2011

FLOOD MANAGEMENT & DRAINAGE STRATEGY

2011 Overseas Study Tour Report

by Chris Lyne

Municipal Engineering Foundation Victoria

MORNINGTON PENINSULA Shire

COMMITTED TO A SUSTAINABLE PENINSULA

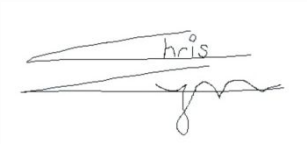
SYNOPSIS

2011 Overseas Study Tour – Canada, USA & UK

In September 2011 the Municipal Engineering Foundation's study tour group met with 10 councils and organisations in Vancouver, Seattle, Denver, New York and London. The purpose of the tour was to discuss their experiences with Flood Management, Drainage Strategies, Climate Change, Flood Mapping and Flood Mitigation among other things.

The tour included attendance at America's International Public Works Congress & Exposition in Denver, Colorado.

The following report details my experiences and findings from the tour. Information that will provide valuable insights as to how international councils approach and resolve similar issues faced within Victoria.



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ACKNOWLEDGEMENTS

There are a lot of people I wish to extend my gratitude to in supporting, assisting and being part of the 2011 Municipal Engineering Foundation (MEF) Victoria's Overseas Study tour.

To the MEF and Trustees who provide the opportunity every year for local government engineers to travel overseas and learn from the experiences of international councils. For placing your confidence in me by awarding the scholarship means a great deal; thus enabling me to broaden my horizons and gain a greater understanding of how the wider engineering community tackles issues similar to those we experience here in Victoria.

Massive thanks to my tour group:

- **Katherine O'Connell** (Project Manager – Stonnington City Council)
- **Peter Robertson** (Director City Infrastructure - Warrnambool City Council)
- **Warren Roberts**, Tour Leader (Chief Executive Officer - City of Stonnington and Trustee of the Municipal Engineering Foundation Victoria)

Our group (including Warren's wife Sue) worked extremely well together, in both the preparation phase and on tour. Decisions were easily made and from the time we made contact with all the host organisations the tour ran very smoothly. I cannot thank you all enough and I look forward to continuing our on going professional relationships.

To my employer the Mornington Peninsula Shire who has completely supported me throughout the process. Without which, it would not have been possible to participate in the study tour. I hope I can bring valuable ideas into the Shire and implement them where possible. Indeed discussions have already taken place with some interest in Permeable Paving and Storm Flood warning. In particular I would like to thank my Director, Manager and Derek Rotter (Team Leader) for their ongoing personal support and assistance.

I want to personally thank all the direct contacts from each place we visited and for the time and effort they put into assisting our study tour. Without you the 2011 MEF study tour would not have been the fantastic success it was:

- Lambert Chu - City of Burnaby, British Columbia, Canada
- David Desrochers - City of Vancouver, British Columbia, Canada
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- Max Tant - Kent County Council, England
- Gordon Hunt - Oxfordshire County Council, England
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To my beautiful wife and boys, you support me every day. Without you life in general would be too hard, you are my home, my life. Words are never enough to express how I feel, thanks for everything you do every day. Especially my wife for looking after a 2.5 year old and new born on your own while I was on the tour!!

INTRODUCTION

During the time I spent with various organisations around the world I began to develop a greater understanding of their approach to dealing with stormwater. Each location has their own unique set of circumstances and they dictate what sort of strategies should be put in place to manage their respective flooding issues.

Burnaby, Canada, for example has roughly twice as much total rainfall as the Mornington Peninsula and yet rarely do you see a standard Side Entry Pit as you would in the Mornington Peninsula Shire. Their rainfall tends to be light and long in duration; it's common for them to experience 20 days straight drizzle. In Mornington Peninsula, storms tend to be short and sharp (no more than a few hours typically), this identifies with common Climate Change predictions for a tropical type environment.

Flooding is a natural worldwide phenomenon. In urban areas where drainage relies on pipe networks, open channels and creeks, flooding can cause infrastructure damage (both private and public), loss of amenity, environmental degradation and pose safety risks.

As my knowledge of natural drainage systems and flooding improves, the Shire and its residents will gain greater certainty which can lead to enhanced community confidence and reduced economic loss through the implementation of flood mitigation, planning control and emergency action plans.

Climate change has raised the need to act expeditiously to plan to achieve knowledge of the performance of the Peninsula's drainage infrastructure network, and flooding of vulnerable areas. This knowledge is essential to establish flood mitigation works, planning controls and community understanding.

In this report I have provided information from each of our host organisations about how they tackle the issues of flood management and drainage strategy. Including various mitigation options planned and implemented to protect local properties and infrastructure from damage.

STUDY TOPIC

Flood Management and Drainage Strategy

The Mornington Peninsula Shire is developing and implementing the Integrated Local Flood Management and Drainage Strategy. The key parts of the strategy are flood mapping and mitigation; incorporating the potential effects of climate change. The specific areas of study are:

Integrated Local Flood Management and Drainage Strategy – The purpose is to provide the framework to build on the understanding of the Shire's drainage systems, flood extents, climate change impacts and actions required to plan for a sustainable future.

Flood Mapping – Detailed flood mapping is a complicated process with a great deal of assumptions; it is the assessment of those maps that provides a wide range of mitigation options.

Flood and Drainage Mitigation Options – There is a diverse range of options available when determining a solution to a specific flood or drainage problem. Investigation of unique and innovative flood mitigation projects will be invaluable to developing and implementing a drainage strategy.

The objective of the study tour is to learn about different approaches to stormwater management, the impact of climate change and the delivery of capital flood mitigation works. These are all areas in which I am directly involved in my role as a Project Manager. I believe that I will be able to apply knowledge gained from the Study Tour directly to my work. This will bring an immediate impact to the Shire's strategies and Capital Works Program; thus enabling an improved level of service to the residents of the Mornington Peninsula Shire and the wider local government community.

MORNINGTON PENINSULA SHIRE - BACKGROUND

The Mornington Peninsula supports a wide range of land uses including residential, agricultural, commercial and industrial across a variety of land forms.

There are over 70 drainage catchments on the Peninsula which drain over short distances into Port Phillip Bay, Western Port and Bass Strait. Generally the urban areas are along the coast and many are impacted by discharges from the upper reaches of catchments.

Whilst regional drainage responsibilities (major riverine outlets and main outfall drains) were transferred to Melbourne Water in June 1994 (old Shire of Hastings areas) and November 2005 (balance of Mornington Peninsula) it is estimated that in the order of 90% of the drainage system (length of pipes) on the Peninsula is under the control of the Shire. The drainage system includes pipes, culverts, open channels, creeks, retarding basins, wetlands, soakage pits, and flood-ways.

Historically flooding has occurred across the Peninsula and there has been some infrastructure works undertaken to mitigate the effects of the flooding. Some areas have had records kept which has resulted in flood levels being set through historic knowledge and catchment investigation. Most areas have not had sufficient catchment investigation to identify flood levels.

