



Trees can make our space

Make space for trees

CABE Space Research Scholarship - Designing a compatible treescape

Itinerary

2nd - 4th June: Stockholm, Sweden

- Host: Orjan Stal of Swedish University of Agricultural Sciences
- Attend 'Trees and Stormwater' workshop.
- Visit bespoke tree pit design project under construction
- Visit tree pit rejuvenation sites.
- Visit combined tree pit and stormwater management projects
- Assess the green infrastructure of Stockholm

23rd - 29th July: Chicago, Illinois

- Visit to Moreton Arboretum - meet Dr Gary Watson and Dr Yukio Kida.
- Meet with city foresters and engineers, landscape architects, arboricultural consultants and urban designers.
- Tour of Chicago greenspace - Illinois Arborists Association.

(Period includes two days non-scholarship activity - attending International Society of Arboriculture annual conference)

30th July: Minneapolis, Illinois

- Host: Peter MacDonagh of Kestral Design Group.
- Visit MARQ2 project downtown Minneapolis.
- Visit Century College parking lot, White Bear Lake.
- Meetings with; Lois Emberhart, Water Resource Administrator, Bob Kost of Short Hendrickson Inc and Randy Neprash and John Uban of Bonestroo Engineering.

31st July - 3rd August: Vancouver, Canada

- Host: Mike James of Deeproot Ltd.
- Visit Silva Cell project on Granville island (reclaimed land).
- Visit Fairmont Hotel tree vaults project.
- Visit Maple Ridge urban improvement project.
- Visit False Creek (Olympic Village) promenade project.
- Meetings with city forester and engineers and arboricultural consultant.

4th - 9th August: Portland, Oregon

- Host: Kevin Perry of Nevue Ngan Associates, Landscape Architects
- Visit a variety of street and open space improvement projects incorporating rain gardens.
- Visit a variety of sites to assess Portland's 'Green Streets' project
- Visit roof garden projects
- Meet with Tom Liptan, Ecoroof Technical Manager, Jennifer Karpis, Urban Forest Canopy Coordinator, Mathew Krueger, Grey to Green Tree Canopy programme and Emily Hauth, Sustainable Stormwater Management.

(Period includes one day non-scholarship activity - visit Redwood National Park)

10th - 13th August: San Francisco

- Meet with Dr Larry Costello, University of California
- Meet with Matt Fabry, Civil Engineer, City of Brisbane
- Meet with Graham Ray, founding Director of Deeproot Ltd.
- Visit rain garden in Brisbane city
- Visit variety of greenspace sites and street tree planting around San Francisco

Project objectives

The primary objective of this project was to undertake research to enable the production of best practice guidance in the principles and technologies associated with design, establishment and compatible longevity of trees planted in hard surfacing, specifically car parks and urban, hard landscaped open space.

The best practice guidance seeks to ensure informed urban design that is not only aesthetic and practicable but also sustainable, addressing long term compatibility of the complex range of components that comprise its infrastructure.

The following list of enabling objectives provided the basis for an effective project plan that would ensure delivery of the primary objective.

- To visit cities and specific sites that have pioneered new design principles and engineering technologies to secure high quality green infrastructure
- Meet with those responsible for conception, design, construction and management of these projects to compile a comprehensive assessment of the drivers, pitfalls, successes, benefits and alternatives that were encountered and consider the potential for adopting such design in the UK
- Draw comparisons of the different projects, designs and techniques being applied and consider their suitability and effectiveness in certain situations
- Cross reference with a range of specialists to enable informed critical analysis of these new design principles and technologies
- Explore the potential for integration of green infrastructure with other urban infrastructure requirements, particularly stormwater management.

Stockholm



Introduction

As my first destination, I held great expectations for my brief visit to Stockholm. It did not disappoint. Within hours of landing, my host Orjan Stal of the Swedish University of Agricultural Sciences collected me from my hotel. I was invited to an evening reception that had been arranged for the specialists who would be running the 'Trees and Stormwater workshop the next day. The group comprised an eclectic mix of professionals from a broad range of disciplines from Europe and the US. These included landscape architects from Paris and Portland, soil scientists from Helsinki, structural engineers from Switzerland and arboriculturists from Stockholm.

