Engaging ecosystem services in the redesign of a commercial parking lot

by

Noman Syed

A Practicum submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfilment of the requirements of the degree of

MASTER OF LANDSCAPE ARCHITECTURE

Department of Landscape Architecture

University of Manitoba

Winnipeg

ENGAGING ECOSYSTEM SERVICES IN THE REDESIGN OF A COMMERCIAL PARKING LOT

A Landscape Architecture Design Practicum
by Noman Syed

Abstract

The main goal of this practicum is to explore the issues of ecosystem services associated with a commercial parking lot in a temperate climatic condition. The site chosen was in Sydney, Australia. The intention of the design is to examine how ecosystem services can be engaged to reduce carbon emission; improve air and water quality; reduce stormwater runoff; mitigate temperature fluctuations; increase biodiversity and enhance human comfort and delight.

Acknowledgements

I would like to express my sincere appreciation to the members of my advisory committee; Ted McLachlan (Chair), Brenda Brown, and Chantal Alary, for their advice, criticism and encouragement throughout the whole process.

I would also like to thank my professors and instructors who guided me through challenging studios and course work.

I would also like to thank my brother Adnan Syed, for useful discussion, site observations and visits.

In addition, I would like to thank my friends and colleagues for their encouragement; and to my sweet daughter Meesha for her much needed smiles and hugs.

And finally, to my wife Rehana; for her boundless support, patience, and love throughout the course of my studies at the University of Manitoba.

Table of contents

PART ONE

INTRODUCTION

"Ecosystem services" are free goods and services provided by the ecological process of healthy landscape systems, i.e. those living, nonliving elements and processes which clean air and water, modify climate, pollinate plants, filter and recycle nutrients (The Sustainable Sites Initiative, 2009 b).

Ecosystem services occur at various scales, from large pristine wilderness areas to pocket parks. These services are not always tangible and sometimes not easily explained; the value of these ecosystem services are often underestimated or simply ignored when making land use decisions (The Sustainable Sites Initiative, 2009 b). By understanding the value of ecosystem services, and integrating this knowledge in decision-making, cities will be better equipped for the sustainable use of natural resources.

Regardless of scale, these services can be engaged in any landscape, whether a large subdivision, a shopping mall, a park, an abandoned railyard, or a single home. Such engagement has the potential both to improve and to regenerate the natural benefits and services provided by ecosystems in their undeveloped state (The Sustainable Sites Initiative, 2009 a). One of the drastic changes caused by urbanization and the growth of auto-centric culture is the degradation of natural ecosystems. Parking lots are one consequence of urban sprawl. As Joni Mitchell laments in her song "Big Yellow Taxi", "They paved paradise and put up a parking lot''. Parking lots are everywhere and range in scales, and their number is still growing. ''It is estimated that about 500 million surface parking spaces exist in United States alone - a number that increases every day'' (Ben-Joseph, 2012, p.xi). Parking lots have become the most dominant feature of urban and suburban landscapes. They are here to stay as a necessary evil as long as the main mode of transportation remains the car.

Parking lots have a significant impact on the environment, as well as the design and character of cities. They are the spaces where we first enter and consequently leave. They are the gateways through which all customers, visitors and employees pass. Yet, parking lots are most often dull and mundane in design. With few exceptions, parking lots have traditionally been built with a focus on accommodating a quantity of vehicles rather than creating a quality pedestrian environment.

Generally, most parking lots around the world are made of impervious layers such as asphalt and concrete. These vast exposed surfaces have a tremendous impact on local, regional and global environments. These large impervious layers inhibit the water cycle, degrade water quality, impact aquatic life and increase the heat island effect (Ben-Joseph, 2012). A typical parking lot design raises fundamental questions: How can ecosystem issues be addressed and adverse effects mitigated? How can these perceived dull spaces be transformed into delightful places? How can the focus be changed from a space for storing cars to a place that enhances pedestrian comfort and experience?

This practicum explores the key ecosystem issues associated with commercial parking lots. These issues include: carbon emissions, air and water pollution, extreme temperature fluctuations, storm water runoff, loss of biodiversity and the human/social component.

The goal of this practicum is to explore the issues of ecosystem services associated with a commercial parking lot set within the temperate climatic condition of Sydney, Australia. The intention of the design is to examine how ecosystem services can be engaged to:

- reduce carbon emission;
- improve air and water quality;
- reduce stormwater runoff;
- mitigate temperature fluctuations;
- increase biodiversity and;
- enhance human comfort and delight.

Ecosystem services:

The concept of "ecosystem services" highlights the services that ecosystems provide, and that humankind is dependent upon. This is guided from studies like the United Nations Millennium Ecosystem Assessment (2005), and gathered from many other organizations and knowledge holders around the world (SITES, 2009 b). In order to understand the overall benefits, the term "ecosystem services" needs to be clearly defined.

Definition:

A common and generally accepted definition of ecosystem services is provided by the Millennium Ecosystem Assessment as "the goods and services of direct or indirect benefits to humans that are produced by ecosystem processes involving interaction of living elements and non-living elements" (SITES, 2009a).

These services include clean air, food, water and other raw materials. They are categorized as provisioning, regulating, cultural and supporting services (Millennium Ecosystem Assessment, 2005).

- *Provisioning — products obtained from ecosystems (e.g. food, fresh water, wood, fiber and fuel).*
- *Regulating — regulating benefits obtained from ecosystem processes (e.g. climate regulation through sequestration of greenhouse gases, water purification through filtering, disease and flood regulation).*
- *Cultural — non-material benefits obtained from ecosystems (e.g. aesthetic and spiritual values, recreation and education).*

- *Supporting — services that are necessary for the production of all other ecosystem services, (e.g. soil formation, nutrient cycling, pollination).*

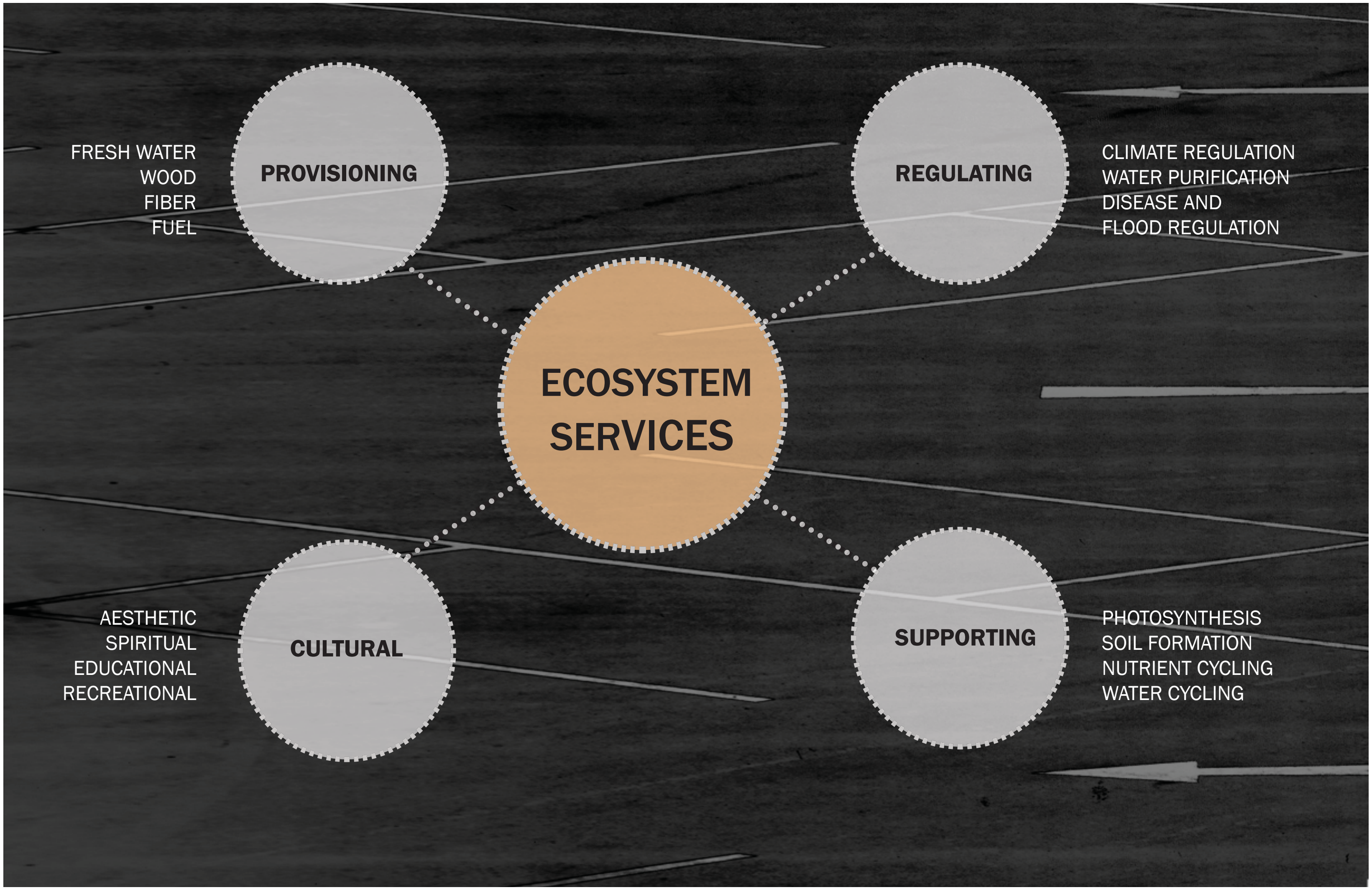


Figure 1. Ecosystem services diagram abstracted from the United Nations Millennium Ecosystem Assessment.

Because these services are often taken for granted by governments, business and the general public, the United Nations emphasizes there is a need to change the way we considered these services in economic development decisions. "At the heart of this assessment is a stark warning. Human activity is putting such strain on the natural functions of Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted" - MEA, (Windhager et al., 2010, p.108).

Economic Benefits + Examples:

Ecosystem services have also substantial economic value. These economic values are in the form of benefits such as carbon sequestration, energy use and temperature regulation, habitat improvement, contaminated soils remediation, real estate values enhancement, and provision of economic and social well being to communities. "The Millennium Ecosystem Assessment estimates the value of the services that wetlands alone provide to humanity at $15 trillion annually, including the water supplies on which an estimated 1.5 to 3 billion people depend (Calkins, 2012 p.6). Another study estimated that "urban trees in the contiguous United States remove an estimated 784,000 tons of air pollution annually with a value of $ 3.8 billion, and store 770 million tons of carbon valued at $14.3 billion" (Calkins, 2012, p.6).