The Mornington Peninsula Planning Scheme only identifies planning control overlay areas around Hastings as 'Subject to Inundation' whereas other areas are known to flood and need to be included into the Planning Scheme.

Research by CSIRO has established benchmarks for the effects of climate change on the sea level, increased rainfall intensity, temperature rises and storm severity that provide the basis to undertake catchment investigation and analysis of flooding within the Shire.

Two pilot catchment studies have been undertaken to establish the most efficient way to achieve the level of understanding of the catchment sufficient to plan infrastructure works and introduce planning controls to protect the built environment. Both of these studies have taken into consideration the effects of climate change.

As a result of those pilot studies the Shire is modelling the 5, 10, 20, 50, 100 and 100 plus climate change events. Generally the Shire undertakes to provide a minimum 1 in 5 year storm protection with its drainage systems. With protection for larger storm events becoming increasingly expensive and in a lot of cases, cost prohibitive.

STUDY TOUR DISCUSSION

The overseas study tour commenced on 9 September 2011 in Melbourne and finished on 30 September 2011 in London. During that time we visited nine different organisations and attended the International Public Works Congress & Exposition in Denver, Colorado.

Each visit was interesting and varied in success; from full day tours and meeting with staff, councillors and a mayor to *"ah, what are you here for again?"* Accordingly we received a vast array of information across varying fields. Overall the tour was a great success and everyone learnt a great deal about international engineering.

To help gain a greater understanding of each location's specific characteristics I have included some key statistics for direct comparison, starting with our own.

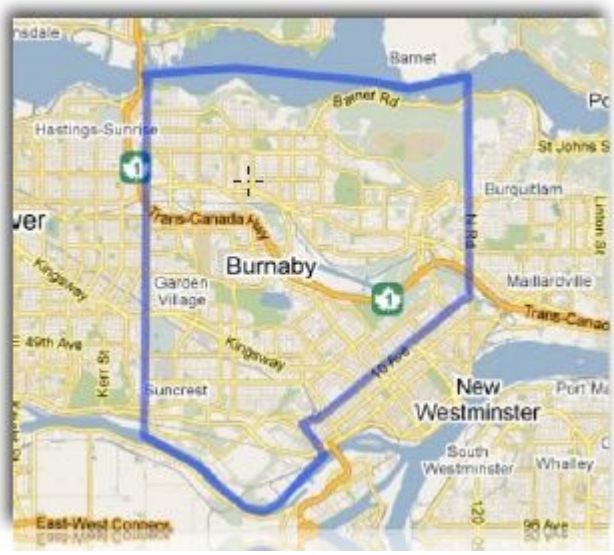
Mornington Peninsula Shire Statistics:

Population – 150,000
Annual Average Rainfall – 74 cm/year
Area of responsibility – 720km^2
Website – www.mornpen.vic.gov.au

City of Burnaby, British Columbia, Canada

Population – 225,000
Annual Average Rainfall – 147 cm/year
Area of responsibility – 92km^2
Website – www.burnaby.ca

The city of Burnaby is located immediately adjacent to the City of Vancouver and is also bounded geographically by the Fraser River (south) and Burrard Inlet (north). With more than 130 parks, 25% of their municipality is designated as green space. The municipality is quite hilly and with low intensity rainfall typical, the risk of flooding and property damage is of lower concern than we have on the Mornington Peninsula. Having said that; Burnaby is very committed to sustainability and environmental protection of its streams and waterways.



Policy and Governing Regulatory Elements:

- In 1971, Burnaby City Council adopted an 'Open Stream' policy which promoted open-channel conveyance of water and left the city with an impressive legacy of urban streams and ravines.

- The Watercourse Bylaw enacted in 1988 focused on reducing contamination of stormwater and local waterways.
- Metro Vancouver Liquid Waste Management Plan (2000) set the stage for integrated storm water management planning at watershed (catchment) level.
- "Total' Stormwater Management Policy (2003)
- Zoning Bylaw (Sec 6.24) requires residential lots built after 2005 to have not more than 70% of the total area of the lot to be covered by impervious materials

Integrated Stormwater Management Plans (ISMP's):

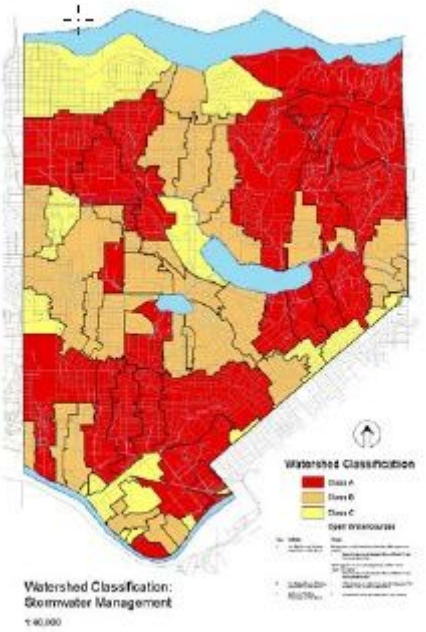
- Regionally required under the Liquid Waste Management Plan to complete ISMP's for each watershed by 2014 and reviewed every 12 years.
- The focus of an ISMP is the integration of stormwater management and land use planning.
- An ISMP is an integral component of a municipality's land development and growth management strategy because upstream activities (land use change) have downstream consequences (flood risk and environmental risk).

Objectives of an ISMP are watershed-specific, but generally encompass the following:

- *Drainage Objectives* - Alleviate existing and/or potential drainage, erosion, and flooding concerns.
- *Stream Protection Objectives* - Protect and/or restore stream health, including riparian and aquatic habitat.
- *Water Quality Objectives* - Remediate existing and/or potential water quality problems.
- *Engage Community Stakeholders / Community Groups*

'Total' Stormwater Management Approach:

Watershed Classification Map for Runoff Management



- Risk based management strategy
- Classified in three categories based on level of concern relating to flooding, erosion, infrastructure capacity, and fisheries concerns

Stormwater Management Standards (Classes pre-defined in adjacent plan)

- Class A watershed: Development > 0.4Ha (1 Acre) to provide storm water management up to the 5 yr frequency storm standards for water quantity and quality enhancements
- Class B watershed: Development> 0.4 Ha (1 Acre) to provide storm water management up to the 2 year frequency storm

standards.

- Class C watershed: Requirement for Best Management Practices only.

Best Management Practice Tools

- Development project designer to select from: sediment trap and basin / detention pond / infiltration swale / bio-filtration feature / green roof structure / impervious area reduction / stream corridor protection

Public Education and Communication

- Inform the development community and public of the importance storm water as a resource

System Monitoring

- Evaluate the effectiveness of the plan with respect to the program objectives.