We only got halfway across the road outside the hotel before my work started. Orjan explained that three years ago the trees growing in the central reservation were struggling to grow in a much more hostile environment completely encompassed by paving.

Orjan's work has focussed on improving the growing environment of existing, established street trees, where they are struggling to survive and where possible, combining this process with stormwater sequestration. The paving is lifted around the trees and the ground carefully excavated using an airspade and a large vacuum device. The compacted soil is replaced with a mixture of large aggregate and fertile structured urban soil. Wherever possible, the stormwater from the streets and surrounding rooftops is then channelled into the tree pits to reduce runoff and potential for flooding. There are

numerous examples around Stockholm where trees have been given a new lease of life and the stormwater runoff volumes are slowed and reduced prior to being fed into the antiquated city drainage systems which have been reaching capacity in recent years.



Renovation of tree trench in central reservation

The evening provided me with a unique opportunity to liaise with the group and to learn first hand of their individual specialism's and projects they had been involved with.

Trees and stormwater workshop

The workshop started the next day in the beautiful venue of van der Nootska Palatset, a 17th century palace which is now a conference and events venue. The various specialists I had met the night before gave brief presentations before we joined into group discussions associated with research, design and implementation of innovative green infrastructure.

The debate covered a broad range of subjects;

- The influence of increasing development densities and climate change on stormwater management
- The potential to incorporate rain gardens, bespoke tree pits and green roofs into urban design
- The complexities that face retrofit design compared with new development

- The need to research the site specific opportunities and constraints relating to soil type, existing infrastructure, site uses/functions, local policies, available budget

In the afternoon we were able to visit a site where a new street tree project was under construction enabling us to see the principles we had discussed being applied.



The whole of the pavement had been excavated to create a huge tree pit using large rocks and urban soil.



The trees are planted in cast concrete frames that deflect the tree root growth down below the construction detail of the pavement to the structured soil beneath.

We went on to visit a second well established site. This urban greening project saw the redevelopment of this small square incorporating raised planters for the shrubs. In addition, the whole of the paved area has structured soil beneath to accommodate the trees.



Hornsgaten: is now a popular open space

Rainwater from the adjacent roofs is fed into the tree pits below the paving

City tour

The next day the city foresters had arranged a guided tour of the city for the experts who co-hosted the workshop and I had the privilege of also being invited. We spent the day visiting a variety of sites where structured tree pits had been used to either renovate existing street tree sites or create new ones. Many were combined with stormwater management. In addition to learning more about the management of Stockholm’s green infrastructure the tour provided an excellent opportunity for further debate amongst the group.



Erik Dahlbergsallen: Open topped trench with roof water feed

Hamngatan: Young limes thriving in structured trench





Having invested a lot in structured tree pits these cherries are given extra temporary protection during events such as this food festival that was taking place when we visited



Linden or lime is the dominant tree in Stockholm. Their extensive planting is part of the city's character and adds a significant contribution to the quality of the environment



Stormwater is harvested from this bridge into swales beneath. Information boards help to inform the local community of the sustainable design principles that are being applied

Chicago



As well as being known as 'the windy city', Chicago is now also known as one of the greenest cities in the US. It boasts 552 parks comprising some 3,000 hectares and over 250 green roofs. The timing of my visit also coincided with the International Society of Arboriculture annual conference and although my CABE project did not include attendance, I arranged to attend some of the seminars in my own time.

The ISA conference meant that other events and numerous specialist experts were in Chicago at the time of my visit and this enabled me to maximise the benefits of visiting this dynamic city.