Although some ecosystem functions are limited in scale and continuity, most are not. These functions can be regenerated within our urban landscape and can contribute significantly to our regional ecosystems. As there are more negative environmental impacts within urban landscapes, the value of engaging ecosystem services in these areas is greater than in nonurban areas. Urban areas with varying landscape types -

residential, commercial public parks, campuses, roadsides, recreation centers or utility corridors, may be designed to regenerate specific ecosystem services, such as carbon sequestration and air quality, the reduction in stormwater runoff and its quality, and reduction of local heat island effects (SITES, 2009a).

One way to engaging ecosystem services is to use of vegetation or other shading techniques around buildings. The shade created by added vegetation can cool the air around the buildings and reduce costs for interior cooling associated with urban heat island effect. The U.S Department of Agriculture, Forest Service estimated that "the establishment of 100 million mature trees around residences in the United States is estimated to save about $ 2 billion per year in reduced energy costs" (Calkins, 2012, p.6). "Shade trees in the parking lots can reduce evaporative emissions of volatile organic compounds (VOCs) - precursors to ground-level ozone - from parked cars" (SITES, 2009, p.120). A 2011 report by Alberta Environment, focusing on the southwest edge of Calgary, revealed that the cost for replacing the storm water services, currently provided by the area's wetlands, with built infrastructure would be $338 million.

Increasing vegetative biomass in the form of native plantation can provide habitat for native wildlife including important pollinator species, such as insect, birds, and bats, that are necessary for plant reproduction. "About 80 % of the world's food plant species are dependent on pollination by animals" (SITES 2009, p. 114).

Potential ecological services also include indirect savings such as reduced health care costs due to improved air quality. A 2013 article in the American Journal of Preventive Medicine indicated that there is evidence of high mortality rates related to heart disease and lung illness associated with air pollution. Similarly, a Japanese study indicated that retired people who walked every day in tree-lined and leafy surroundings were more mental and physical efficient than those who walked in less leafy surroundings (Brown & Grant, 2005).

Incorporation into Design:

The aim of this practicum is to reveal the importance and value of ecosystem services and apply this knowledge into design and planning decision-making specifically regarding parking lots. Once the value of ecosystem services is understood, "regional planners and policy makers need to identify regional priorities and designers should ensure that their design features integrate the processes and components essential to provide appropriate levels of these priorities" (Windhager et al.,2010, p.111). A design approach focused on a single service can have multiple benefits. For instance, photosynthesis supports services such as carbon sequestration, oxygen production and improved air quality (Windhager et al.,2010). This is demonstrated in green roof designs where the water runoff is retained by plants through evapotranspiration and water retention. Green roofs also provide other benefits such as reduction in the urban heat island effect, improved air quality and wild life habitat. Properly designed parking lots with focus on priority ecosystem issues can provide multiple valuable services to our communities in a similar way to parks, gardens, utility corridors, urban forests and stormwater wetlands.

Urban form and parking lots:

" The parking lot is the antithesis of nature's fields and forests, an ugly reminder of the costs of our automobile-oriented society. But as long as we prefer to get around by car, the parking lot is here to stay. It is hard to imagine an alternative" (Eran Ben-Joseph, 2012, p.1).

Etymology + Evolution:

The origin of the parking lot predates prior to the invention of the automobile. According to the Oxford English Dictionary, the word "park" was first used around the eleventh century to describe a " large enclosed area of land or woodland maintained for the decoration of a castle or country house, or for pleasure or recreation". Its etymological roots are linked to the medieval Latin word parricus, meaning an "enclosure". Later around the 1800s, the word was used in the military as a context verb for an area set aside for artillery wagons. Finally, around mid 19th century, the word was widely used as a verb "to place or leave (a vehicle) in a designated area" (Oxford English Dictionary, 2013).

The evolution of transportation has generally led to changes in urban form. By the mid twentieth century, the motor vehicle was the dominant mode of transportation and has remained unchallenged since. This increased automobile usage created many traffic issues and urban congestion. The problem of congestion corresponded to a major shift in urban structure and parking lots, and more so the growth of suburbs and decline of city centers. "The booming growth of suburban development and its associated auto-centric culture spurred the decline of the central business districts (CBDs) in many cities" (Ben-Joseph, E., 2012b, p.62). The dispersed urban form of most cities in many countries are linked to these conditions.

Urban form is subject to administrative realities such as zoning and regulations as well civil as engineering requirements, including configuration and geometry. Engineering studies have been conducted that focus on demand and supply rather than overall aesthetics and quality. Developers have a different perspective and are more concerned with quantity, maintenance and operation of space rather than the quality of space within the parking lots (Bin-Joseph, E., 2012). This all leads toward unattractive, harsh and unpleasant parking environments within the urban conglomerate. As a result of the increased growth of suburbs and an abundance in the number of cars occupying cities, the demand for parking lots has grown exponentially. It is estimated that in the United States alone, there are about 800 million spaces covering about 4,360 square miles which is greater than the area of Puerto Rico (Ben-Joseph, E., 2012 b). In another survey by the World Bank 2009, the United States ranked top in terms of cars per population, that being of 802 cars (road motor vehicles) per 1000 people, while Australia and Canada rank fourth and tenth in the world, respectively.

Environmental costs:

The vast amount of surface area used for parking comes with environmental and energy costs. Asphalt surface parking lots are comparatively cheap to build, but the large developed landscapes of impervious surfaces alter the interaction of air, water, nutrients and sunlight within an ecosystem (Figure 2).

In substituting the natural vegetative surface with low albedo and dark colored surfaces, particularly asphalt, parking lots directly affect the microclimates and city climates. They create a heat island effect which refers to the localized warming due to the increase in the surface area of anthropogenic material. Paved surfaces can contribute to this phenomenon in two ways. First, black pavements such as asphalt have less solar reflectance compared to the lighter pavement thus accumulate more heat. Second these paving and building materials are water tight, so no moisture is available to dissipate the sun's heat through evaporation. A remote sensing experiment in Huntsville, Alabama by the National Aeronautics and Space Administration (NASA) identified a temperature difference of 15.4°C between a mall and its surrounding asphalt parking lot and a nearby forested area (Venhaus, 2012).

Parking lots' large expanse of impervious surfaces also have hydrological impacts. These surfaces do not allow the precipitation to be absorbed by the land, and thus affect the quality and the quantity of water. "A one acre parking lot produces almost 16 times the volume of runoff as that from a similarly sized meadow"(Ben-Joseph, E., 2012, p.33). The adverse effects of peak flow are flooding, water pollution, erosion, sedimentation and loss of both in-stream and streamside habitat.

Parking lots also have a drastic effect on air quality. Emissions from motor vehicle exhausts such as nitrogen dioxide, sulpher dioxide, volatile organic compounds and particulate matter present in the air can pose risk to human health and well being.

Habitat loss with a corresponding loss of biodiversity is another consequence of poorly designed urban and suburban infrastructure. These large impervious areas result in the reduction of habitat both above and below ground.

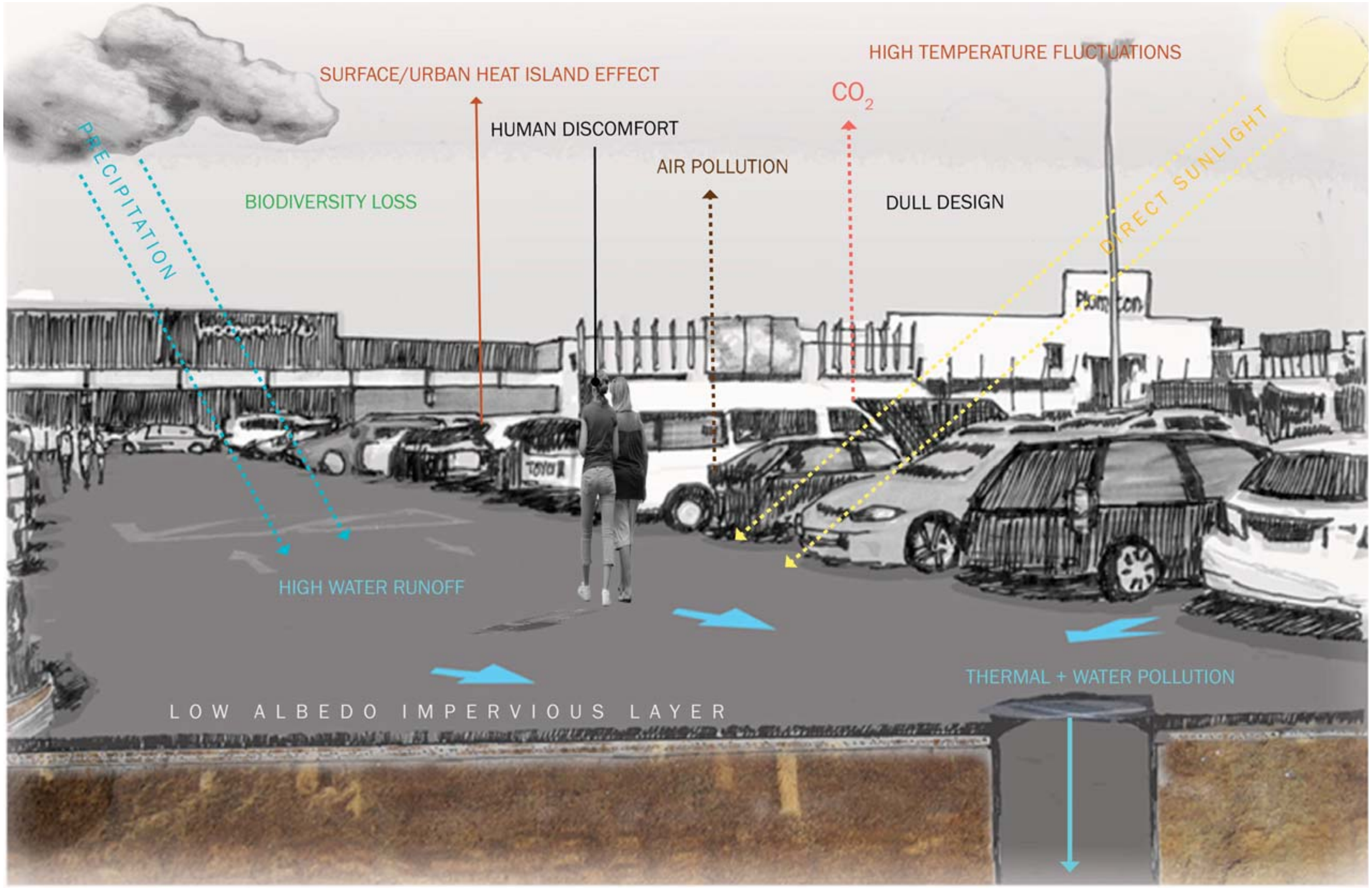


Figure 2. Ecosystem issues related to parking lots.

