Best practice design and implementation of urban tree planting – Victoria Avenue Pedestrian Mall upgrade, Chatswood NSW

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Background
Arterra Design is a professional consultancy specialising in landscape architecture, site planning, consulting arboriculture and water sensitive urban design. Our mission is to design, communicate and construct memorable places that are creative, elegant, functional and enduring.

Willoughby Council engaged Arterra in May 2009 to design and document the upgrade works to Victoria Avenue Mall, in Chatswood. Chatswood is a major business and shopping hub in Sydney’s northern suburbs. It had been approximately 21 years since the creation of the mall. The brief required Arterra to review previous schemes and preliminary designs prepared by Council and previous consultants. Arterra then developed a new, simple design which rationalised the use of space in the mall. Council resolved to adopt the design as put forward by Arterra. It was then documented and put out to tender. Construction works commenced early in 2010 and were completed in early 2011. During the design process there were regular meetings with Jeff Ellis, Project Director and Gary Parsons, Property Contracts Coordinator with Willoughby Council who in turn negotiated and met with many other Council staff and service providers. A budget had previously been allocated by the Council of $3.16 million for the project.

This paper outlines the possibilities and constraints which were explored in the development of the preferred design. In particular it focuses on the initiatives that were developed to ensure the best possible outcomes for the proposed new tree planting within the mall. Other items are discussed to provide a background into the multiple factors that must be considered and addressed, alongside the tree planting, in major urban environments such as Chatswood Mall.

Brief history of Chatswood Mall
The following summarises the chronological history of the development of Chatswood and in particular the development of the mall to the western side of Chatswood Station commonly known as Chatswood Mall.

- 1836 – Area originally known as Kings Plains – Richard Hays Harnett (later it was his 2nd wife after whom Chatswood Station was named – her name was Charlotte but was shortened to Chattie and then turned into “Chats” “Wood”)
- 1860 – Much of the Chatswood area was essentially dominated by orchards
- 1865 – Willoughby was proclaimed as a Municipality
- 1882 – Victoria Ave area was cleared by the Baldry family
- 1887 – Construction started on the North Shore Railway
- 1890 – Market gardens flourished and Chatswood Railway Station was opened
- 1890-1900 – Saw a huge building boom now that there was ready transport to the area
- 1898 – Trams were extended throughout Chatswood and up to the railway station along Victoria Ave.
- 1900-1940s – Most retail development was on the western side of the railway.
- 1959 – The focus shifted to the eastern side with both Waltons and Grace Bros opening stores
- 1988 – A new bus interchange was built
- 1989 – Victoria Mall was created by closing the road between the station and Anderson Ave to the east.
- 2005-2008 – The Epping to Chatswood Railway was constructed resulting in a major upgrade of the station and impacting on the existing mall.
- 2007-2010 – Civic Place to the eastern end of Chatswood Mall was designed and constructed.
- 2009-2010 – Victoria Ave Mall was identified as needing refurbishment and planned to be upgraded to coincide with the opening of the Civic Place.
The 12th National Street Tree Symposium 2011

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The site
The existing pedestrianised portions of Victoria Avenue and the intersecting Victor Street formed the major part of the site that was to be upgraded. The footpath on the eastern side of Orchard Road above the interchange was also to be included in the upgrade. This represented a site area of approximately 4300m² of pedestrian mall. The main mall was 165m long and a standard road reserve width of 20m wide. It also included portions of the adjoining Orchard Road and Victor Street.

Chatswood Mall is a major hub of pedestrian activity. It provides important links between the Chatswood station and the newly upgraded Civic Place and the major shopping centres within the Chatswood CBD. The construction of the new Rail/Bus Interchange had left the existing pavement torn up and patched. The space, at the beginning of 2009, appeared very old and tired and in great need of an upgrade. The existing trees, although some in reasonable health, had not achieved their true potential. Upon excavation they exhibited extremely restricted root structures.

Arterra Design's scope on the project
Arterra was engaged and contracted to perform the following key components of the project:

- Conceptual design and refinement of the designs until accepted by Council.
- Contract documentation of the approved design, including co-ordination with all the other necessary sub-consultants.
- Assistance to the Council in Construction Contract establishment, and advice on the Contract and Construction realities.
- Co-ordination of necessary soil testing.
- Periodic quality control.