Morton Arboretum

One of my first visits was to Morton Arboretum to meet with Dr Gary Watson, Head of Research at the arboretum and Dr Yukio Kida, visiting from Japan. In addition to the impressive collection of over 4,000 species of trees covering some 700 hectares, the arboretum has developed as an enterprise and has many other functions related to research, environmental conservation, education and recreation. It is a prime example the multiple community benefits that urban greenspace can provide to city residents and visitors. The car park design at the visitor centre has adopted some of the on site stormwater management principles I had come to learn about. It was interesting to see how subtle changes to standard practices can facilitate sustainable design.



The photographs show how a simple dropped kerb can allow runoff into the central rain garden planters rather than be channelled directly into the stormwater system



Dr Watson's work in tree science is world renowned and the 'Landscape Below Ground' series of publications, which he co-edited have provided a wealth of knowledge for the arboricultural profession. His primary research has focussed on understanding how to maintain a healthy balance between the crown and the root system of trees on difficult urban landscape sites, the benefits of mulching and the performance of roots in a variety of soil types and conditions.

I was also interested to meet Dr Kido. His company provides a variety of products and materials for the landscape industry in Japan and we discussed in some detail, the potential to use pumice as the rock content in structured soils. This is something I had also discussed with colleagues in Stockholm. The fact that the water holding capacity of pumice is 30% of its volume significantly increases the overall holding capacity of a structured soil that uses pumice.

Millennium Park - roof garden



Although its conception and cost of construction were the subject of considerable political conflict, Chicago is now very proud of its Millennium Park and it was a high priority on my itinerary and well worth the visit.

The park is not only a fascinating combination of architecture, art and landscape providing a prestigious city centre venue for a broad range of events and recreational activities, it is also an incredible feat of engineering. Being constructed over existing car parking and railway sidings to create an underground car park, it is



effectively a huge roof garden and this was a primary attraction to me.

The park construction involved the importing of all the soil. Trees and shrubs were positioned on site and the soil levels built up around them, as if potting a geranium. It demonstrates how, with appropriate design and engineering principles, trees and structures can coexist compatibly. The photographs show the results.



A complex blend of art, architecture and nature. Painted dead trees create a striking statement on the edge of the park next to the highway

The grills between the trees cover vents to the car park directly below



Green space tour



Downtown Chicago has some prestigious, high quality green space

I was able to attend an enlightening tour of Chicago's parks, green spaces and street tree planting initiatives guided by the city foresters and engineers and hosted by Illinois Arborists Association.

Some facts learnt:

1. Highway trees

- Chicago Department of Transportation (CDOT) maintain 73 miles of landscaped medians (central reservations) throughout the city
- At one stage they were constructing an average of 5 miles a year although at approximately \$1m per mile this has now reduced to 1 - 2 miles
- The medians contain some 6,000 trees comprising 27 genera
- Medians are filled with structured soil of average pH although this can be influenced by the local water and has to be managed
- Irrigation is applied by tankers rather than fitted systems and all median maintenance is contracted to private companies
- The medians are often constructed above grade and this restricts the potential to integrate these features with stormwater management



This well established green space with 40 year old trees was also constructed on top of a car park

2. Green Alleys project

- The streets and public rights of way comprise some 25% of the city's total area
- This large area of land primarily under public control, is recognised as an 'on site' facility with the potential to accommodate climate adaptation and stormwater initiatives
- Adopting sustainable design techniques for surfacing, drainage and lighting has enabled the city to address urban heat island and climate adaption issues even where there is no capacity for soft landscape features
- Local climate and conditions can influence the effectiveness of certain techniques e.g. efficiency of permeable paving can be reduced where there are high levels of de-icing salt and other contaminants

3. Street greening projects



A diverse mix of large species trees line the streets of the residential suburbs

- The projects utilise the more resilient species on the main arterial routes and then diversify the mix with other species on the side roads providing a healthy blend across the street matrix
- Standard street tree pit size is 1.5 x 1.5m although linear tree pits are utilised where the site and budget allow
- Residents are tasked with maintaining the verges and small areas of green space outside their homes
- Re-design streetscapes, utilising 'dead space' in road layouts for landscaping and greening to create improved, pedestrian friendly environments
- Replacing concrete and asphalt with permeable paving, traffic calming 'bump outs' trees, rain gardens and bioswales,
- These projects attract businesses and rejuvenate the economy of these areas
- Despite experimenting with a variety of tree pit designs and techniques, there has been a lack of controlled monitoring of the performance