Vegetation mitigation strategies:

Keeping in mind the mentioned ecosystem issues, different vegetative strategies can be applied to mitigate these issues. For instance, to create a comfortable microclimate, reduce the heat island effect and improve energy conservation, hardscape and reflective surfaces can be replaced, covered and removed with vegetative surface (Calkins, 2012). As shade is directly proportional to the amount of sun intercepted, different suitable type of tree species that provide shade can help heat island effects. Vegetation provides cooling through shading and evapotranspiration. "Evaporation alone can reduce peak summer temperatures by 2 to 9° F" (Sustainable Sites Initiative, 2009 a,p.120).

For removal of pollutants and CO_2 plants and specifically trees, are very effective in stripping carbon from the air and releasing pure oxygen into the air (The Sustainable Sites Initiative, 2009a). Plants also reduce levels of pollen content, dust particles and other airborne pollutants by mechanical friction and release of moisture. Thus, increasing and maintaining vegetative biomass on-site can improve air quality (Calkins, 2012) and improve biodiversity on the site. Adding pervious areas and diverse native vegetation can also provide food and cover for many species of organisms (Figure 3).

Furthermore, to emulate the predevelopment hydrology of a site, it is critical to replicate that earlier interception, evapotranspiration, infiltration and runoff. Bioswales (linear bioretention designed areas) contribute by providing vegetation to intercept and evapotranspire precipitation, allow pervious soils to infiltrate rainfall and reduce the rate of runoff and allow safe conveyance in case of large storm events (Calkins, 2012).

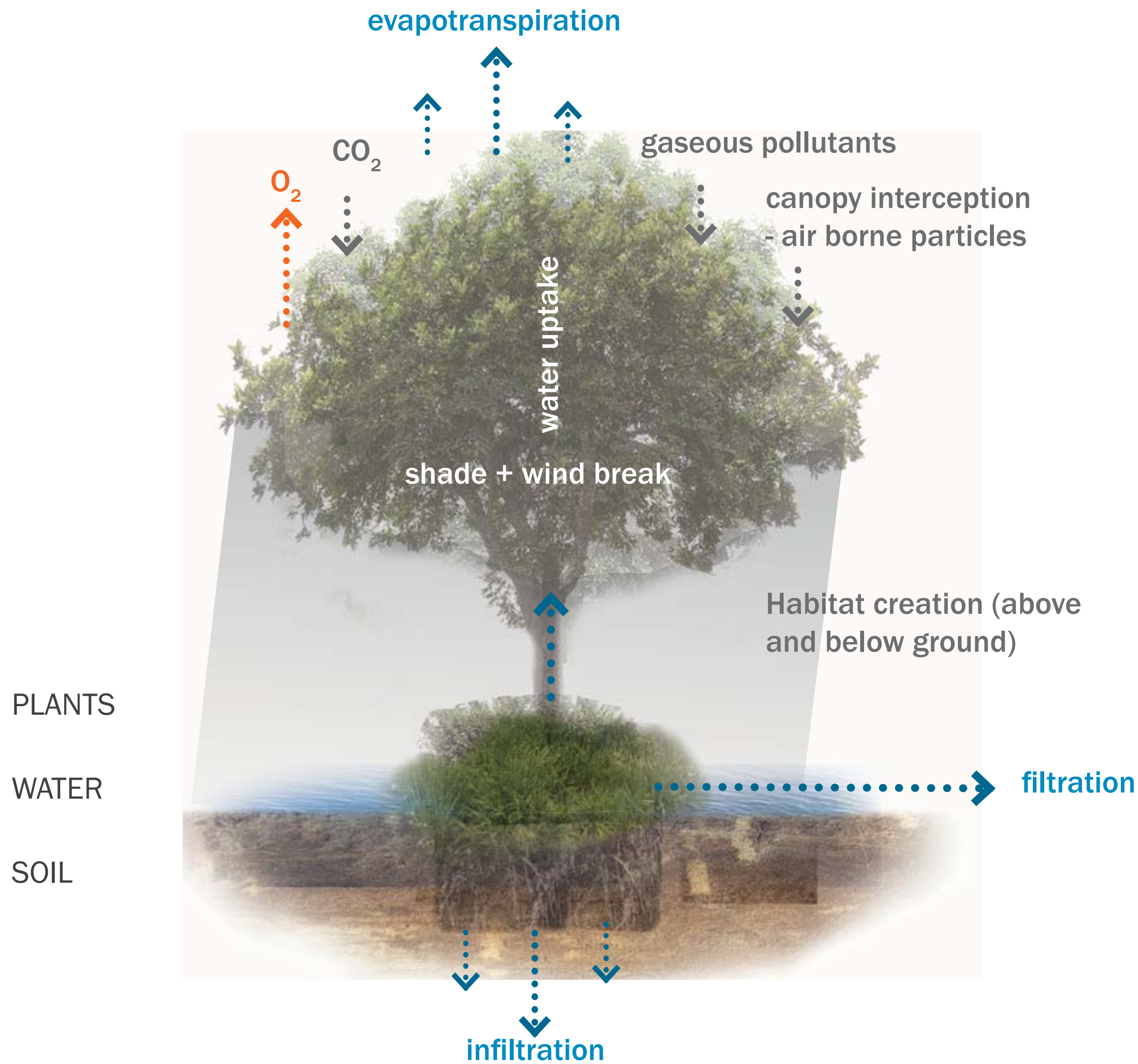


Figure 3. Ecosystem services provided by plants.

PART TWO

PRECEDENTS + DESIGN STUDY

A literature review of surface parking lots revealed a limited number of case studies and design precedents that explored ecosystem services and parking lots. As a way to investigate and begin to understand various ecosystem issues associated with surface parking lots and their design solutions, three precedents were selected based on context, scale, uniqueness and their design solutions. As a way to explore the key issues, a special topics design studio was developed to investigate Grant Park shopping centre, in Winnipeg, Manitoba which is summarized here. The study's aim was to understand parking lot issues, particularly within northern climates.

Precedent One - Florida Aquarium Parking Lot and Queuing Garden:

Project Type:	Urban redevelopment; Greyfield
Year built:	1995
Firm:	Ekistic design studio, Florida, USA.
Size:	11.5 acres

Florida Aquarium is a low impact parking lot design in Tampa, Florida. The main goal of the project was to reduce runoff and improve the quality of water flowing into the Tampa Bay. In addition, the focus was to create a demonstration area to promote environmental education objectives of the Aquarium.

Florida Aquarium is an urban redevelopment site, built on a former Coca Cola bottling facility. Situated in downtown Tampa, on the waterfront next to the Ybor Channel, the Florida Aquarium site is near entertainment venues, restaurants and shops, and draws many visitors. The study area is an 11.25 acre parking lot that currently serves approximately 700,000 visitors annually (Sustainable sites, 2002).

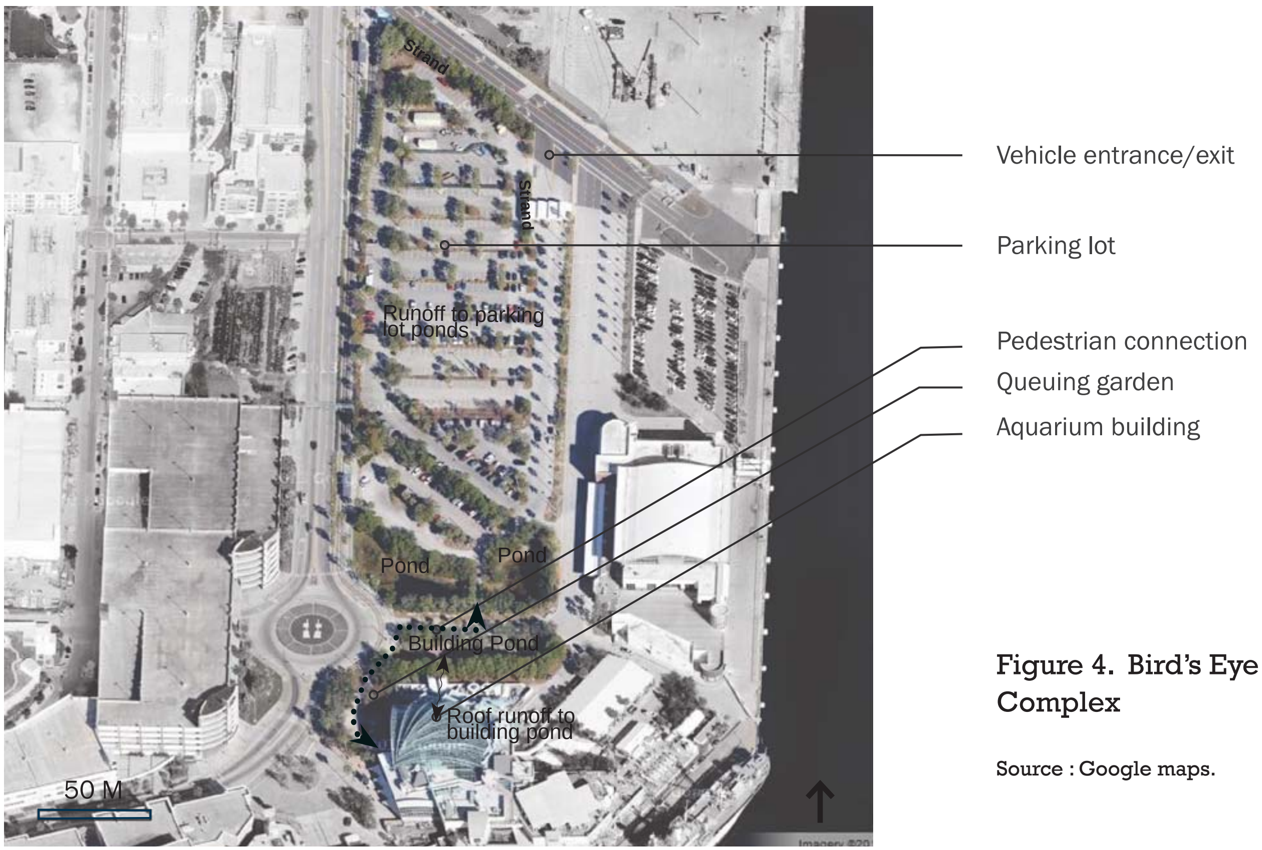


Figure 4. Bird's Eye View of Florida Aquarium Complex

Source : Google maps.