A great example of these plans and policies in operation is SFU UniverCity (Simon Fraser University) which we were lucky enough to visit during our day with the City of Burnaby. SFU UniverCity is a newly developed university committed to a minimal environmental impact with a comprehensive stormwater management system designed to mimic nature by returning nearly 100 percent of stormwater to the ground. The objective is to maintain pre-development stormwater runoff quality and quantity so that downstream aquatic life is not adversely affected by the new development. The system is comprised of two detention ponds and an extensive network of open watercourses, bio-swales, pervious pavers, and underground infiltration chambers.

The City of Burnaby and Canada in general have very similar local government processes and protocols to Australia, to the extent that I could easily fit into a council role with a minimum of disruption. This makes the potential for an exchange program within Canada very inviting.

City of Vancouver, British Columbia, Canada

Population – 600,000
Annual Average Rainfall – 122cm/year
Area of responsibility – 114km^2
Website – www.vancouver.ca

Our visit with the City of Vancouver was brief by the necessity of our travel arrangements. We however managed to visit several interesting sites and I will discuss the Crown Street project in detail. This was a pilot project delivered within the Southlands Community of Vancouver. The basis of the design was to remove the traditional kerb&channel and drainage system. These have been replaced by bio-

retention swales and concrete edge strips; allowing stormwater to run directly off the pavement, into the swales. The swales then treat the water with natural filtration though vegetation and permeation into the ground. The integrated system is designed with flow and retention capacity for a one in ten year storm.

The key point to highlight with this project is the integration of many different elements into one solution thus making it very successful; including:

- Better water quality
- More filtration into the ground and through the vegetation
- Improved wildlife areas
- Retardation/reduction of stormwater flows
- Traffic calming treatments – slowing drivers through visual impact of narrow lanes
- Aesthetic improvement to the neighbourhood

The stormwater from this project discharges directly into the Musqueam and Cutthroat Creeks, which both bear Salmon. One of the successes of this project was the sighting of Salmon swimming in those creeks not long after completion of construction. Meaning that all the planning, design and construction practices put in place were worthwhile.

The 2010 Winter Olympic athletes village site 'False Creek' has also implemented a similar system of bio-retention swales, which we briefly visited. More information on this project is available by searching the Vancouver City website.

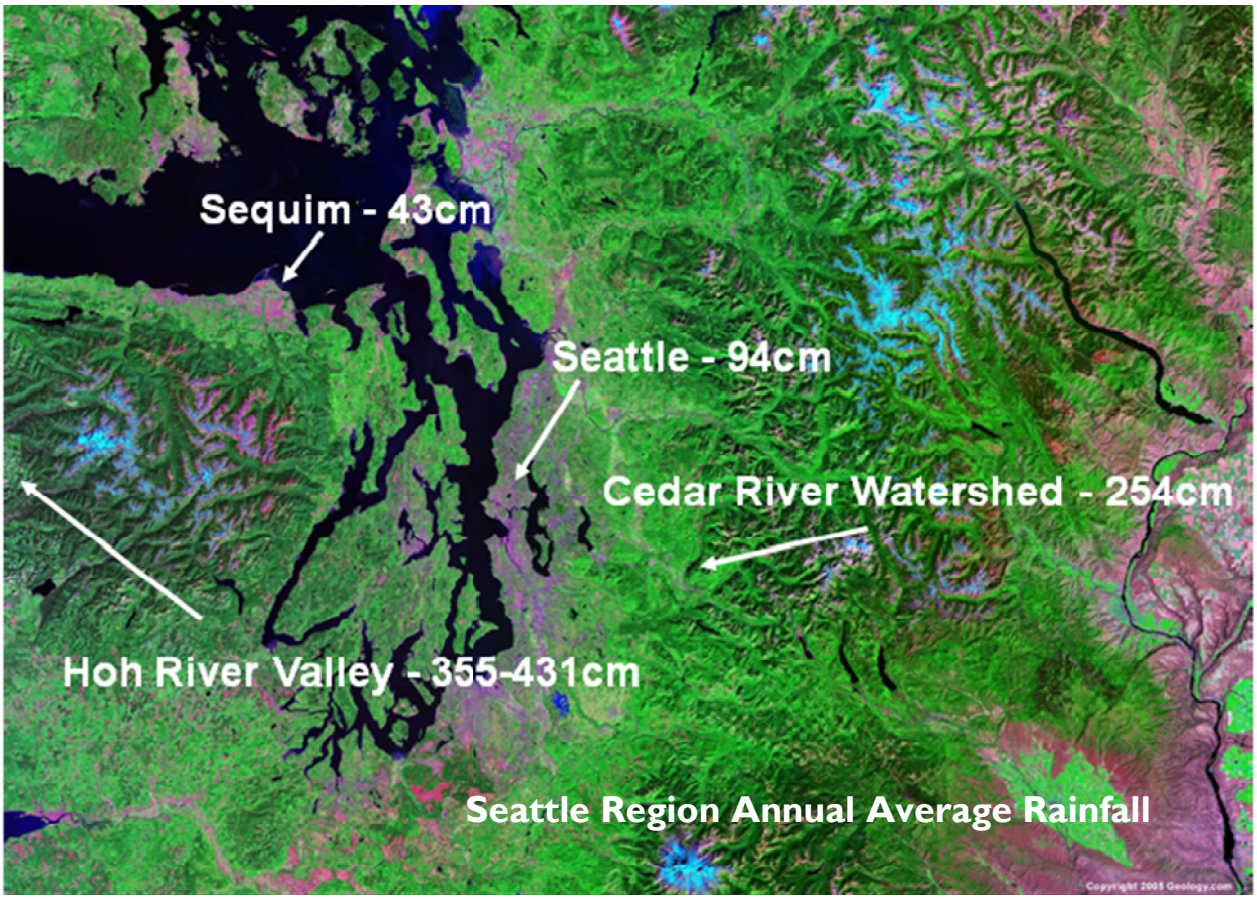
In addition to this project we were able to visit a couple of Country Lanes, where the city in conjunction with the residents turned paved rear access lanes into country style roads with structural grass (supported by interlocking plastic honeycomb cells) splitting the two paved wheel paths. In one location this was done in conjunction with a City Farm demonstration garden, where best practice methods are being used to recycle household waste.

The city of Vancouver is also trying to become the worlds greenest city and these projects form a key part of the process to achieve that goal.

Seattle Public Utilities, Seattle, Washington, USA

Population – 608,000
Annual Average Rainfall – 92 cm/year
Area of responsibility – 217km^2
Website – www.seattle.gov/util

Seattle Public Utilities (SPU) is a department of Seattle City Council that provides water, sewer, drainage & solid waste services for the City of Seattle. Washington State has a wide range of annual average rainfall (as shown in the satellite photo below), with 60% of Seattle's water supply coming from the Cedar River Watershed (Catchment). This wide variance in rainfall is quite unique and is a result of the vast range in the region's topography, including mountains, rivers and large water bodies.