Many of the greening initiatives for the city have been made possible as a result of a strong political will, with Mayor Daley keen for his city to be seen as the greenest city in the US. There is strong competition between the mayors of major US cities, creating significant opportunities for sustainable green infrastructure projects. Both public and private sector enterprises are keen to provide support, working in partnership to facilitate and fund these initiatives. The majority of the projects I saw were joint funded by both city and county enterprises and organisations.

Where this model falls down in relation to sustainable infrastructure, particularly tree establishment, is in the relatively short lived nature of political campaigns. The funding tends to be available to initiate the projects but not to maintain and sustain what they have created.



Residents take ownership and put their mark on verge management



The road layout was changed to create more space for this mature oak and ensure its retention

Minneapolis



Pit stop

A tight project schedule meant that I had just one day to explore Minneapolis and this would have been very ambitious had it not been for my very efficient and generous host, Peter MacDonagh. Peter is Director of the Kestrel Design Group, landscape architects specialising in sustainable landscape architecture, bioengineering and stormwater management.

Peter had not only committed his day to showing me around but had gone to the trouble arranging a full itinerary of meetings and site visits that meant I came away from Minneapolis with a wealth of information and inspiration.

Our itinerary included:

Marq2 Project

The linear crating systems provide 20 cubic meters of uncompacted soil per tree below the paving

The Marquette Avenue and Second Avenue South Transit Project (MARQ2) is primarily a city transportation improvement programme with the primary driving objective being improvements to public transportation service and traffic flow. It is a prime example of partnership working across city departments resulting in the multi-benefits of urban greening, environmental improvement, improved sustainability and improved public transport services. Capital funding was sourced mainly from a federal grant and from city and county authorities.

I met with Peter in downtown Minneapolis at the SW end of the Marq2 project and we walked the streets discussing design specifications and the practicalities of their application. Peter explained how the crated tree pit design beneath the sidewalk and permeable paving combinations facilitated large soil volumes which absorb the runoff from the sidewalk whilst providing extensive rooting medium for the street tree planting. It was disappointing to note that despite the considerable investment in the hardscape (some of the bespoke tree grills cost up to \$2,000) and yet we still saw poor quality treestock in very expensive tree pits.

Permeable pavers enable the rain water from the sidewalk to reach the crating system below



Client side project planning

We met with Lois Eberhart, Water Resource Administrator, City of Minneapolis Public Works. Lois was instrumental in the adoption of the crating system technology for the Marq2 project. Unfortunately the adoption of the crating system was proposed after the project brief had been agreed and more importantly, after budgets had been set. This timing restricted the potential to maximise stormwater sequestration and currently the system primarily provides extensive tree rooting volumes within this high density urban development. However, the system has the capacity to retain and filtrate significant volumes of stormwater.

Lois hopes to develop the area as a 'stormwater district' utilising this facility through future refinement of the infrastructure, enabling more of the stormwater runoff from the road and sidewalk to be retained and filtrated on site. The plans also extend to local residents and businesses whereby they will have the option to pay reduced rates if they discharge stormwater into the system from their roofs rather than pay the higher rates for discharging into the mains, thereby reducing the volumes fed into the main drainage system.

Project management

On leaving Lois' office we headed to the NW end of Marq2 where we met with project manager Bob Kost, Director of Planning and Urban Design for Short Hendrickson Inc (SEH). Bob gave us an insight into the design and management of the project from the contractor's side and the complexities of implementing such a high profile project with so many stakeholders to consider whilst meeting deadlines and staying on budget.

Extensive public consultation informed the project brief. The conflicting interests between public opinion, local business requirements, political objectives, design specifications and practical engineering constraints were demanding and time consuming elements of the project. The multiple benefits do not come without a cost and the more complex the partnerships and diverse the stakeholders, the more difficult it is to find an acceptable compromise.