Source : Ekistic design studio, Florida

Figure 5. Parking lot vegetated open channels or swales.

Source : Ekistic design studio, Florida

Figure 6. Queuing Garden.

The development concept proposed by the Ekistic design studio for the Florida Aquarium is a low-tech solution, applying ecological principles to redevelop an abandoned industrial site. The site was configured to maximize the use of space vegetated with native plants to direct, infiltrate, and filter stormwater runoff.

The site was designed to direct stormwater runoff from the aquarium roof and parking lot into a "chain of bioswales, into smaller basins that converge into larger ones (i.e. strands), and finally, through a linear progression of vegetated filtering zones. The strands feed the parking lot pond before the pond is discharged to the Ybor Channel. Runoff from the pedestrian areas is also redirected to help support vegetated areas" (Sustainable sites, 2002 p.3).

Onsite vegetation was increased by 10% by reducing the width of individual parking stalls by 2 feet which allowed the incorporation of bioswales. Even, with these modifications, the site did not compromise the number of parking spaces.

The Queuing Garden is designed near the entrance as a pedestrian plaza providing seasonal shade and seating for waiting visitors (Sustainable sites, 2002). This design provides information for visitors about the importance and linkage of water with urban development and water quality through interpretive signage and brochure at the aquarium centre.

An extensive monitoring study (Post Occupancy Evaluation - POE) was conducted to understand the effectiveness of the low impact storm water treatment system design. The research focused on determining pollutant-load reductions measured from three elements in the parking lot: bioswales, a planted strand with native wetland trees, and a small pond used for final treatment. The study also included testing of different types of paving - asphalt, concrete and pervious paving for thermal loads, total suspended solids (TSS), nutrient and metal pollutants. The results revealed that the sustainable practices significantly reduced runoff volume and protected water quality. When the calculations regarding volume of water discharged from all the three different elements (the swale, the strand and the pond) to the treatment train were compared, the results showed that almost 99% of runoff was retained on site. In the case of percent removal of pollution loads, porous pavement showed the best results (greater than 75% and up to 90%). Sediment samples indicated that asphalt paving material was the primary source for metals and other contaminants (Sustainable sites, 2002).

Conclusion:

This project is a good example of how effective design solutions can be implemented within the redevelopment of an existing parking lot. Urban stormwater runoff is one of the primary ecosystem issues in Florida, due to high annual rainfall. This project provides an effective stormwater management solution within an urban environment. The monitoring study also attested to the benefits gained. Furthermore, this project is successful in promoting sustainable practices. "This project has opened up opportunities for new approaches to stormwater management in Florida, and Florida regulatory agencies are now working to incorporate some of these elements in a proposed Unified State Stormwater Rule" (SITES 2009b, p. 114).

While the overall design creates an effective low impact water management solution, the design does not offer a pleasant pedestrian environment through the parking lot. The overall design lacks safe, direct and pleasant pedestrian paths through the parking lot.

Precedent Two : Fiat Lingotto factory parking lot:

Project Type:	Urban redevelopment; postindustrial
Year built:	2002
Firm:	Renzo Piano Building Workshop (RPBW)
Size:	Total area (building + parking lot) about 62 acres

The Lingotto Building was once a massive car factory about a third of a mile long constructed by Fiat in Turin, Italy. Built by Giacomo Matte' Trucco, it was completed in 1923. The factory became outdated in the

Figure 7. Aerial image of Fiat Lingotto building + parking lot

Source : Google maps.

1970s and finally closed in 1982. After its closure, there was a lot of debate about its future. An architectural competition was held, and later awarded to Renzo Piano. He envisioned an exciting public space for the city. The old factory was rebuilt into a modern commercial complex with concert hall, theatre, convention centre, shopping arcades and a prestigious hotel (Turnbull, 2007).

The two key challenges presented by this project was its immense size of 2.7 - million square foot factory complex and the proper integration of its complex with the surrounding urban fabric (Bin-Joseph, 2012). The winning design proposed by architect Renzo Piano focused on linking the building and the surrounding

Source : International urbanism

Figure 8. Planted rows of trees in a grid to guide pedestrians and the parked cars.

Source : International urbanism

Figure 9. Bird's eye view of the site.

landscape. " The architect brought the building into the landscape, by copying its structural grid onto the horizontal plane and using it as an organizing element for the placement of trees. Conversely, the landscape was brought into the building, by importing lush greenery into the previously barren inner courtyard" (Bin-Joseph, 2012, p.131).

Piano's strategy was quite different from other proposals that focused on tearing down large sections of the original building. “Instead, it adopts a clever strategy of blurring the lines between the building, its surrounding infrastructure (parking lots), and the larger landscape” (Bin-Joseph, 2012, p.131). “In his description of the project” he used the word “mineral “ system for *work* and “vegetal” system for *leisure and comfort* (Bin-Joseph, 2012, p.131). To connect the huge building to the urban fabric of the city, Piano eliminated all the existing curbs and parking islands and instead planted rows of trees in a regular grid. The rows of trees act as a form of guidance to pedestrians and cars, and provide shade in summer while regulating the temperature (Figure 10).

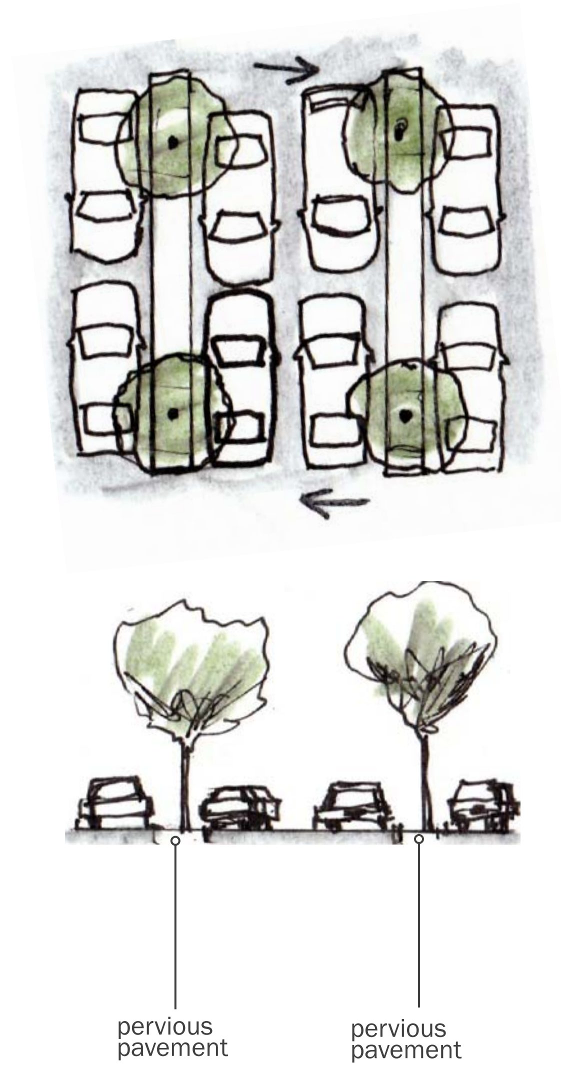


Figure 10. Plan (grid pattern) + section

Conclusion:

This example shows a direct and careful approach to integrate the building with a parking lot layout and surrounding context through its layout and vegetation. The overall design, provides some ecological benefits while maintaining parking capacity. “ What one sees in Lingotto’s parking lot design is a carefully choreographed version of the fabled image of nature reclaiming the postindustrial landscape" (Bin-Joseph, 2012, p.131). However, keeping in mind, the huge size of the parking lot and a high average rainfall in the region, the design could have achieved more in terms of onsite effective stormwater management system, habitat creation and biodiversity.

Precedent Three - Dia Art museum parking lot:

Project Type: Urban redevelopment; postindustrial

Year built: 2003

Firm: Robert Irwin + Open Office

Size: 31 acres

Figure 11. Aerial view of Dia site

Source : Google maps

The Dia Foundation opened an art museum in Beacon, N.Y. in 2003 in a former printing plant built in 1929 by Nabisco, a national biscuit company. Located above the eastern banks of the Hudson River, the site is about 31 acres. The site includes an art exhibition area, landscaped grounds and an arrival parking lot (Bin-Joseph, 2012, p.131).

The task of designing the building and the outer area (parking lot), was given to American artist Robert Irwin in conjunction with OpenOffice (an architectural firm). Irwin with OpenOffice considered the whole project in both experiential and environmental terms (Dia Art Foundation, 2012). The main goal of the project was to integrate the building with its surrounding landscape.

The design team realized the importance of first impressions and identified the entry into the museum building, more specifically the parking lot, as a key feature to the overall design. They designed the site with a circulation sequence - an entry road, a parking lot, and an allée that leads to the main museum lobby.

Source : flicker.com

Figure 12. Pedestrian path (allée)

Source : flicker.com

Figure 13. Parking lot with Corten steel edged planted medians.

Source : flicker.com

Figure 14. Permeable area in front of the entrance (grassy court).

Within the parking lot the design comprised of Corten steel-edged planted medians and rows of trees help define the parking stalls and add attraction and shade during each season. This parking lot design guides visitors, transitionally to the main entrance. In front of the main entrance there is a grassy court to reduce water runoff and provide infiltration. The grassy area is also lined on both sides with evergreens, providing a clear visual cue for wayfinding.