The United States National Climate Assessment has a goal and vision:

- The overarching **goal** is to enhance the ability of the United States to anticipate, mitigate and adapt to changes in the global environment.
- The **vision** is to advance an inclusive, broad-based, and sustained process for assessing and communicating scientific knowledge of the impacts, risks and vulnerabilities associated with a changing global climate in support of decision-making across the United States.

As such, Seattle is trying to position itself as a credible if not the most informed voice on what the climate change impacts will be on systems they manage and services they provide. Seattle has developed a climate change program with the following objectives:

- Enhance our knowledge
- Engage the science
- Assess impacts
- Establish collaborative partnerships
- Influence our operating environment
- Inform decision-making
- Reduce our contribution
- Enhance system resiliency

Seattle's major flood management plan involves controlling the water flow coming from its largest watersheds with its main dams. Controlling these flows protects Seattle from large riverine type flooding. There are three seasons during the year for managing the water in those reservoirs:

- **Spring Reservoir Refill** – mid March to mid June
- **Waiting for Fall Rains to Return** – mid June to mid October/November
- **Flood Management** – October/November to mid March

The flood management season involves daily management of water release, taking into account snow depth, soil moisture content and the predicted weather.

During a presentation from Paul Fleming about Climate Change he mentioned the Seattle RainWatch system for forecasting rainfall and by extension the ability to predict flash flooding. Seattle RainWatch is a real-time weather system that provides rain accumulation totals for the past 1- to 48-hours and forecasts rain accumulation for the next hour for the Seattle metropolitan region. It uses rainfall estimates derived from radar data that are calibrated with local rain gauge networks to improve accuracy over other radar only indicated precipitation estimate products. The forecasts are made using radar echo motion vectors over the past hour and are extrapolated outward temporally and spatially. The system gives the ability to predict rainfall an hour in advance of it falling; with potential for extending that prediction to three hours.

SPU have been proactive in managing their stormwater runoff, from implementing kerb side rain gardens to major drainage projects and entire water sensitive subdivisions. We were fortunate enough for SPU to show us some of these projects and I describe in more detail below.

Madison Valley Stormwater Project

In 2004, 40 homes flooded. In 2006, 55 homes were flooded and one loss of life. In June 2008, the Seattle City Council and the Mayor authorized SPU to design and construct a new stormwater pipeline and storage in Washington Park.

Phase 1 consists of the expansion of an above-ground stormwater holding area at 30th Ave E and E John Street, including purchase of half a city block from existing residents.

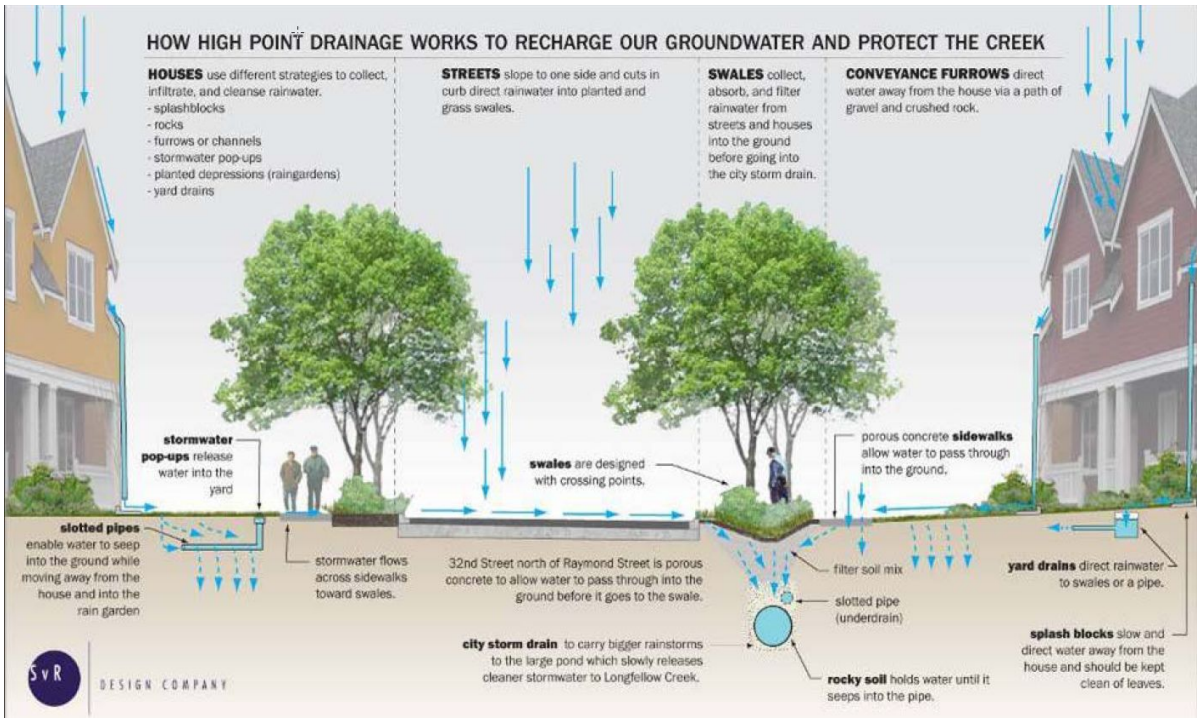
Phase 2 consists of design and construction of a new stormwater pipeline and in the NW section of the Madison Valley basin and a combination of above and below ground stormwater storage in Washington Park. The below ground storage tank will have a capacity of 5 million litres.

There are no stormwater inlets into the 6.4 million litre phase one retardation basin. Stormwater entering the watershed (catchment) will only enter the basin when the existing system surcharges and backs up through the drainage system. The basin will store water until the drainage system can cope and the stored water will flow out via the 1200mm outlet pipe. The retardation basin is designed for a 1 in 40 year storm event. The total cost for the project is $30million.

High Point Estate

Because of its size and its relationship to Longfellow Creek, the redevelopment of the High Point neighbourhood in West Seattle offered SPU a unique opportunity to implement a large scale natural drainage system in an urban environment. High Point features the largest natural drainage project that the City has undertaken. Designed in partnership with Seattle Housing Authority, this natural drainage system will treat about 10 percent of the catchment that feeds into Longfellow Creek, which is one of Seattle's priority waterways.

The natural drainage system at High Point mimics nature in many ways by using features such as swales to capture and naturally filter stormwater, open landscaped ponds or small wetland ponds to hold an overflow of storm water.



Street Edge Alternative (SEA) Streets and Rain Gardens

SPU have constructed several SEA streets and many rain gardens. The objective being to create a natural drainage system and change the visual amenity of the streetscape. The projects have generally been very successful with the SEA in 2nd Avenue NW treating and removing 99% of all runoff during its first two years.