The elaborate tree grills were commissioned works of art

The final project specification included the installation of 173 trees along the new bus route corridor using the 'Silva Cell' modular crating system that supports the sidewalk. The system creates a void that holds 0.3 cubic meters of uncompacted soil per unit. The project used 10,800 units, providing an average of nearly 20 cubic meters per tree.

The late addition of the crating system to the design meant that the costs had to be incorporated within the already agreed budget and this, along with the time frames, was obviously restrictive to some extent in terms of the multi-functionality of the system. This emphasises the need to ensure that all stakeholders are involved from the beginning to ensure an informed design and specification.



Blindly following the plan has resulted in the poor positioning of this new planting and shows a lack informed supervision

Inspired engineering

Peter's plans for the afternoon took us out of the city to the offices of Bonestroo, specialists in engineering, planning and environmental science, where we met with Randy Neprash, engineer and stormwater specialist and John Uban, landscape architect. Our discussions focussed around the potential to incorporate and utilise trees within urban stormwater management systems and the need for a more open minded, innovative approach to infrastructure design and engineering. It was also recognised that we need quantifiable, well proven research before we can expect engineers and designers to sign up to these innovative proposals.

Car park project

Our final site visit was to Century College campus, White Bear Lake, north of Minneapolis. Scott Krahn, also from Bonestroo met us here to inspect the college's car park renovation project which includes the 'stormwater education island' that has incorporated a variety of stormwater management systems and surfacing options in trial plots within the functional campus car park. These include a large crated tree pit system with stormwater piped into the cells, pervious concrete and tarmac and recycled mulching materials, all of which are being carefully monitored in terms of their potential to contribute to more sustainable urban design.



The permeable concrete proved to be surprisingly effective. Having the variety of products and specifications on the one site not only provides an educational and training facility but also makes an ideal monitoring site for performance research



Vancouver

From the moment I stepped out of the airport Vancouver's green credentials were on display. The living wall that faces you as you exit the airport terminal immediately suggests that this city is serious about its green infrastructure. The city's geographical setting provides a wealth of opportunity to blend the natural environment into city life and Vancouver has certainly made the most of this opportunity.

Bank holiday weekend

Arriving on a bank holiday weekend created some constraints to my research. However, my host Mike James, Sales Director for Deeproot Ltd producers of the Silva Cell crating system, had kindly agreed to meet on a Sunday to look at some of the urban greening projects Deeproot have been involved with.

Our first destination was the Fairmont Waterfront Hotel where a vaulting system (the tree pit is completely encased in concrete) had been employed to accommodate a group of acacia trees to create an artistic streetscene feature outside the hotel. Tree vaults were considered appropriate here due to the car park below and the high density concrete jungle surrounding them on all sides.

This feature has significant impact in this harsh landscape but it was obviously designed for immediate effect with little thought for future compatibility. The trees are very densely planted. The overall impact could be achieved with half the trees providing twice the available soil volume per tree, a prime example of the need for arboricultural input at design stage.



Tree vaults mean the trees are totally reliant on the soil within the vault and are effectively containerised plants

We visited two other projects that day looking at a variety of tree pit designs utilising Silva Cell technology. The next day I took advantage of the bank holiday, hiring a bicycle to explore the city green spaces of Stanley Park and the waterfront promenades.



The promenades and cycle routes provide miles of waterfront recreational space and a rich treescape

The following day was spent visiting a range of projects and meeting the people involved with them. The itinerary and lessons learnt are summarised below.

Maple Ridge suburb: phased street improvement project under construction, utilising crated linear trenches to accommodate replacement planting. Met with city engineer managing this partnership funded project on the client side



'Bump outs' and narrowing of traffic lanes create additional space for tree trenches

Poor workmanship means this root deflector is badly installed restricting the effective pit size



False Creek (Olympic Village): waterfront renovation project attracted massive funding as part of the Olympics Village development project enabling state of the art tree pit design within the promenade. Soil volumes averaged 24 cubic meters per tree. Met with city engineers responsible for maintenance of the project since completion.