By thoughtfully addressing the sequence of arrival to the site, Dia art museum is a excellent example of how landscape, architecture, art, and parking can complement one another (Bin-Joseph, 2012). From a pedestrian perspective, the overall design offers an attractive and smooth arrival/departure experience.

Although part of the area is a permeable grassy area, there is no effective system of water removal from the active car park area. The water flow could have been drained through the planted medians. The Corten steel edges blocks the water to flow into the planted medians. In addition, the overall system is costly and cannot be applied on a large scale and in a northern climatic condition.

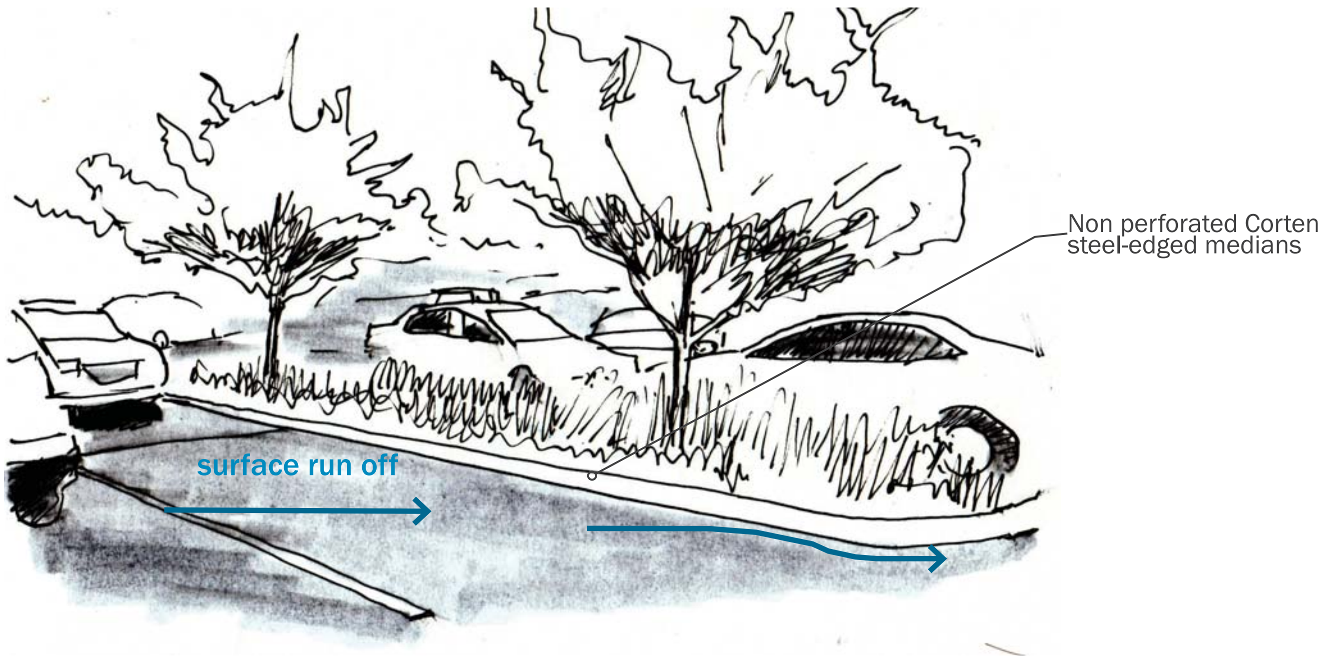


Figure 15. Inefficient onsite stormwater management design.

Design Study: Grant Park Shopping Centre

Project type: Commercial parking lot redesign.

Size: Approximately 32 acres (12 Hectare).

The main aim of this design study was to test out the potential of improved ecological performance in a parking lot within the northern climate. The main objectives are: to reduce carbon emissions and improve air quality; to regulate temperature and energy management; to increase biodiversity, and to reduce the surface water runoff and improve the quality of downstream water within a northern climate setting.

The site selected is Grant Park Shopping Centre in (Southwest) Winnipeg, Manitoba, Canada. Winnipeg is located near the longitudinal centre of North America and experiences an annual precipitation of 513.7 mm in the form of snow in the winter and rain in the summer, with the highest precipitation events occurring in the summer months. Average high temperature in summer is 26 °C, with an average low of about -21 °C in winter (Environment Canada, 2012).

Grant Park Shopping Centre opened in 1962 and has approximately 70 stores. It is anchored by Target, Safeway, Manitoba Liquor Mart, Shoppers Drug Mart, Empire Theatres, and McNally Robinson. Food vendors include Tim Hortons, Koya Japan, Pizza Place, and A&W. McDonald's, Petro-Canada, Applebee's and Pony Corral have stand-alone locations in the mall parking lot.

The site is typical of a North- American commercial landscape, having exposed surface parking

Source : Google maps

Figure 16. Aerial view of Grant Park Shopping Centre + parking lot.

associated with a concentration of commercial activities. The lot is a windswept, unattractive space with vast expanses of impervious pavement providing extremely low ecological performance and poor pedestrian circulation.

Figure 17. West side of the wall showing vast asphalt surface + blank windowless walls.

Figure 18. Front street facade of the parking lot along Grant Ave.

In the design project, I attempted to achieve increased ecological performance and effective and comfortable pedestrian and vehicular circulation within the parking lot. A series of allées were proposed to link the main entrances of the building with streets and bus stops to facilitate safe, direct and comfortable pedestrian movement through the parking lot (Figure. 19).

The design offers an overall reduction in hard and reflective surfaces by adding vegetation. Closely planted, suitable deciduous trees will provide seasonal afternoon shade and solar gain during winter. In addition, plantings around the main building, specifically in the form of green walls, green roof and buffers, will reduce energy consumption and provide a comfortable exterior space. The design also promotes

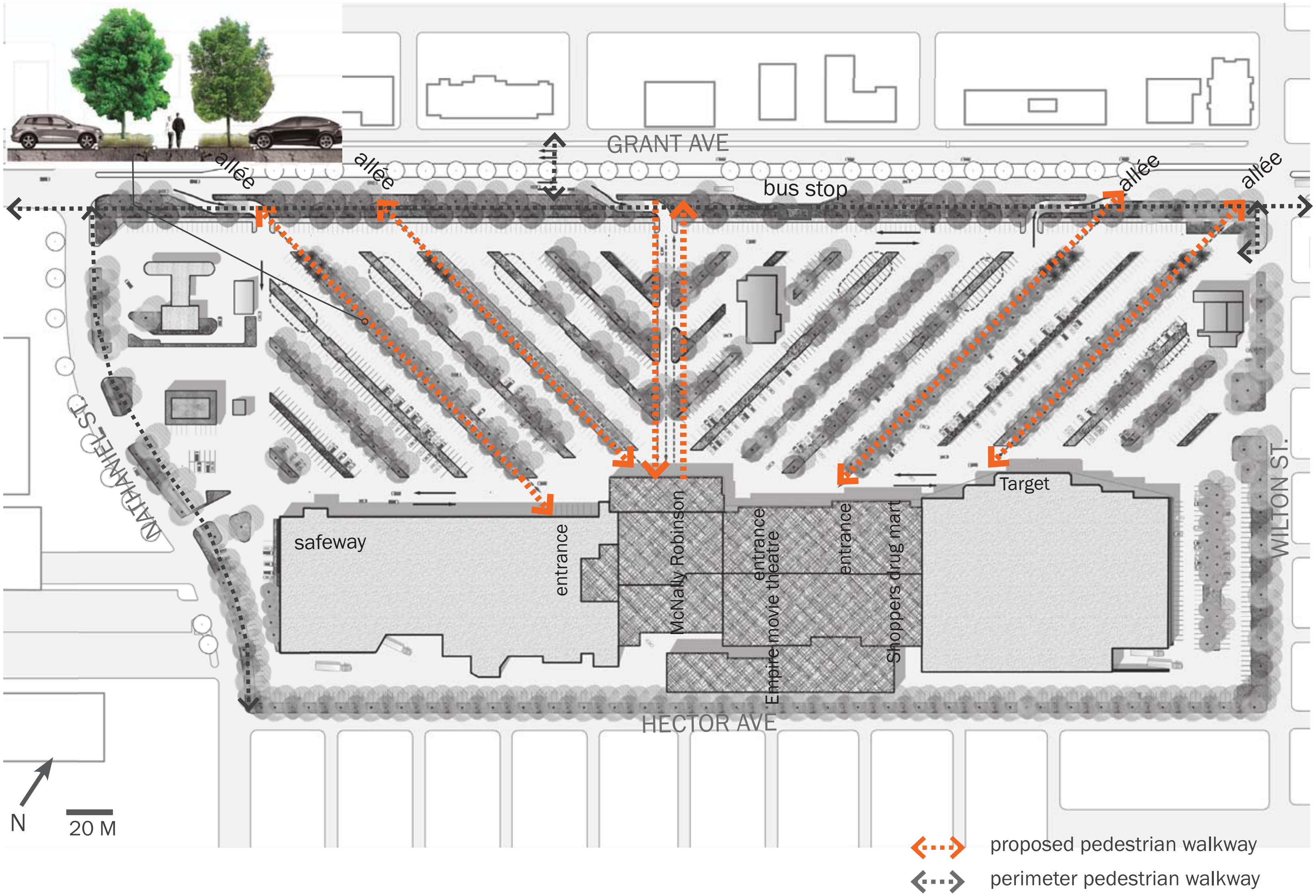


Figure 19. Site Plan - proposed circulation.

evapotranspiration rate for cooling the surrounding environment and ambient temperature during the summer.

The design increases the vegetative area by introducing 200 dense woody trees. This will result in improved air quality performance through stripping carbon from the air in the form of CO_2 for photosynthesis, water uptake and release of moisture through respiration.

The design also offers about 30 different native plant species of deciduous, conifers, shrubs, grasses and annuals. The choice of plant material intended to significantly increase the value of food cover and habitats. In addition to the vegetative area within the parking lots, the proposed green roof and green walls result in increased enhancement of habitat quality. The design attempts to provide as much connectivity between the planted areas as a parking lot will allow, while maintaining maximized stall count

To manage rainwater and snowmelt onsite, the design offers a series of bioswales, pervious landscape areas with a combined area of 349,431 m^2. This overall system minimizes the reliance on the existing storm sewer system and captures and treats contaminated surface runoff. Bioswales are linked to the existing catch basin system reinforcing the existing drainage. This allows the existing stormwater infrastructure to better handle flow of large storm events and maximizes the filtering capacity of stormwater system (Figure 22). Since snow storage and removal are significant issues in northern climates, a portion of bioretention areas are identified for snow storage, and the curbs area also designed to accommodate efficient snow clearing requirements (Figure 23).