Unfortunately the residents in one area where extensive rain gardens were installed strongly objected to the works and their loss of direct property access. These gardens are to be removed in the immediate future. The cost of removal is the same as the cost to construct them, $600k. The lesson being that in the future a more extensive community consultation program should be carried out prior to construction commencing.

Seattle still has a lot of combined sewer systems and there is a long term commitment to separate the sewer from storm water. This will take some time as the combined sewers are typically in highly

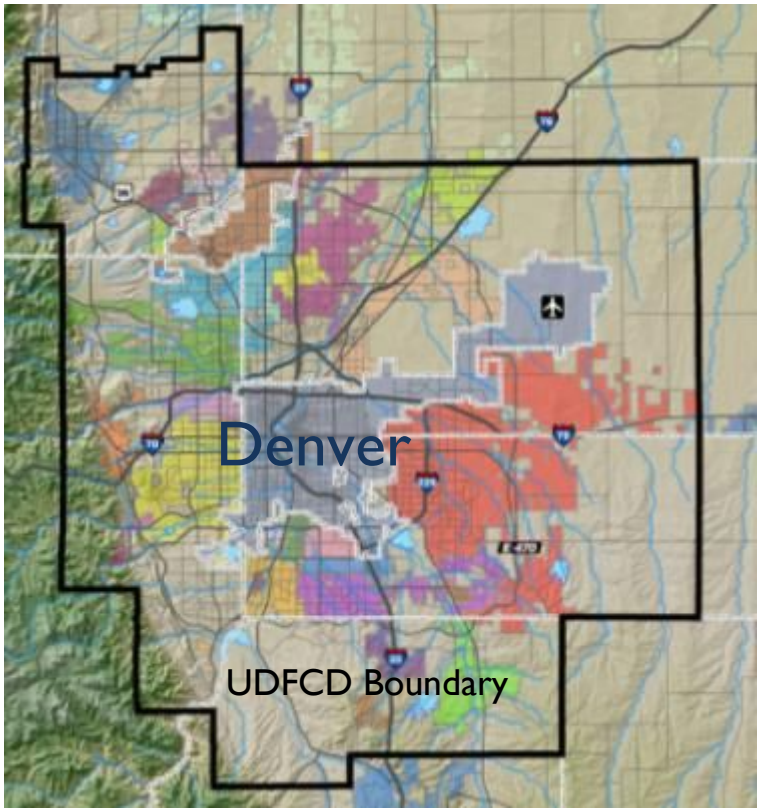
developed areas and the cost for each project will be big. Unfortunately some of the good work being done upstream with the projects I have previously discussed is wasted when good clean treated storm water enters a combined sewer. However, it is clear to see how much effort and commitment Seattle is putting in to improving their environment.

Urban Drainage & Flood Control District, Denver, Colorado, USA

Population – 3,200,000est
Annual Average Rainfall – 40 cm/year
Area of responsibility – 1036km^2
Website – www.udfcd.org

The Urban Drainage & Flood Control District (UDFCD) is a body similar to Melbourne Water. They were created in 1969 to look after the greater Denver metropolitan area, as the watersheds (catchments) often cross municipal boundaries.

Most of the District's resources go to the planning, design, construction and maintenance of remedial projects to fix past mistakes of development in the floodplains. The District's Floodplain Management Program was established in 1974 to prevent new flood damage potential from being constructed in the floodplains. Traditionally this has been done by mapping the 100-year floodplains, with the help of the Colorado Water Conservation Board (CWCB) and the Federal Emergency Management Agency (FEMA). Work is then done with their local government partners to utilize floodplain regulations and other land use regulations to require developments that are "safe" from the 100-year flood.



The UDFCD have been developing and delivering an Integrated Local Flood Management and Drainage Strategy for the past 42 years; very similar to the one the Mornington Peninsula Shire recently adopted. Including flood mapping of all their at risk areas, data which is available through their website.

The UDFCD is responsible for managing a wide variety of capital projects and maintenance programs. All of which are 50% funded by the local municipality/city and 50% by UDFCD. We were fortunate to see some of these projects. Including permeable pavement trials (which I will discuss in

greater detail later), fish ladders, waterway reconstruction and lowering the South Platte river by one metre. The river is being lowered (at great expense) as part of their drainage strategy to protect the central business district of Denver from a 100 year storm event.

UDFCD have also for the past 20 years adopted the approach to return waterways back to their original state where possible. This means the removal of concrete lining and traditional 'engineered' waterways. Re-creating waterways that are far more environmentally friendly, cleaning the water and visually attractive.

Western Water Rights – Prior Appropriation Rights

In the United States, there are two divergent systems for determining water rights. Riparian water rights (derived from English common law) are common in the east and prior appropriation water rights (developed in Colorado and California) are common in the west. Each state has its own variations on these basic principles, as informed by custom, culture, geography, legislation and case law. California law, for example, includes elements of both systems. In general, a water right is established by obtaining an authorization from the state in the form of a water right permit. A legal right is formally consummated, or perfected, by exercising the water right permit and using the water for a beneficial purpose.

Under the prior appropriation doctrine, water rights are "first in time, first in right." That is, the older, or senior, water right may operate to the exclusion of junior water rights. The concept of "priority date" is significant. The priority date is generally associated with the date that water was first put to beneficial use, or the date that a successful application for a water right was submitted, and indicates the relative status of seniority among competing users. Older rights are senior. More recent rights are junior. The legal details vary from state to state; however, the general principle is that water rights are unconnected to land ownership, and can be sold or mortgaged like other property.

This means only the owner of the water right is allowed to use the water. If you don't own the water right, even rain that falls on your property can't be used. So installation of rainwater tanks at your house is against the law unless you own the right. This is completely different to how we operate in Australia. Fortunately for Denver, the UDFCD owns most of the water rights within their area of responsibility; therefore they have greater control over stormwater flows and flooding.

Department of Environmental Protection, New York City, New York, USA

Population – 8,400,000
Annual Average Rainfall – 114 cm/year (including 71cm snow)
Area of responsibility – 802km^2
Website – www.nyc.gov

Our visit with New York City's Department of Environmental Protection (DEP) was brief; however it revealed a great deal of information. As if to prove to us how their drainage systems operate, it poured down with rain all day, showing us some minor street and subway flooding.

The DEP's mission statement:

DEP must supply, deliver, and treat the water 8.4 million New Yorkers need every day; protect and improve the waters that surround us, the air we breathe, and New Yorker's overall quality of life.

The DEP has 100 Strategies and Initiatives to achieve this mission in 4 core areas:

- Serving 8.4 million customers
- Operating the safest, highest-performing water utility at the lowest possible cost
- Building capital projects on time and on budget
- Delivering clean waters, clean air, and a sustainable quality of life for all New Yorkers

Subway flooding

This is all contained within New York's Strategy 2011-2014 policy.

