
- Empower communities through weaving a water narrative into our cities which educates in terms of water quality, flood resilience and our roles in the interrelationships between our urban centres and the wider environment.
- Monitor success in terms of social and economic metrics as well as purely technical performance.

In terms of specific enabling factors which have the potential to support New Zealand's transition to improved urban water management, the following factors are specifically itemised.

1. ***Stronger legislation around the protection of indigenous fish species will translate to a mandate to protect water quality and habitat (including design of structures and changes to hydrology).***
    a. Updating policy to provide similar levels of protection to native fish and invertebrates as is currently given to many land-based species will provide further drivers to improve water management whilst also reflecting the importance of biodiversity and mana whenua connections with many taonga species.
    b. Legislation should encompass protection of water quality (including physical and chemical characteristics) in addition to habitat and should address all stages of migratory species lifecycles.
    c. Likely political challenges given public interest in activities such as white baiting.

2. ***Develop and implement different funding models to offset increased investments in CAPEX and OPEX for stormwater management. This should be focussed on principal of 'polluter pays' whereby cost recovery from landowners covers costs of public infrastructure to manage.***
    a. Funding models could include; imperviousness taxes, targeted stormwater rates or increased developer contributions based on lifecycle cost considerations. Funding model should provide incentives for developers/landowners to voluntarily reduce impacts through improved design.
    b. Funding for traditional infrastructure is never politically appealing. Need to look at using incentives in tandem with charges to enable individual homeowners to better

understand the implications of different facets of three waters and to motivate change in behaviour.

c. Uniform metering and charging for water supply recommended to provide baseline for alternative investment strategies and to support education to enable proper assessment of options.
d. Economic evaluation of intangible benefits (and costs) can better enable alternative funding models which incentivise activities that deliver non-binary economic benefit (such as community health, mental wellbeing and property values).

3. ***Enable public/private partnerships with delivery of three waters infrastructure to support uptake of less centralised systems and innovation at precinct scale.***
    a. Current reliance on Councils (or utilities) to manage all aspects of three waters is considered to limit innovation and transformative change. Injection of private funding (at discreet scale rather than privatisation of city scale utilities) has potential to use non-traditional market drivers to defer investments in new city scale infrastructure (such as new water supplies) whilst also delivering integrated solutions that deliver benefits at a range of scales.

4. ***Find mechanisms to incentivise uptake of green roofs and use to better manage water quality and hydrology in developments as well as improving biodiversity, urban ecology and urban heat island. Work with structural engineers to alleviate seismic fears and establish sharing of knowledge with west coast USA cities which are seismically active whilst still promoting green roofs.***
    a. Well aligned with use of imperviousness taxes whereby green roofs reduce the effective impervious landcover and therefor provide savings to developers.
    b. Investigate planning rules whereby dispensations to increase building height or site coverage with inclusion of green roofs.
    c. Research potential for green roofs to specifically support New Zealand biodiversity through habitat suited to lizards, insects and bird species.

5. ***Develop enabling policy (required at LGA level) to support councils/utilities to manage surface assets (roads and parks) as critical stormwater assets with systems in place to ensure any action is based on interdisciplinary collaboration to optimise outcomes.***
    a. Current restrictions on funding and expenditure on 'traditional' infrastructure creates limitations on the potential to co-manage flood waters within the landscape.
    b. Existing approach to progressive resurfacing of roads with elevated central crown results in a progressive reduction in flood capacity and increased risk to properties adjacent to roads.

6. ***Change our attitude to flood waters and design surface storage into cities to be integrated with public open spaces, roads or on private land parcels.***
    a. Infrequent traffic disruption in non-essential connecting roads (i.e. not main arterials or lifelines) balanced against ability to reduce flooding in more critical locations and reduce damage to private property.

7. ***Amend planning rules to enable economic activity (commercial lettable floorspace) in areas where flooding could occur with appropriate protection and warning systems in place.***
    a. Work with next generation forecasting models to better predict high intensity rainfall events which will trigger required protection. Any development would need to be

appropriate for residual level of risk with full disclosure required to manage insurance etc.

8. ***Promote and support large scale stormwater harvesting for fit for purpose non-potable reuse to reduce reliance on mains water (with associated treatment and conveyance footprint), increase resilience in times of network disruption and manage excess runoff to protect instream ecosystems.***

9. ***Break down existing silos within councils/utilities where three waters infrastructure planning, design and implementation is often undertaken in isolation from other key groups such as roading engineers and parks/urban design.***
    a. This disconnect is worsened by the tendency towards standalone public utilities which tend to make integrated land use and infrastructure planning more difficult.
    b. Collaboration and inter disciplinary work practices require shared understanding and increased technical capabilities across a range of professions.
    c. Need to understand the true potential (and meaning) of integrated water management and the range of benefits this can deliver in terms of environmental, economic, social and cultural outcomes.

10. ***Find ways to effectively connect communities with their catchments and use an awareness of this to drive retrofit of stormwater treatment and downstream stream restoration.***
    a. Historical disconnect with waterways (many of which are piped and/or highly degraded) isolates communities from these important resources. Citizen science and community education important to involve people in receiving environments and get them to connect land use activities with downstream impacts.