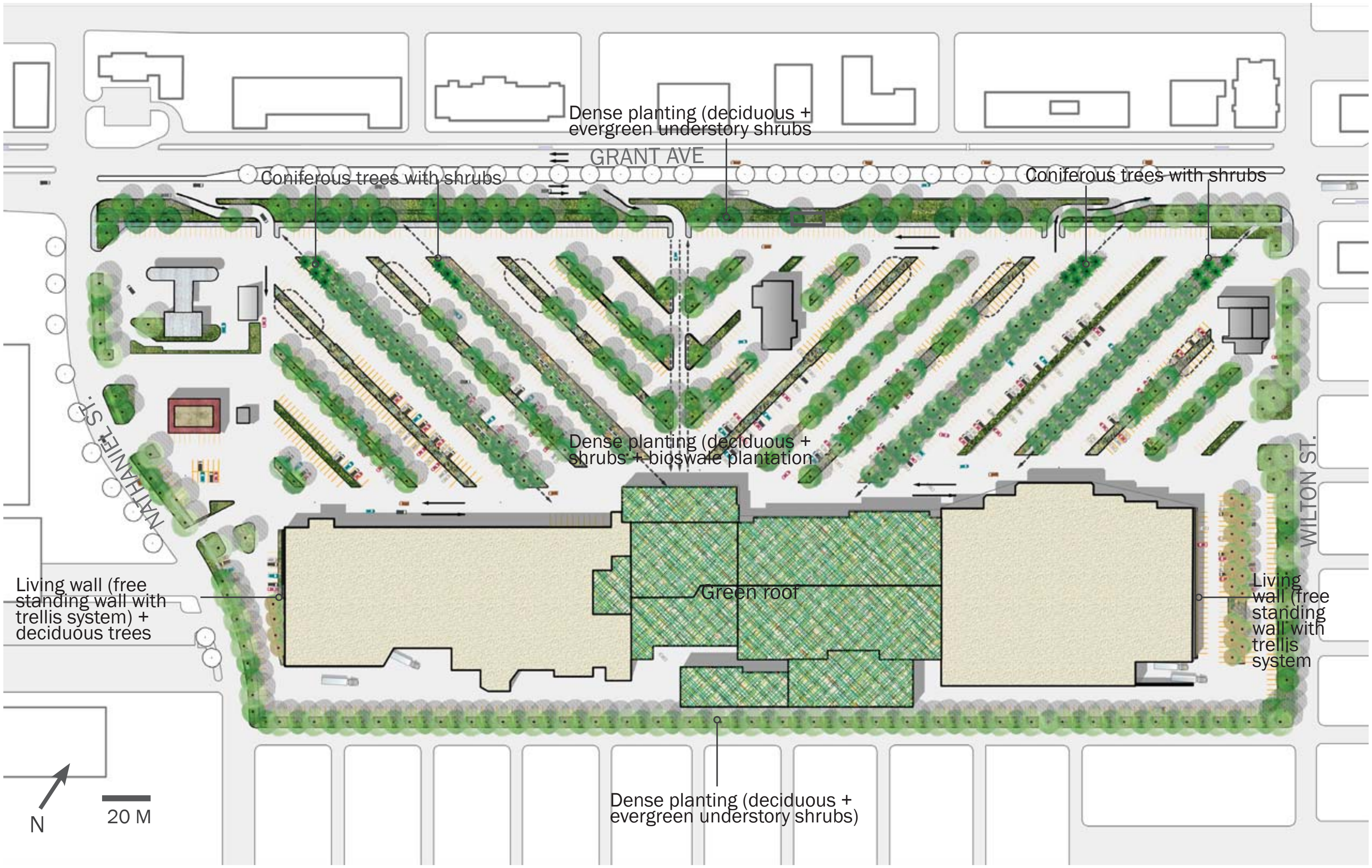


Figure 20. Site Plan - Proposed planting design around the building can reduce energy consumption in the building and provide comfortable exterior space.

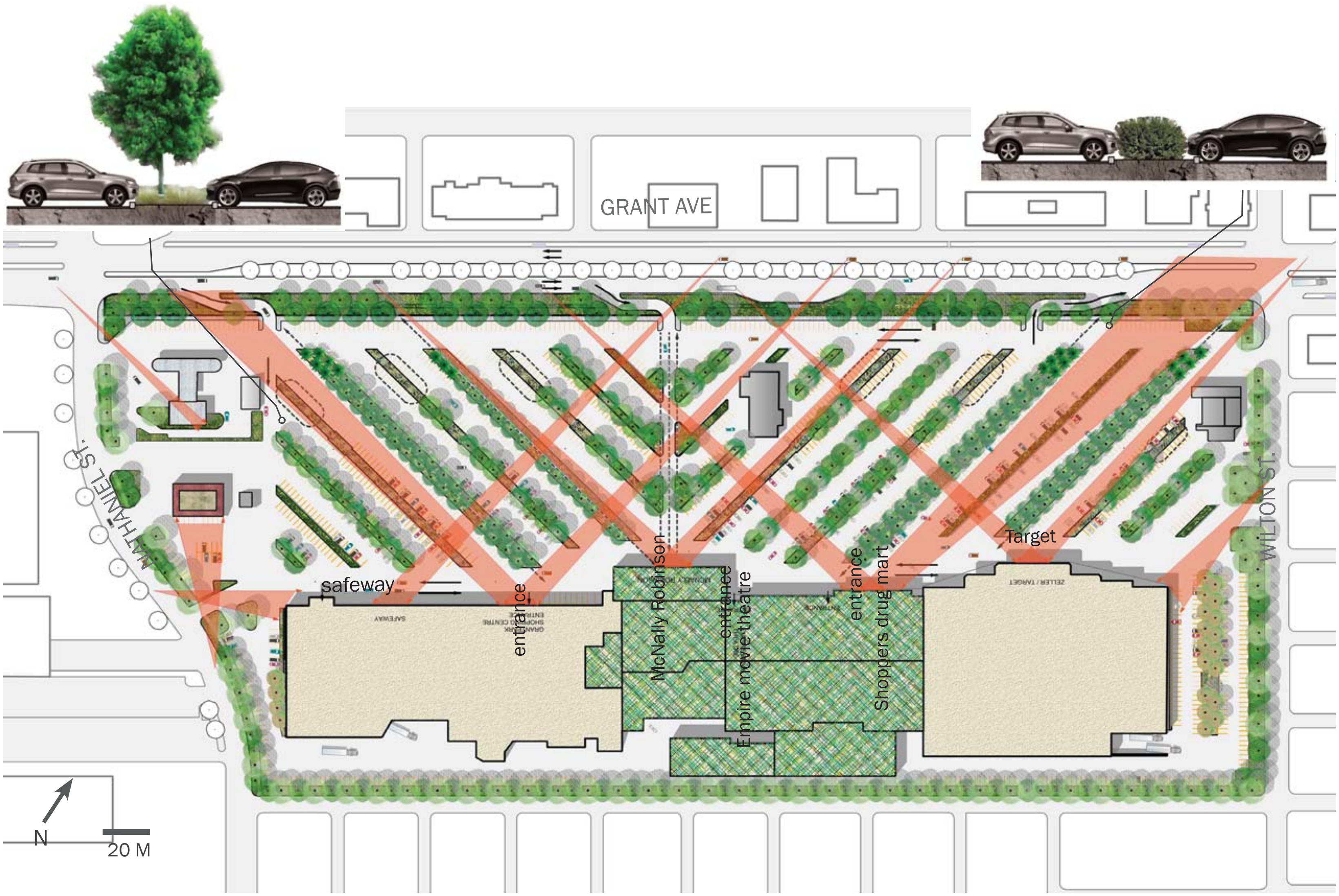


Figure 21. Site Plan - Trees, shrubs and perennials are strategically placed so that views from Grant Avenue to each storefront are maintained.