The DEP supplies 3.8 billion litres of water per day to residential and commercial customers. Employs 6000 people, including a 200 strong police force and has an annual budget of $3.8 billion. 70% of their runoff still flows through a combined sewer system. The one thing I still find hard to believe, in such a developed city, that there are areas of Downtown Manhattan that have no stormwater drainage at all. Meaning the streets regularly flood and images like this photo (an underground subway flooding) are common.

There is a significant Urban Heat Island effect in New York, meaning the temperature can be as much as 10 degrees warmer in the CBD, compared to the surrounding areas. This was very apparent during our visit. The streets were very humid and the subway system almost unbearable when standing on the platforms. The DEP is beginning to realise this and have begun to put strategies in place such as the Green Infrastructure Plan to help deal with the problem. The Green Infrastructure Plan has five key components:

1. Build cost-effective grey infrastructure (typically pits and pipes)
2. Optimize the existing wastewater system
3. Control runoff from 10% of impervious surfaces through green infrastructure
4. Institutionalize adaptive management, model impacts, measure Combined Sewer Overflows (CSO's) and monitor water quality
5. Engage and enlist stakeholders

To implement this Green Infrastructure Plan, New York City is prepared to spend up to $1.5 billion over 20 years, including approximately $187 million in capital funds over the next four years, to build green infrastructure.

ENGLAND

During our visits with the four English councils we found they are covered by the same water act and their site visits showed similar things. I have therefore combined the general discussion for these council visits.

England has had a history of major flooding over the last 40 years:

1968 – 15-16 September, flooding across South East England, with over 14,000 properties flooded.

1998 – 9-10 April, flooding across the Midlands, with 5 people killed, 4,500 properties flooded and £350 million in damages.

2000/01 – Winter, 6 major storms across the United Kingdom, with 10,000 properties flooded (many several times) and £1 billion in damages.

2004 – 16 August, Boscastle in Cornwall, received a 1 in 400 year storm in 3 hours, with a 1 in 1300 year storm intensity.

2007 – June/July – 4 major storms flooded large parts of Northern Ireland, South Wales and England, with 13 people killed and £6 billion in damages.

As a result Sir Michael Pitt produced the 'Pitt Review' in June 2008. The Review included 92 recommendations for England to reduce flood risk and increase flood preparation.

On 8 April 2010, the English parliament adopted the Flood & Water Management Act 2010. The Act takes forward some of the proposals in three previous strategy documents published by the UK government: Future Water, Making Space for Water and the UK Government's response to the Sir Michael Pitt's Review of the summer 2007 floods. The Act also takes forward parts of the draft Flood and Water Management Bill and takes into account pre-legislative scrutiny of the draft Bill by the Environment, Food and Rural Affairs Committee. The Act is being phased into government processes one step at a time to reduce the financial impact and requirements for internal structural change.

These documents form the basis for flood strategies across England and have many requirements that must be adhered to. For example; the Counties will become the Lead Local Flood Authorities (LLFA's) and from discussions during our tour, some of the Counties don't have drainage engineers on staff. Meaning they would push the responsibility down to the District (Local) level, some of which don't have drainage engineers either. This is just one of the many challenges England faces to develop a flood prepared community.

The LLFA will also have to develop Local Flood Risk Management Plans as part of their requirements. A plan that should link all relevant authorities, personnel and information together to assist in the reduction of flood risk and a better prepared environment.

SUDS or Sustainable Drainage Systems was a common theme across our visits in England. SUDS is becoming normal practice in new developments throughout England and is similar to Water Sensitive Urban Design (WSUD) as found in Australia. We saw many examples of this practice already in place, with bio-retention swales, permeable paving and wetlands. The following is a description of SUDS as taken from The SUDS Manuals' Executive Summary, by CIRIA, London 2007:

Surface water drainage systems developed in line with the ideals of sustainable development are collectively referred to as Sustainable Drainage Systems (SUDS). Appropriately designed, constructed and maintained SUDS are more sustainable than conventional drainage methods because they can mitigate many of the adverse effects of urban stormwater runoff on the environment. They can achieve this through:

- Reducing runoff rates, thus reducing the risk of downstream flooding
- Reducing the additional runoff volumes and runoff frequencies that tend to be increased as a result of urbanisation and which can exacerbate flood risk and damage receiving water quality
- Encouraging natural groundwater recharge (where appropriate) to minimise the impacts on aquifers and river base flows in the receiving catchment
- Reducing pollutant concentrations in stormwater, thus protecting the quality of the receiving water body
- Acting as a buffer for accidental spills by preventing direct discharge of high concentrations of contaminants to the receiving water body
- Reducing the volume of surface water runoff discharging to combined sewer systems, thus reducing discharges of polluted water to watercourses via Combined Sewer Overflow (CSO) spills
- Contributing to the enhanced amenity and aesthetic value of developed areas
- Providing habitats for wildlife in the urban areas and opportunities for biodiversity enhancement.

Reigate & Banstead Borough Council, England

Population – 138,600
Annual Average Rainfall – 61 cm/year
Area of responsibility – 129km^2
Website – www.reigate-banstead.gov.uk

Reigate & Banstead is a district of Surrey County located an hour south of London. Having a unique geology, the northern half is chalk which is full of fissures that can take all the storm water flows where available. Consequently there is next to no flooding, waterways or water bodies in this region. The southern half of the borough has a typical clay profile and subject to flooding, such that we would expect in the Mornington Peninsula Shire.

Birmingham City Council, England

Population – 1,150,000est
Annual Average Rainfall – 76 cm/year
Area of responsibility – 268km^2
Website – www.birmingham.gov.uk

Birmingham is in the process of developing their Local Flood Risk Management Plan and going through the process of implementing change to deal with requirements of the Flood & Water Management Act 2010. Their flood modelling covers both the 30 year and 200 year storm events. This is different to Australia where the Shire is modelling the 5, 10, 20, 50, 100 and 100 plus climate

change events. The Shire undertakes to provide a minimum 1 in 5 year storm protection with its drainage systems. With protection for larger storm events becoming increasingly expensive and in a lot of cases, cost prohibitive.

Kent County Council, England

Population – 1,427,200
Annual Average Rainfall – 60 cm/year
Area of responsibility – 3736km^2
Website – www.kent.gov.uk

Our time spent in Kent consisted of a tour through the County with stops at various drainage and flood management projects, including:

- The Hothfield Flood Storage Reservoir (FSR) – along with its twin the Adlington FSR protect the town of Ashford from flooding by acting as retarding basins.
- Eureka Park, Bockhanger, Ashford – a major new business and leisure development. The development SUDS scheme includes a series of three interconnected balancing ponds that treat runoff water and attenuates the outflow from the development to 2-4 litres per second per hectare (greenfield flow).
- West Street Rain Gardens, Ashford – utilising SUDS techniques to change the streetscape and treat the stormwater runoff.
- Park Farm East, Ashford – new SUDS sub-division.