Figure 1: View of Victoria Street in 1957 from Chatswood Station – note the tram lines. The hotel to the left of the picture still exists today as do many of the adjoining shops. (Source: Warne 2005)
Existing use of the site
The site was used in various ways:

- It was a major pedestrian corridor linking the Railway/Bus Interchange and the western side of the CBD with the eastern side of the CBD and adjoining residents.
- It was the home of a variety of small shops and food outlets, banks, a Westfield shopping centre entrance, Lemon Grove centre, and the Orchard Tavern Hotel.
- It accommodated weekly markets and outdoor café seating.
- It was a stage for performances and special events.
- It was an access way for service and delivery vehicles.

Existing site features & trees
Existing physical features of the site:

- Victoria Avenue falls from the railway interchange down to Anderson Street at 1 in 20 and there is a cross fall on the adjoining Victor Street of a corresponding 1:20.
- The cross-sectional profile of the mall was similar to a typical road profile. It crowned in the centre and there was a swale on each side, seven metres in from the building line.
- The existing light posts, raised planter boxes, seats, bins and trees were loosely aligned in two rows. One each side of the mall roughly corresponding with the two original road kerbs.
- There was a shade structure at the intersection of Victor Street and Victoria Avenue.
- There were many existing underground services and surface access pits.
- Shop awnings extended into the mall 3 m on each side. Shop signs hung below the awning leaving a clearance of between 2.5 to 4 m.
- Victor Street was a popular sitting area, particularly in the winter because it caught the sun.
- There was a concrete base under the existing paving.
- The remnant base of the old tram line was thought to run through the mall just north of the centre line.

There was one Honey Locust, *Gleditsia triacanthos* ‘Sunburst’ and a further 28 smooth-leaved elms, *Ulmus minor* ‘Variegata’ existing within the mall. A detailed and independent arborist assessment of the existing trees was carried out. Generally the trees were considered to be in reasonable condition and vigour. However they were noted as having a relatively short safe useful life expectancy (S.U.L.E) of 5 to 15 years and they had only moderate significance. It was considered that they could be retained if desired, but should not constrain any proposed development. It was also noted that any substantial upgrade works to the mall would be likely to adversely affect the trees, given their planting often within raised and restrictive planter boxes. Also any future redevelopment of adjoining properties would be likely to affect the trees given their proximity to the awnings and building line.

From a landscape architectural perspective, Arterra believed the trees would never reach their full potential and were already compromised because they were very close to and overlapping the building awnings. Given that the life expectancy of the proposed pavement works was far greater than the S.U.L.E rating for the trees, it was recommended they be replaced.

The existing vehicular and pedestrian circulation was separated into three zones by the two rows of trees and furnishings. The two outer zones provided shelter and window-shopping opportunities for pedestrians but could only accommodate very small delivery vans. The central zone could accommodate larger service vehicles and large numbers of pedestrians and commuters moving through the space.
Key project constraints
As with all urban design projects the development had several key constraints which needed to be managed and designed as part of the work. The major factors that needed to be dealt with and addressed included:

- Client brief and desires / Fixed budget / Council politics – shops had to remain accessible throughout upgrade.
- Existing services and structures – Many major lines that could not be moved, insufficient time and budget to relocate.
- Existing grades – Shop front entries, existing sub-base/ structures concrete, services, meant that major grade changes were impractical. There was also very thick concrete associated with the old tram tracks construction.
- Essential Circulation - Pedestrian, vehicles, emergency vehicles, stalls and activities needed to be accommodated.
- Existing drainage was under-utilised and there was a client desire to undertake stormwater treatment / WSUD / passive irrigation, within the realities of the space and services.
- The proposed paving type, style and performance were critical to the design.
- Trees and soil – If to be successful in the long term, it was essential to achieve soil volume, specifications, and correct species selection.
- Artwork – There was a key desire to achieve integration of meaningful public art.
- Use Program – The area needed to accommodate functions, events, and markets.
The concept design – A ‘clear’ vision

The final design solution replaced the existing two rows of trees with a single row in the centre of the mall. The existing light posts, planter boxes and furniture were replaced with new multi function light poles and new furniture aligned with the trees in a central spine through the mall. In short, the main idea was to de-clutter the space and open up areas for multiple uses and pedestrian movement. The stormwater was to be better controlled and utilised – using the existing grades to funnel water to the trees, filter through the soil medium and then discharge to the existing drainage system. A major public artwork was created at the highest point as one enters the Mall from Chatswood Station.