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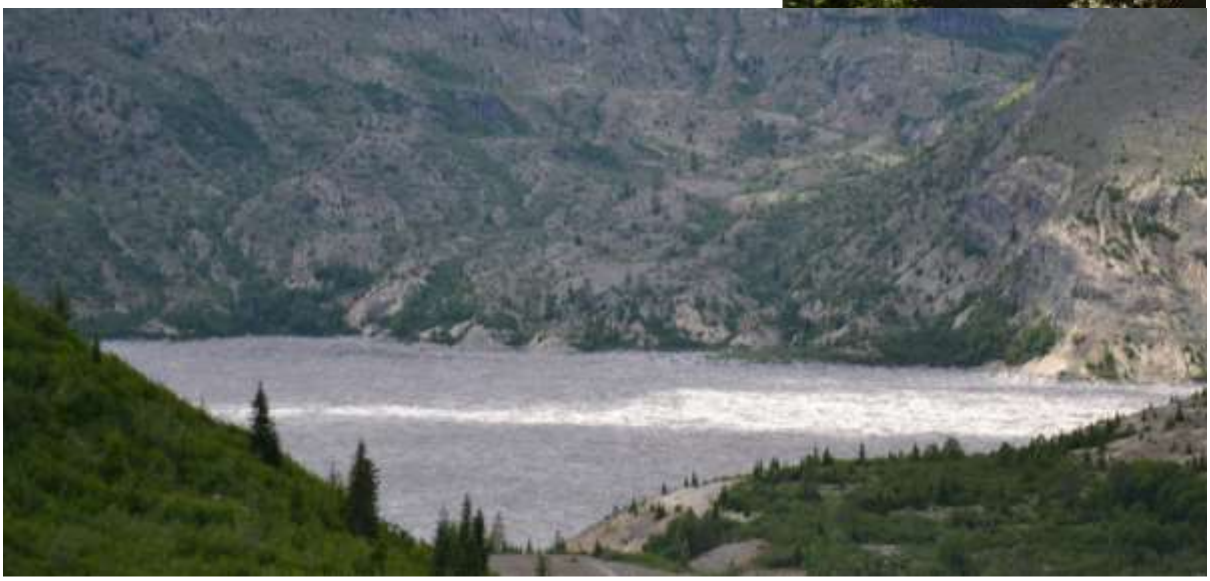

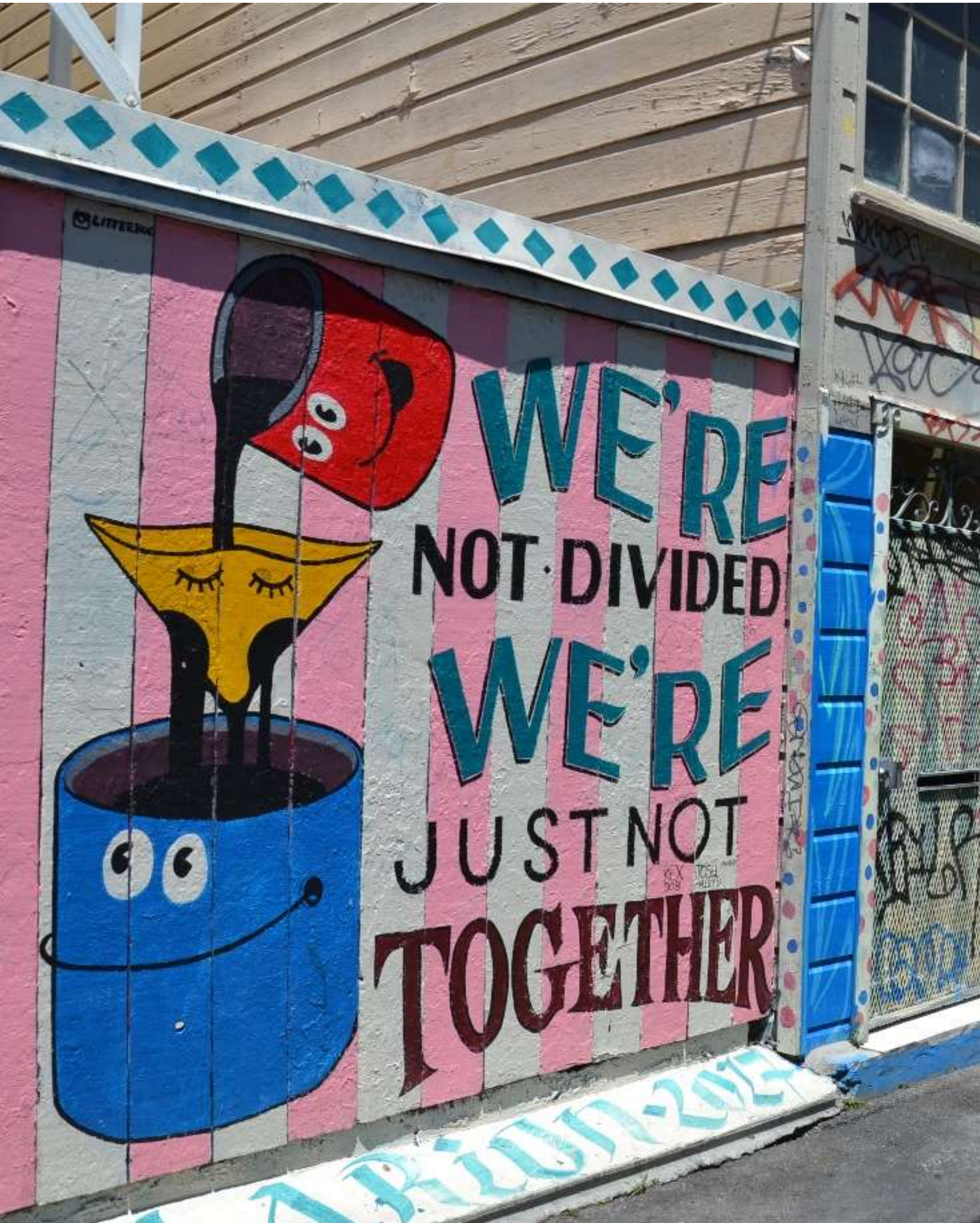
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NOT·DIVIDED
WE'RE
JUST NOT
TOGETHER