West Street Rain Gardens, Ashford

- Canterbury Sluice Gates – control the water flows and levels on the River Stour as they pass through Canterbury. To this day they are still manually operated by a dedicated worker.
- The Stonar Cut, Sandwich – provides a direct release of flood water from the river Stour, bypassing Sandwich. This provides flood protection and is operated via sluice gates to prevent tidal flows coming upstream, while still allowing normal river flows through the town.

Oxfordshire County Council, England

Population – 631,900
Annual Average Rainfall – 65 cm/year
Area of responsibility – 2605km^2
Website – www.oxfordshire.gov.uk

Oxfordshire have completed their Local Risk Management Report and lead the phasing requirements of the Flood & Water Management Act 2010.

SUDS developments are numerous in Oxford and combine many elements such as permeable paving, bio-retention swales and wetlands. We visited similar projects like The Acres development in Horley, (Reigate & Banstead) and Park Farm East in Kent County.

The Acres, Horley – Bio-swale & Permeable paving

Permeable paving is a common, highly successful method used in SUDS. Typically stormwater flows between the brick pavers and filters into a no fines crushed rock layer. Water then runs along the pavement below the surface to an outlet, pipe, bio-swale, water course, etc. Comments from Oxford suggest that these pavements are doing well, with only 20% of the paver gaps required for the system to operate at 100%. Initially the pavers were to be pulled up, cleaned and relayed every five years. Although there is a project in place that hasn't been cleaned and relayed for fifteen years; it's still operating very effectively, particularly during the 2007 floods.

International Public Works Congress & Exposition

Denver, Colorado, USA

The International Public Works Congress & Exposition was held in Denver, Colorado, USA and run by the American Public Works Association. The Congress was very well run with the opening ceremony full of colour, sound and the comic relief of 'Anita Rhode'.

The Congress ran over four days including valuable information, with more than 125 education sessions, hundreds of exhibitors covering nearly 90,000 square feet of exhibit space. I was fortunate enough to hear several key note speakers and attend many of the education sessions, including:

- Safe to Proceed: An Examination of the San Antonio Flood Emergency (SAFE) Program
- The Haiti Experience
- The Colorado River Basin: Vital Lifeline of the Southwest
- Using the Design Build Approach to Multipurpose Stormwater Management – City of Fort Collins
- The Stormwater Summit – Full day, including several speakers and site tour around Denver

The Congress also included many networking and social opportunities with breakfasts, chapter dinners, functions, cocktail parties etc. Overall the Congress was a great experience and well worth attending. The Congress is being held in Anaheim, California in 2012.

OUTCOMES

Strategy

Whilst on the study tour I came across many different approaches to tackling the unique circumstances that applied to each location. These approaches included various types of strategies set up to provide a solution to a problem. So how do we define *'strategy'*?

Strategy can be defined as a method or plan chosen to bring about a desired future, such as achievement of a goal or solution to a problem. Strategy, in short, bridges the gap between "where we are" and "where we want to be".

The Mornington Peninsula Shire (MPS) knew where it was, *'with significant problems'* and where it wanted to be, *'with a plan in place to deal with all current and future problems.'* We then developed the Integrated Local Flood Management and Drainage Strategy to provide clear direction to proceed with ongoing drainage and flooding issues across the Peninsula.

Seattle has a flood management strategy that includes controlling flood waters from its watersheds by use of dams and spillways. It is also committed to a program of creating Natural Drainage Systems, a low-impact approach to stormwater management.

Seattle like many cities around the world still has Combined Sewer Overflows (CSO's). CSO's are typically in older highly developed areas and very expensive to upgrade and separate. This is unfortunate when projects like bio-retention swales, rain gardens and wetlands are put in place to treat stormwater that then flows into a CSO becoming contaminated again. However, the places we visited generally had a strategy or policy in place to separate the CSO in the future. Meaning that they are not wasting their time by installing stormwater treatment projects up stream of CSO's.

Where ever we went Climate Change was part of the conversation at some point. There are many wide ranging debates about this topic: Is it happening? What's going to happen and to what extent? What if anything should we do about it? Nature is by its nature, unpredictable and to put your head in the sand and say the environment will always stay the same is exceptionally short sighted. Although it's impossible to accurately predict what's going to happen in the future, these strategies are being put in place to prepare for that Change and make the world a better place for us and our children to live.

Flood mapping

When I commenced the process of applying for the study tour award from MEF Vic I had only just been introduced to flood mapping and modelling. Over the intervening period I have learned a great deal about flood mapping as part of my secondment to Cardno Pty Ltd, in my working relationship with Melbourne Water and in dealing with other consultants. During the study tour I didn't learn a lot about mapping, although the UDFCD in Denver have mapped their region of responsibility, the data and flood extents are available on their website; including mapping the 500 year storm event. The MPS and Melbourne Water typically only use mapping data up to the 100 year storm event, which is suitable for the Shire given the small comparative catchment sizes and lack of historical data showing consistent larger storm events.

When meeting with Kent County and Birmingham we discussed flood maps, to find that most of England has been mapped. The plans only provide preliminary surface maps for locating flood extents

and are not very accurate. Any development proposed inside the flood shape would require further detailed analysis.

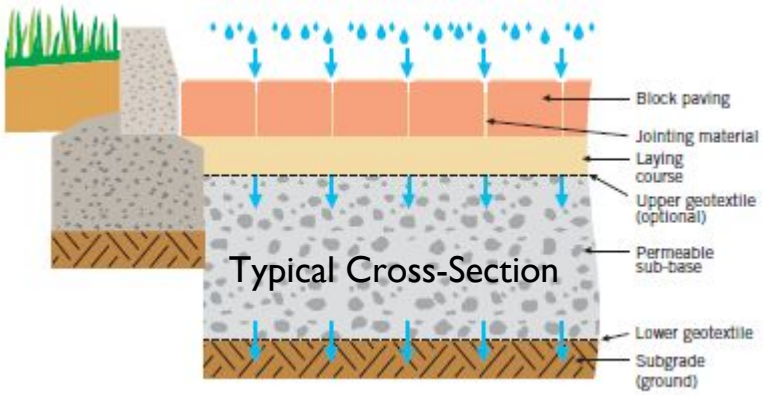
As the worlds' population expands, we are forced to live in areas such as swamps and floodplains. It's how we deal with those developments now that will protect those people from inundation in the future.

Flood and Drainage Mitigation

Permeable Paving

During the tour and particularly in England, permeable paving kept being identified as an excellent alternative to traditional kerb & channel, pit & pipe street drainage techniques.

In conventional pavements, rainwater is allowed to run across the surface to pits that collect and direct it into pipes, removing it as quickly as possible. This means that water with the pollutants contained in it is rapidly conveyed into overloaded drains, streams and rivers, leading to floods in extreme conditions.