The circulation was divided into two zones, one on each side of the central spine. The overall clear circulation space therefore was slightly increased. More importantly, it became rationalised and more versatile than the existing circulation pattern. There was still a zone in the middle of the mall where people could take refuge under the trees. Each side of the mall now caters to window-shopping and large numbers of pedestrians and commuters moving through the space as well as large and small delivery and service vehicles.

The proposed design allows for outdoor café seating in the central spine as well as market stalls similar to the previous set-up. The existing shade structure at the intersection of Victor Road and Victoria Avenue was removed. This area was kept open and available for events, performances and temporary structures such as Christmas Trees, temporary stages or marquees.

A variety of materials were considered for the paving finish. Maintenance staff, councils accessibility officer and various other Council office staff were all consulted. The proposed material chosen was a dark grey granite paving known as ‘Austral Black’. It is a highly durable material, of Australian origin, which has been used extensively in the Sydney CDB and many other urban centres.

It was used in two formats. The larger format covered the majority of the space. It was 400 mm wide by varying lengths, 400, 500 and 600. It was laid in a running bond across the mall. This makes the mall feel wider and the varying lengths allow greater flexibility for future repairs or modifications.
The smaller format known as ‘muffin tops’ are a modern version of a cobble stone which have a more even surface than traditional cobbles. These were used as highlights in the central spine and the two drainage swales. They also defined the areas that will be available for outdoor café seating.

Figure 4: Concept design of the refurbishment with new signature tree planting to centre of mall, soil volumes were accommodated clear of services and generous pedestrian movement spaces adjacent to shops. (Image: Arterra)

Figure 5: Artists impression of the mall as designed by Arterra. (Image: Arterra Interactive)
Figure 6: Plan view of a central portion of the design showing the general arrangement of trees, planting pits and pedestrian spaces. (Image: Arterra)

Proposed detailed landscape features and elements
A detailed analysis of currently available lighting and furnishings was carried out. Along with the new tree planting, the following new features were included in the upgrade:

- Timber bench seats with timber back rests, metal frame and arms.
- Informal seating opportunities provided via a series of sculptural concrete seatwall forms surrounding the base of the trees.
- Additional garbage bins.
- A filtered water drinking fountain and bottle refill.
- Multi function light poles similar to others already used in the Chatswood CBD. They included provisions for banners, power outlets and public address systems.
- Public telephone stands.
- Signage.

Proposed tree selection and placement
A detailed selection process was carried out to assess suitable replacement tree species. This was a highly political and emotive topic and resulted in many of the normal debates about native versus exotic, evergreen versus deciduous, large versus small. Consideration had to be given to flowering and fruit drop, branch height and forms, tolerance to urban conditions and most importantly availability in large nursery production sizes (due to short lead time). A short list of four species was presented to Council staff for review and further consideration. The preferred and proposed species was the Chinese Elm, *Ulmus parvifolia*. It is a handsome broad and spreading deciduous tree. It has proven itself to be hardy and reliable in urban settings throughout Sydney. It is not known to be highly allergenic and is not a tree which drops a lot of fruit, seed or flowers which may become messy and slippery. The deciduous habit allowed summer shade and winter sun.

It was determined that each tree would require approximately 60-70 m³ of fertile growing soil to reach their full size and remain healthy long into the future. It was anticipated that the soil would need to be fully imported because the existing sub-grade would not be suitable for growth. This was verified during construction and excavation.

Located in the middle of the mall at 15 metre centres the new trees will have room to develop a full and balanced canopy without colliding into building awnings or each other.
Tree planting and soil design

As defined in numerous arboricultural references, some of the key limiting factors to the growth and establishment of trees in urban area are inadequate soil volumes, poor soil quality and below ground conditions. As we were going to remove the existing trees, it was our aim to ensure that any new trees proposed were installed with best-practice tree planting in mind. History also showed that the space is very likely to be refurbished in 20-30 years time and we wanted to design a system that may allow the trees to withstand 2-3 refurbishments without being removed or overly affected by future work.

Provision of adequate soil volume was essential. Soil volume calculations were based on Lindsey and Bassuk (1991) which, in summary, specified 0.6m³ of soil for every m² of tree crown projection. It was also noted that the surface area is often more important than the depth. The calculations undertaken were based on an ultimate 10-12m spreads on the chosen trees, and therefore each tree needed approximately 67m³ of soil to sustain long term healthy growth. We wanted to aim high because construction realities will always nibble away at the final volumes. For example non-vertical excavations of trench sides, services, footings, slab depths and other variations all potentially limit the final available soil volumes.