The scale of this well funded project enabled 24 cubic meters of soil per tree

Whilst stormwater is managed on site, it does not utilise the tree pits



Lansdowne Station: Crated tree pits; some within soft landscaped areas, others within hard surfaced areas with tree grills



Garden City Park: Tree pits set within hard surfaced areas with 'break outs' in construction detail enabling roots to access adjacent open space



North Vancouver: Meet with city forester Bill Stephens and arboricultural consultant Mike Mills. Mike is an advocate for and producer of, structural soils and was keen to promote the cost benefits in comparison the crating systems



Lessons learnt:

- The need to get objectives and principles policy led to ensure delivery e.g. soil volume standards adopted by city councils as in Toronto
- Missed opportunities for more integrated design, utilise exceptional circumstances (Olympic Games) to promote innovative concepts
- The need to ensure scientific performance monitoring of the alternative designs
- Benefits of public consultation prior to implementing environmental changes
- Range of tree pit design options - optimal design requires informed decision making process
- Less trees = more soil per tree = better establishment, compatibility and longevity = increased canopy cover
- Implementation requires comprehensive supervision by informed project management
- Register tree pit/stormwater facility as a utility to ensure it is mapped to avoid future damage from street works

Portland



Green reputation

Portland has an established and internationally well respected reputation as a city leading the way in the sustainable design of green infrastructure. A wealth of well established green infrastructure projects supported by strong policies and partnerships, have enabled an extensive range initiatives to be successfully implemented.

It therefore provided an opportunity to assess establishment success, maintenance and management issues of schemes that had been in place for some time and this was one of the primary reasons for visiting Portland. Another element that impressed me, which would seem to be a significant reason for city's green status, was the dedication and enthusiasm of the City of Portland staff and the willingness and pride with which they welcome visitors and promote their work.

City led initiatives - policy driven design

On my first day I had planned to visit a variety of rain garden and roof garden projects in central Portland. I met with Tom Liptan, Landscape Architect, Ecoroof Technical Manager for Portland City. Having worked for Portland for many years Tom has been involved with many of the city led green infrastructure and stormwater management initiatives as well as inputting to city policies that steer private development. Tom has some convincing figures on cost benefit of these projects compared with standard utility engineering specifications. He convinced engineers by setting up demo plots and using fire hydrants to simulate 1 in 10 year stormwater events. The engineers themselves then used the data produced to calculate the potential savings of millions of dollars. Such convincing evidence brings political and financial support. Portland's 'Grey to Green' initiative will receive \$50 million to *"make stormwater management more sustainable, restore watershed health, and enhance Portland's livability."*



Planning policy requires developers to fund sidewalk landscaping and street tree planting adjacent to development sites in addition to the on site landscaping and stormwater requirements that may apply



If development creates or alters an impervious area of more than 50 sq m it has to include on site stormwater management for that area as part of the design.

Walking within a few blocks of the City offices Tom was able to show me sites where these principles and policies had been applied.



On average a roof garden retains approximately 50% of the rainfall on that roof



Innovative design transforms drainage into an attractive water feature



The water also irrigates the trees and other landscape vegetation

City greening initiatives

Jennifer Karpis, Urban Forest Canopy Coordinator and Mathew Krueger, Grey to Green Tree Canopy Programme Officer took me on a tour of some street tree planting sites and explained how the initiatives operated, providing an insight to how they were funded and managed.

The street greening and tree planting initiatives seek to promote the benefits to local residents through community involvement. The city's website promotes schemes such as:

(i). The Treebate programme: residents get a rebate on their utility bill if they plant a tree on their property

(ii) Friends of Trees: provides tree planting in streets and residential property at discounted rates

Unfortunately the community tree planting projects tend to be 'numbers led' and can result in poor tree pit provision and a lack of long term management objectives.