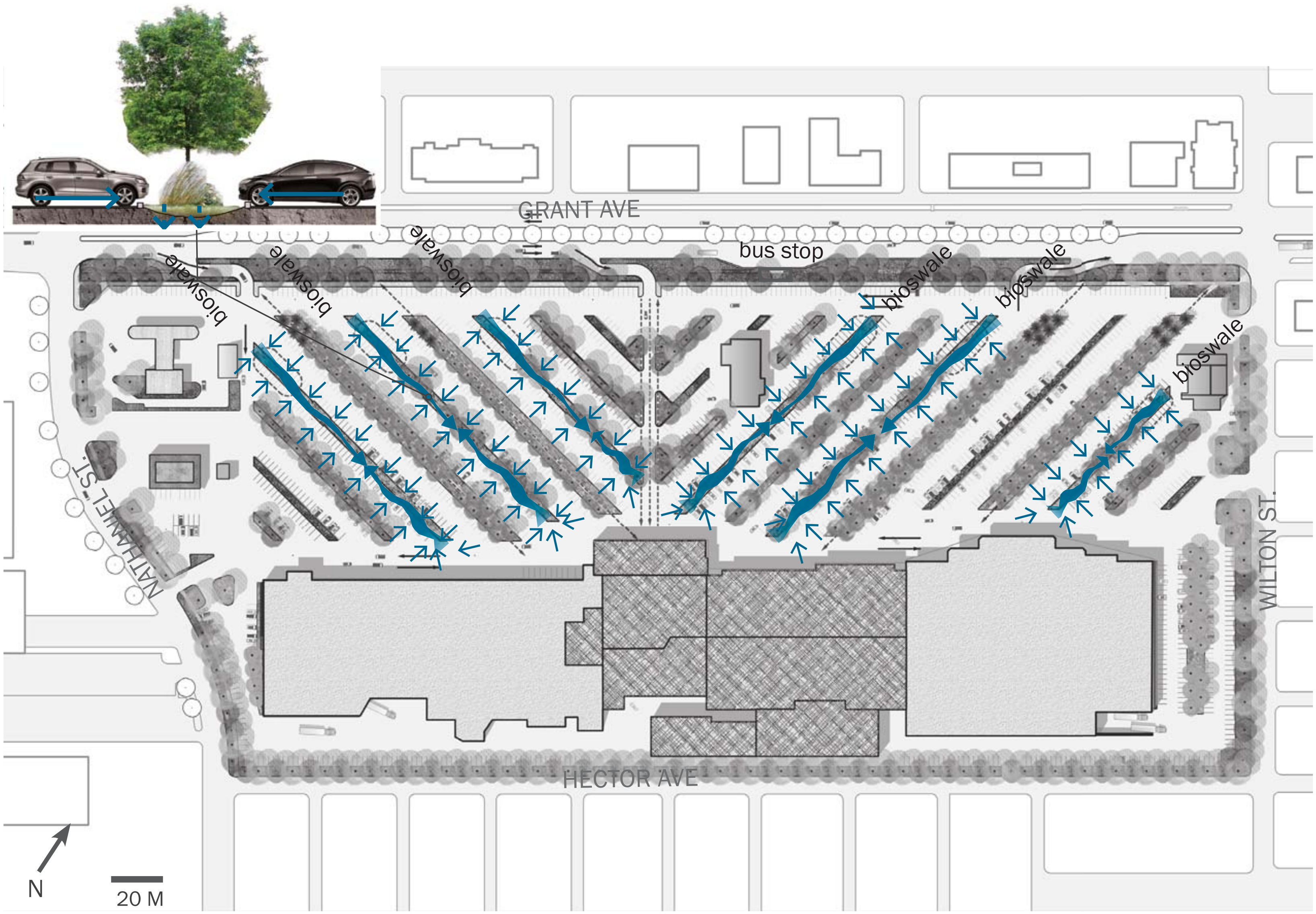


Figure 22. Site Plan showing bioswale system + flow within the parking lot.

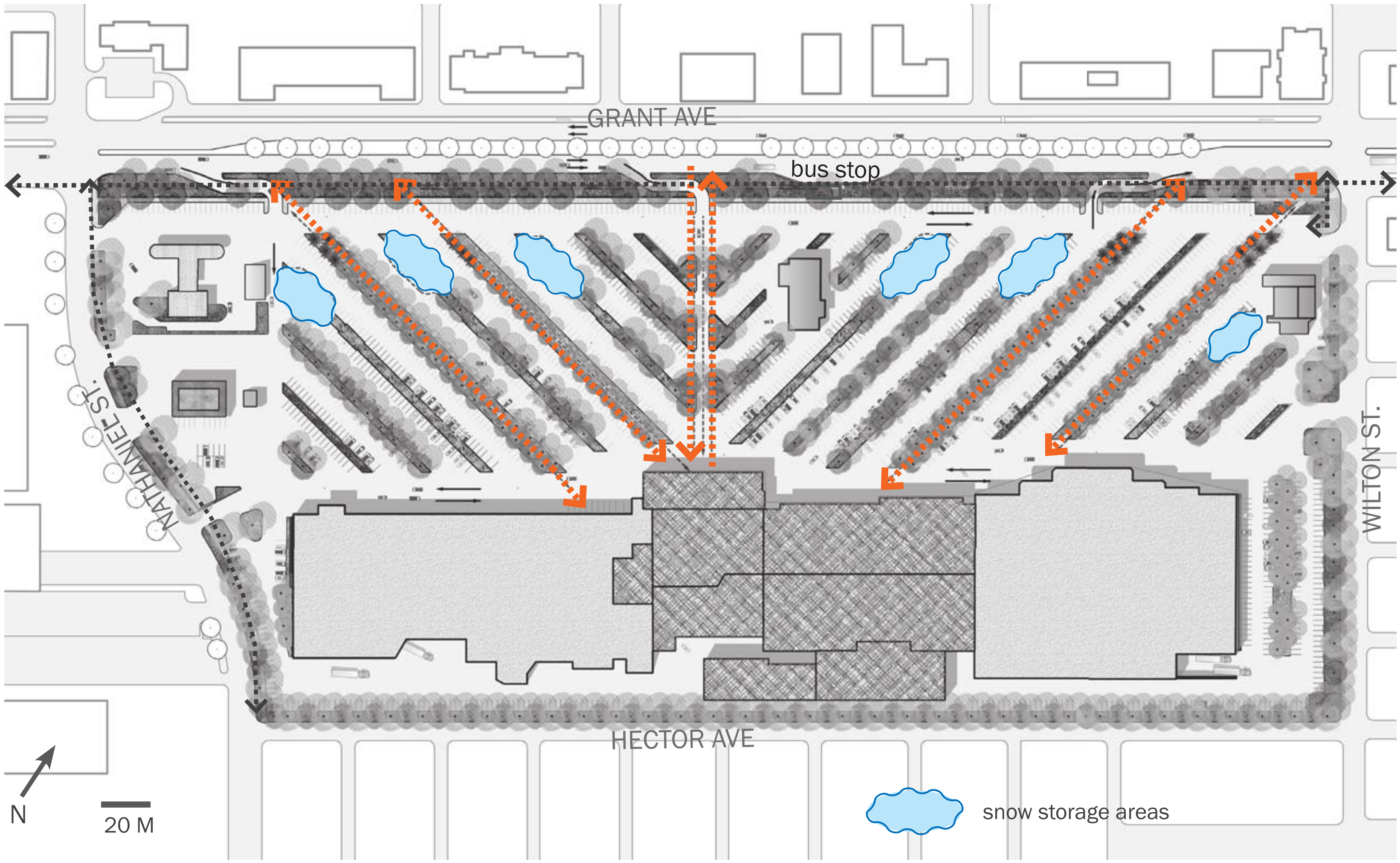


Figure 23. Site Plan - proposed snow storage areas.

Conclusion:

The overall redesign illustrates how a commercial site can be reconfigured and transformed into a more efficient site design with clearer circulation system and retrofitted for improved ecological performance. Ecologically the design, in particular its vegetation offers many long term benefits such as improvement in the air quality due to increase in oxygen production, carbon sequestration, reduction in dust particles and airborne pollutants; an increase of food, cover and habitat; contribution to energy conservation and modification of microclimate; and better management of snowmelt and runoff close to the source. Well connected main entrances to the building from streets, public sidewalks and the regional bus system will enhance pedestrian movement to the mall.

While an improved ecological performance and site circulation are achievable, it would be costly to reorient the parking lot and there may be too high a compromise on the loss of parking spaces to incorporate vegetation and impervious areas. Furthermore, extra space may be required for snow storage in cases of heavy snow.

PART THREE

SITE ANALYSIS

Throughout this practicum and during the special topic design studio on Grant Park Shopping Centre, the main focus was to explore ecosystem issues and application of the ecological-based design to ordinary everyday parking lots. Having explored these issues in a northern climate, the practicum set out to explore the potential of increased ecosystem services within an Australian urban context. The site selected is in Sydney, Australia. Sydney is the state capital of New South Wales and is Australia's oldest and largest city. Plumpton Market Place was selected, one of three sites in the Sydney area of a scale and commercial activity comparable to Grant Park Shopping Centre in Winnipeg.

The site analysis was conducted by acquiring photographs of the site, the collection of data through remote sensing, the research of literature and sources of land use; parking and vehicular access codes, identification of vegetation type, climate, cultural context and an onsite documentation by a local resident. The goal of the site analysis was to gain a general understanding of the context, existing processes, issues, and physical characteristics. This would allow for the identification of the opportunities and limitations that the site presents for a parking lot design with higher functioning ecosystem services.

Climate and environment conditions:

Sydney is located on the southeast coast of Australia, in the southern hemisphere, therefore, its temperate maritime climate reverses North American seasons. It is bordered by the Pacific Ocean to the east, the Blue

Figure 24. World map showing location of Sydney, Australia.

Mountains to the west, the Hawkesbury River to the north and the Woronora Plateau to the south.

Sydney's climate is largely dictated by its coastal location and the temperate seas that surround it. However, different parts of Sydney have slightly different weather patterns. There are few days with no sunshine at all, even in the middle of the winter. On average there are about 8 sunshine hours a day during the summer season.

Source: Syed, Adnan

Figure 25. Sydney Harbour

Source: Syed, Adnan

Figure 26. Sydney Blue mountains with Eucalyptus Forest.

Source: Google Maps

Figure 27. Site context with respect to the distance from the coastal area and blue mountains.

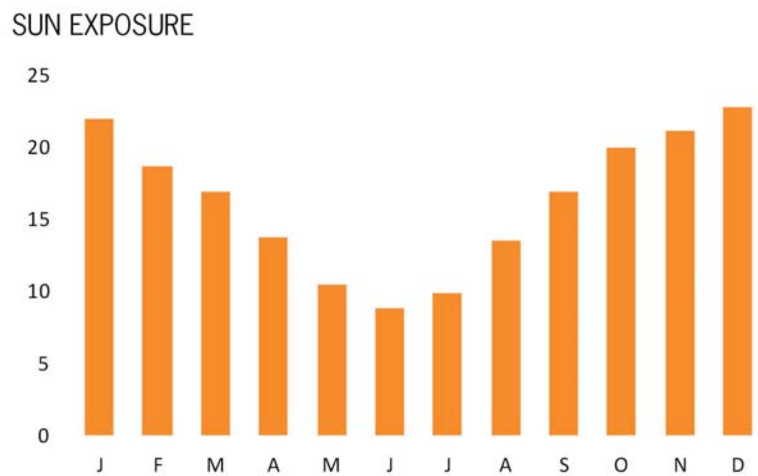
The climate in the inland western suburbs is drier, with hotter summers and slightly colder winters than the coastal area. The warmest month is January with the highest maximum recorded temperature at 46° C and average high at 25.9° Celsius. Although Sydney has high humidity and reasonable precipitation levels in summer, heatwaves are common that bring hot and arid winds from dry areas, resulting in higher temperatures. Hot summer days often end with southern winds, which abruptly moderate the temperature by bringing thunderstorms and strong winds (Australian Bureau of Meteorology, 2012).

Rainfall occurs year round, however winter and spring are slightly dryer than summer and autumn. Rain usually falls in sudden but short storms, which are often localized, which means that one part of the city can be dry while other parts are wet. Western Sydney's wettest months are January and February.