In contrast, permeable paving addresses both flooding and pollution issues. It also has a dual role, acting as the drainage system as well as supporting traffic loads. Permeable paving allows water to pass through the surface – between each brick – and into the underlying permeable sub-base where it is stored and released slowly, either into the ground, to the next sustainable drainage management stage or to a drainage system. Unlike conventional road constructions, the permeable sub-base aggregate is specifically designed to accommodate water. At the same time, many pollutants are substantially removed and treated within the permeable paving itself, before water infiltrates to the subgrade or passes into the next stage of the management train.

This system is also being trialled by UDFCD in Denver, where they have a concrete block pavement beside a porous asphalt pavement. The outlets of these pavements are being closely monitored and early results show the concrete block permeable paving to be far more successful in nearly every way. The biggest problem with the porous asphalt is that the pores get blocked and can't be cleaned. Data coming from England is showing that the block paving will still operate at 100% even if only 20% of the voids are clear. Although the permeable paving requires cleaning twice a year, the pavers have not yet been pulled up, cleaned and relayed as they had expected every five years. Some of the permeable pavements have been in the ground for 15-20 years not requiring relaying and showing little if any damage from traffic loading. Initial reports also show that initial and life cycle costs are less than those of traditional pavement and drainage systems.

I have already spoken about permeable paving systems with officers from the Mornington Peninsula Shire and we are looking to include a trial in one of our capital works projects. This is a system that has great potential for use throughout Victoria and Australia.

Sustainable Drainage Systems

Throughout our tour a lot of the site visits and presentations included some form of Sustainable Drainage Systems (SUDS in England) which is equivalent to Water Sensitive Urban Design (WSUD) in Australia.

We saw rain gardens and bio-retention swales in Burnaby, Vancouver, Seattle, Denver and London. We also saw wetlands, retarding basins, storage reservoirs and many other Sustainable Drainage System elements throughout the tour. Each of these locations had their own version, being designed to accommodate the unique environmental conditions found at their specific sites.

The environment is a very complex thing and one answer is never going to solve every problem. Through observing the various types of treatment, I believe it is in combining multiple best practice techniques that we will achieve the best results in protecting our precious environment.

The High Point Estate in Seattle, the Acres Estate in Horley, the Park Farm East Estate, Ashford and Crown Street, Vancouver are excellent exponents of combining Sustainable Drainage Systems. I will be trying to use this approach and include Sustainable Drainage Systems where possible in the roll out of the capital flood mitigation program within the Mornington Peninsula Shire.

General

Major capital drainage and flood management projects such the Madison Valley Stormwater Project, Seattle; Roof top gardens, Denver; lowering the South Platte River, Denver and The Stonar Cut, Sandwich have all provided invaluable information and new ideas about solving flood and drainage problems within the Mornington Peninsula Shire and the wider local government community.

We also visited several sites, not mentioned in this report as they were either similar to other sites or not relevant to my chosen study topic. However, they have all provided valuable experience and knowledge that will benefit all future projects that I am involved in.

Work Exchange Program

The city of Burnaby and Canada in general have very similar local government processes and protocols to Australia, to the extent that I could easily fit into a council role with a minimum of disruption. This makes the potential for an exchange program within Canada very inviting.

Using contacts made during the study tour, I believe there is a potential basis for setting up a program where equivalent professionals could switch roles, for say 12months at a time. The period would need to be long enough to really gain an understanding of all areas within the exchange council; for example 3 months wouldn't be long enough.

The results of an extended exchange would not only benefit the individual but also the respective councils for the experience and perspective gained during their time spent overseas. The program would be like an extended study tour. A program in which I would be more than happy to pioneer.

RECOMMENDATIONS

As a result of the Study Tour, discussions, research and investigation I present the following recommendations that have potential for future development within Local Government and the wider engineering community across Australia:

Permeable Paving - During the tour and particularly in England, permeable paving kept being identified as an excellent alternative to traditional kerb & channel, pit & pipe street drainage techniques. Some of their systems have been in the ground 15-20 years and their lessons have been learnt. Permeable paving has potential for use in a wide variety of situations across Victoria and Australia and should be investigated for future implementation.

Work Exchange Program – through discussions held throughout the tour with other international local governments, there is great potential to set up a work exchange program. Canada had the most similar processes and protocols; however, given the right contacts I'm sure the exchange would work with any local government across, Canada, USA or UK. The program would benefit both organisations and employees who switch roles. The program should be run over a minimum of twelve months.

Flash Flood Warning System – currently residents rely on the State Emergency Service (SES) and Bureau of Meteorology (BoM) for weather warnings, which are broad scale and not specific in their locations. A system similar to the Seattle RainWatch could easily be put in place. The Shire for example has a series of rainfall stations across the Peninsula, in conjunction with the BoM's radar, all the pieces are in place. They just need linking to make rainfall and flood (flash flood) predictions more accurate and readily available to residents via the internet and other existing warning services. The predictions have the potential to be 3 hours in advance of the storm and define the suburbs in which the rainfall would occur.

WSUD / SUDS – these types of individual drainage treatment projects have become common across Australia, Canada, USA and UK. However the environment is a very complex thing and one answer is never going to solve every problem. Further investigation, modelling and trials should be put in place to replicate entire natural systems; including combining drainage (pits and pipes), sustainable treatments processes, creeks, waterways and the rural/urban environment. If we combine multiple best practice techniques, we will achieve the best results in protecting our precious environment.

CONCLUSION

The resulting combination of site visits organised by Katherine, Peter and I have provided me with a wealth of knowledge that can and is being used in my daily role a Project Manager for the Mornington Peninsula Shire. The ability to learn from international experiences and gain information from a different perspective, about local flood management, drainage strategy, climate change, flood mapping and flood mitigation is invaluable. This has provided me with increased knowledge to solve flood and drainage problems that occur within the Mornington Peninsula Shire.

I wrote the following paragraph in January 2011 as part of my application and chosen study tour topic. I believe the objectives as stated were all met, meaning the study tour was very successful:

> *The objective of the study tour is to learn about different approaches to stormwater management, the impact of climate change and the delivery of capital flood mitigation works. These are all areas in which I am directly involved in my role as a Project Manager. I believe that I will be able to apply knowledge gained from the Study Tour directly to my work. This will bring an immediate impact to the Shire's strategies and Capital Works Program; thus enabling an improved level of service to the residents of the Mornington Peninsula Shire and the wider local government community.*

Finally I want to thank the Trustees and Municipal Engineering Foundation for giving me the award. I cannot recommend highly enough the value the MEF study tour provides in a personal and professional level. The ability to mix formal meetings with informal touring and sight seeing provides a unique, interesting and entertaining trip. To Katherine, Peter, Warren and Sue thanks for making the entire experience absolutely marvellous. To anyone else who's contemplating applying, get on it before it's too late; the tours are brilliant, giving you lifelong friends and memories.

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