'Gator bags' are wrapped around the tree and release water slowly and irrigate effectively

Renovating streetscapes and creating sustainable green space

My main host whilst in Portland was Kevin Perry of Nevue Ngan Associates, Landscape Architects whom I had met at the conference in Stockholm. Kevin previously worked for Portland City and has therefore been involved in the design of the city's green infrastructure from both a public and private perspective.



People enjoying their environment



Tiered landscape features manage runoff flow



Well established rain garden courtyard



Flexibility in design accommodates trees



Educational features



Information on site

Initially we looked at downtown open space sites where Kevin had designed rain gardens. As well as being aesthetic these landscape features seek to inform of their function, providing a better understanding of urban infrastructure and how it works.

We spent a second day visiting a variety of streetscape renovation and greening projects around the suburbs. These streetscape projects utilise 'dead space' in road layouts to create rain gardens and stormwater management facilities.



**Before and after -
transforming 'dead space'
into a green functional
oasis**



San Francisco



Pioneers in street tree technology

My previous destinations had provided me with a broad range of sites and projects enabling me to assess the principles and technologies that were the subject of my research. Whilst I would see further examples in San Francisco, the primary objective of my visit was to meet with researchers and practitioners involved with mitigation of tree root damage to infrastructure and the designers and producers of the Siva Cell.

In 2000, following some 5 years of research, the University of California was instrumental in initiating a research programme to consider ways of reducing conflicts between tree roots and infrastructure. One of the outcomes was the publication of *'Reducing Infrastructure Damage By Tree Roots: A Compendium of Strategies'* L R Costello and K S Jones. Since then many of the principles and strategies proposed in the compendium have been implemented in and around San Francisco.

It was therefore a privilege for me to be taken on a tour of the city by Dr Larry Costello and to discuss a variety of tree management techniques that have been applied across the city. Larry works for an organisation called Cooperative Extension. Working as an arm of the University of California, they have offices across the state and work to provide research support and technical assistance to those working in green industries. This service is primarily funded by the university but also part funded by local government. The training programmes and research are designed to meet the current needs of local industry.



This sequoia grove in central San Francisco brings a taste of California's native forest into the urban environment

Brisbane city

I also met with Matthew Fabry, Associate Civil Engineer at Brisbane City just south of San Francisco. Matt explained how the County passed legislation which put a \$4 surcharge on vehicle tax to provide funding to address transportation related pollution and stormwater management. The funding has facilitated street greening and rain garden construction projects including four demonstration sites like the one outside his office which promote the concept of sustainable infrastructure to the community.



Rain garden demonstration facility at Brisbane City offices

Deeproot Ltd

My final meeting was with Graham Ray, founding director of Deeproot, the producers of the Silva Cell crating system which I had seen applied on several of the sites during my tour. Deeproot's mission statement sums up the ethos of the company and reflects the sound environmental principles which underpin this enterprise and which came over strongly in my conversations with Graham and his colleagues.

"Our mission is to create a more livable built environment, operating at a high level of ecological function, through the integration of green utilities"

Deeproot's success demonstrates that an innovative approach to urban design can provide solutions to some of the compatibility and sustainability issues that face our urban landscape. It is important that we remain open minded to new innovations. Equally we must challenge them and ensure their credibility.

Lessons learnt and concluding thoughts

- The ever increasing demands on our urban space call for increasingly innovative design and engineering solutions. My research suggests that there is potential to better integrate grey, blue and green infrastructure, maximising the potential to fully utilise our limited urban space
- Success will require greater synergy between the broad range of disciplines and stakeholders involved in urban design. There is likely to be resistance from those who are not comfortable with the variables created by introducing biological elements into engineering specifications
- Arboriculturists need to better promote their profession and become recognised as an integral ingredient to urban design ensuring their presence at the decision making table with the other professionals responsible for planning our urban environments
- New innovative technology requires robust research to support it if it is to be accepted as a valid alternative to traditional methods. Implementation must be to a high standard as poor design or poor construction will reflect badly on the concept and deter its adoption