In the final design we spaced the trees so that each tree will achieve its full canopy and shape, while still allowing for the necessary clear space for the central activity zone, overhead structures and emergency vehicle access. This resulted in 10 new trees within the mall. To achieve approximately 60m³ of soil per tree on average, a total of 600m³ of new soil was needed. At an ideal depth of soil, of say 600 mm deep, this equated to a surface area of 1000 m². This was almost ¼ of the malls area and therefore impractical to achieve as an open soil area in a heavily used urban space. We also wanted the trees to be able to share soil volumes as well, so it was important to connect the soil available to the trees. We also had restrictions on the depth that we could drain using existing drainage infrastructure. So how could we do it?
During the design several options were explored to achieve the usable soil volumes beneath the pavement. These included:

- Structural soils (i.e. Filler soils within a structural aggregate such as those developed by Cornell University and utilised extensively at the Sydney 2000 Olympic site),
- ‘Arborgreen’ rigid plastic reinforcing cells, and
- Suspended concrete slab on piers.

Each of these potential solutions was developed and costed. In summary the most cost effective solution on a large scale area, in the circumstances specific to Chatswood Mall, was the suspended concrete slab on piers. It is important to stress that every project would need to be assessed on its merits and special circumstances.

Structural soils were considered difficult to install and handle on the restricted site, relatively costly to acquire, and difficult to ensure consistent quality of supply and installation. There were also questions and doubts as to the total effective soil volume being taken up by the structural aggregates. There was also need to install transition layers between the structural soil and the overlying pavements which further impacted soil volumes available to the trees.

The rigid plastic reinforcing cells were seriously considered but proved to be economically unfeasible on such as large scale. They also involved difficulties and costs in engineering as to how they were to be ‘bedded’ at the base of the trench and finished at the top to achieve the satisfactory paving surface over the top. At that time, the available cells also did not easily allow services and subsoil drainage to be threaded through them.

In the final solution, a suspended reinforced concrete slab was chosen. This solution ended up costing far less than the other systems and provided numerous other benefits such as an air gap beneath the paving and the soil, maximum available soil volumes, and the ability to choose whatever soil we wanted to be placed in the trench without any structural or other considerations other than those required by the tree. It was also a system readily understood and accepted by the engineers and contractors. The only major downside was the inability to easily access any areas beneath the slab without compromising the structure. This was seen as an advantage for the trees as it may limit the desire to change or remove the slab in the future and therefore protect the roots from potential damage.

The final design resulted in an 800 mm depth of soil plus a 100 mm transition layer, plus a 150 mm subsoil drainage layer. Soil that is used in the tree pits and immediately under the pavement is 400 mm deep 90% sand-10% Menangle soil. The soil outside of the trees immediate planting pits, in the lower part of the profile, is a structural soil filler soil, with heavy clay content, good water holding, high CEC, and replicates a natural soil profile. It is 400 mm deep. The transition layer was a coarse recycled glass sand that bridged the drainage layer particle size, allowing a natural filtration between the drainage layer and the clay soils above. This prevented the need for the traditional but usually troublesome filter fabric layer, that often blocks subsoil drainage in the longer term.

The top 300 mm immediately around the planted tree is a typical imported ‘garden mix’ soil - 85% sand, 10% Menangle soil, and 5% organic matter. This is mainly for planting the shrubs surrounding each tree.
Figure 8: Longitudinal section view of the tree pit and soil profile at a typical tree planting pit - illustrating the relationship of the different soil layers and the pavements and other infrastructure. (Image: Arterra)
Figure 9: View of the continuous trench and supporting piers within the tree pits. Note the careful placement of the materials in the designed layers with care not to traffic and compact placed soils. The lowest darker layer is a fine gravel drainage layer topped by a bridging layer of coarse glass sand to avoid the use of filter fabrics. In the background the layer of ‘clay’ topsoil is placed as a 400m layer over the entire area apart from the tree planting pits themselves which needed a higher hydraulic conductivity. (Photo: Arterra)

Figure 10: View of the continuous trench with the upper sandy topsoil layer installed above the clay layer. Within this layer the multiple perforated drain lines that linked between tree pits under the pavement were installed. These provide passive irrigation during rainfall but otherwise facilitated aeration to the soil under the pavement. (Photo: Arterra)
Figure 11: View of the tree pit after the concrete slab was poured over the continuous soil trench, leaving just the tree planting hole. Note the filter fabric that was placed over the installed soil in the tree pit to avoid contamination of the soil with building materials while paving and other works were being finalised. (Photo: Arterra)

Figure 12: View of the tree pit after paving was completed but just prior to tree planting. Levels of the trees were finally adjusted and all conduits and services were installed to the designed levels prior to tree installation. (Photo: Arterra)
Figure 13: View of the trees being installed in the prepared tree pits. Note the slinging of trees via the root ball with a trunk sling only used to stabilise the tree. (Photo: Arterra)

Figure 14: Tree lines and levels were carefully adjusted with reference to the position of north at the nursery. Trees were root pruned prior to leaving the nursery and then supplied wrapped and burlapped to facilitate ease of planting and installation. Lower hessian fabric left to rot in place to minimise further disturbance. Note the water applied directly to the root ball upon installation. (Photo: Arterra)
Water Sensitive Urban Design / Passive Irrigation

Although the health and well being of the trees was of the most critical importance, WSUD was still thought of seriously and the soils designed accordingly. The soils had to be conducive to water flow through, therefore a sandy mix (90% sand -10% Menangle soil) was required where the surface water entered the tree pits.

Stormwater was designed to pond in tree pit to approximately 50-100 mm depth. Virtually all the pavement drains to the tree pits to passively water the trees and then filters through the soil, removing many nutrients and pollutants. Roof water from surrounding buildings and awnings, where it was reasonable to do so, has also been re-routed to surcharge pits within the tree pit where the pit fills up and spreads out on the surface of the tree pit and then goes through soil medium.

In extreme rainfall events the tree pit fills up with water to a depth of 150 mm. Water then starts to discharge directly into a second raised inlet pit which is connected directly to the main stormwater system.

Air breather tubes were designed to come out of the stormwater pits using flexible 100 mm diameter perforated plastic pipes. When they are not filled with water (i.e. most of the time) they are filled with air to aerate the soil. When filled with water, the water runs down the slotted pipes and waters the soil under the slab and improves passive irrigation and helps prevent ‘droughtiness’ that may occur under the impermeable pavement surfaces.

There is no artificial irrigation system installed, although potable water taps for establishment watering and cleaning etc. have been installed in some of the tree pits.

Figure 15: WSUD was incorporated into the design. Each tree pit receives surface water from the surrounding pavement which is filtered through the soil medium to drainage layer and subsurface drain lines below. Most surrounding roof water is also directed to the tree pits via a surcharge pit (centre foreground). This pit has the air tubes/drainage lines which also distribute water to the rest of the soil profile under the pavement. If the rainfall is particularly intense the tree pit is designed to pond and then overflow into a slightly raised stormwater inlet (left of photo) to discharge directly to the stormwater system. (Photo: Artezza)
Conclusion
Using a limited pallet of materials and a very simple layout the upgrade transformed the aesthetics of the mall and maximised the flexibility of the space to provide for a wide variety of uses and events. The incorporation of WSUD principals have contributed to the ongoing improvements in the management of water quality in the city and the health of the trees. Using proven strategies to provide the best possible growing conditions to the new trees in the centre of the mall they will spread to form a natural green canopy over the space for the enjoyment of all. The quality and classic nature of the materials will ensure the mall retains a clean and contemporary appearance long into the future. The attention to the unseen below ground aspects of the project will hopefully see the trees retained even through the next 2 or 3 upgrades and become a valuable asset to the urban forest and character of Chatswood’s central shopping district for a very long time.

Figure 16: Photo of a completed tree planting pit showing surface gravel mulch installed and surrounding shrub planting and up-lighting to the trees. (Photo: Arterra)
Figure 17: Photo of completed mall illustrating the calmer sitting zone and trees in the centre of the mall and the generous circulation spaces on either side for pedestrians and window-shopping. (Photo: Arterra)

Figure 18: Photo of completed mall illustrating the calmer sitting zone and trees in the centre of the mall and the generous circulation spaces on either side for pedestrians and window-shopping. (Photo: Arterra)
Figure 19: Photo of the sculptural seating walls integral to the WSUD initiatives and also a vibrant lighting feature by night. (Photo: Arterra)

Figure 20: Photo of the signature artwork, abstractly depicting the WSUD initiatives of the project and the active markets commonly held in the space occurring in the background. (Photo: Arterra).
References
Lindsey, Patricia and Bassuk, Nina. 1991. Specifying soil volumes to meet the water needs of mature urban street trees and trees in containers. Journal of Arboriculture Vol. 17, No.6: 141-149.

Project Credits
Client & Contract Superintendent Willoughby City Council
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