Variations in wind direction and speed occur at multiple timescales: daily, monthly, seasonally and annually. Western Sydney experiences an average annual wind-speed of 8.8 km/h. Average monthly windspeed values remain at 9.0 km/h ± 1.5 km/h with May exhibiting the lowest average wind-speed and October exhibiting the highest (Australian Bureau of Meteorology, 2012). Lower average wind-speed and variability in Sydney reflect the influence of the mountain range and moderating capabilities of the ocean currents. Typically, average wind direction in Western Sydney originates from south and southwest direction.

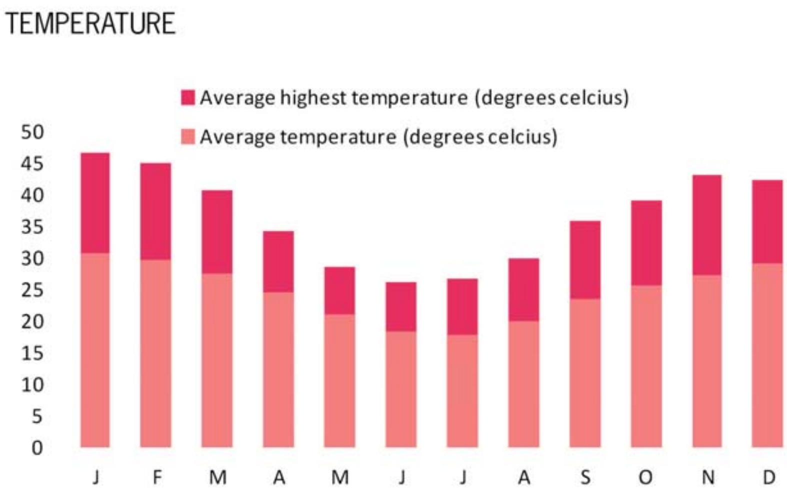
Sydney is also prone to drought due to acute deficiencies in rainfall. An example of the drier conditions is 2009 where the annual rainfall was around 956 mm compared to 1369 mm in 2011 (Australian Bureau of Meteorology, 2012).

While climate determines general weather conditions, the scale is too large to understand how climate affects the human experience. A microclimate represents a specific, localized climate typically restricted to a maximum of 5 meters above grade (Rosenberg et al., 1983). Microclimate conditions exist at a range of spatial scales and may change within the same city block, due largely to the urban heat island effect. Other influences on microclimate conditions involve wind and solar radiation, surface/vegetation cover, exposure,



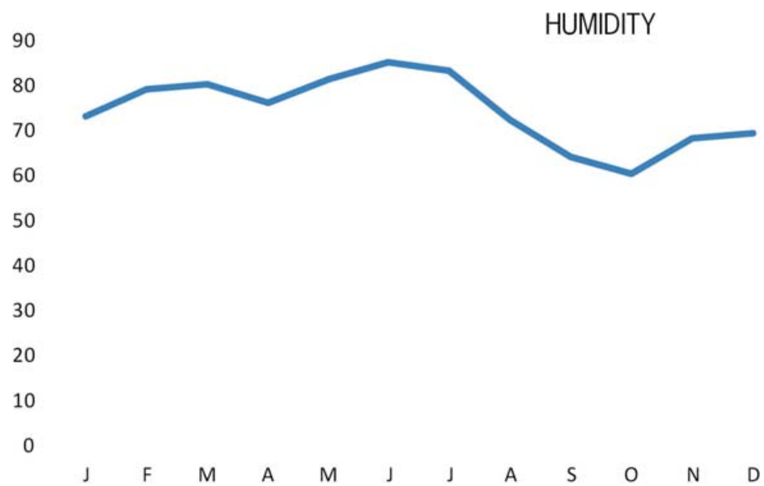
Source: National Climate Centre Bureau of Meteorology, 2012

Figure 28. Average monthly sun exposure for West Sydney, Australia.



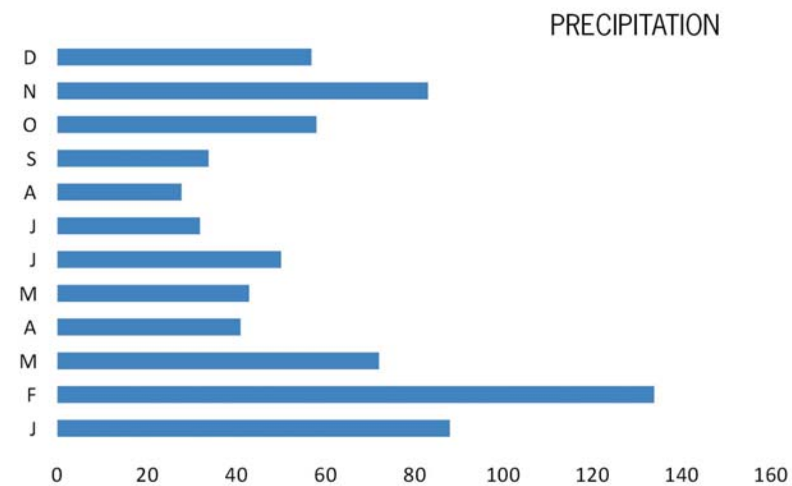
Source: National Climate Centre Bureau of Meteorology, 2012

Figure 29. Average temperature + highest temperature values for West Sydney, Australia.



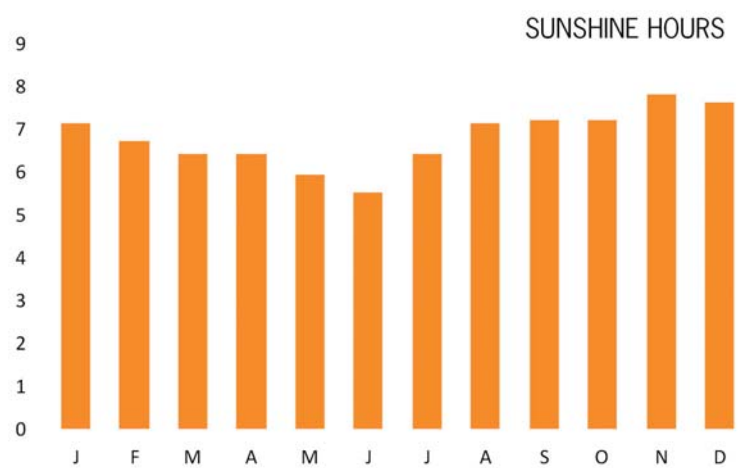
Source: National Climate Centre Bureau of Meteorology, 2012

Figure 30. Average % relative humidity for West Sydney, Australia.



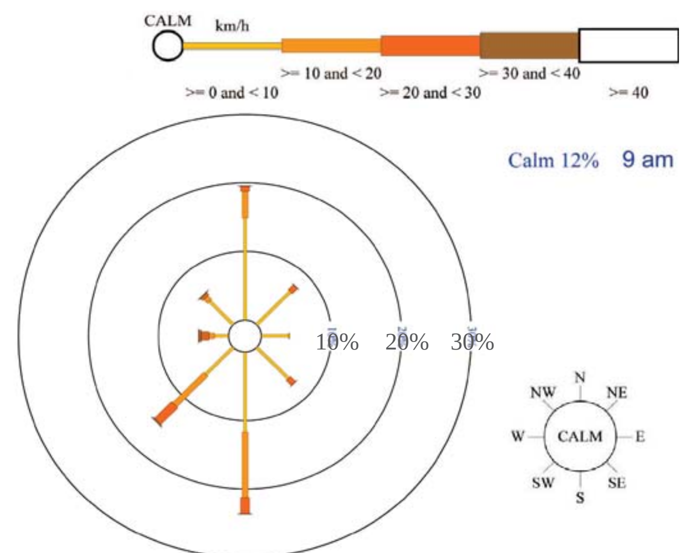
Source: National Climate Centre Bureau of Meteorology, 2012

Figure 31. Average monthly precipitation (mm) for West Sydney, Australia.



Source:National Climate Centre Bureau of Meteorology, 2012

Figure 32. Average daily sunshine hours for West Sydney, Australia



Source: National Climate Centre Bureau of Meteorology, 2012

Figure 33. Wind direction + speed (km/hour) for West Sydney, Australia

slope and proximity to water. Street trees and other large and small vegetative areas are present in Sydney as a part of the Australian government strategy to offset the urban heat island effect. However, a strong urban heat island effect exists for the Sydney area, specifically the western area, as it is exposed and does not receive the moderating influence of a cooling sea breeze (Greening Australia).

Sydney's network of glass, metal, concrete, asphalt and brick surfaces and structures readily absorb and retain incoming solar radiation. Unlike vegetative surfaces, these surfaces retain solar energy for longer periods of time, resulting in increased temperatures extending into the night. The most significant microclimatic design factor experienced during the warmer summer months is solar exposure. Solar exposure is defined by the Australian Bureau of Meteorology as the "total amount of solar energy falling on a horizontal surface with typical values of 1-35 MJ/m^2 (mega joules per square metre)" (Australian Bureau of Meteorology, 2012). In Sydney, the refuge of a shade tree has the ability to create a different microclimate than that experienced just outside the canopy in direct sunlight.

Site context and location:

Like much of North America, much of Australia's urban area is comprised of suburbs on the periphery of the city. Sydney is composed of hundreds of suburbs commonly known as the Sydney metropolitan area (City

Figure 34. Source: Syed, Adnan

Source: Syed, Adnan

Shade is critically important in the Sydney's urban environment.

Figure 35

of Sydney, 2013). The site chosen for this project, is the Plumpton Marketplace, a sub-regional shopping centre located in the Plumpton suburb of Sydney's outer western region. The site is located about 46 kilometers west of the Sydney central business district, in the local government area of the City of Blacktown which is part of the Greater Western Sydney region.

The main retail anchors of this shopping mall are Woolworths and Big W. The mall also has 60 specialty shops, McDonalds, KFC, a Woolworths gas station and green house. The site is rectangular in shape, approximately 290 meters in length and an average of 230 meters wide, with a total area of approximately six hectares. Approximately 4 hectares of the site is occupied by the parking lot and circulation. The parking area has room for 978 cars on site.

Figure 36 shows the location of the site in relation to the important local and regional parks, reserves and the adjacent suburban boundaries. The site is located on the northern boundary of Plumpton suburb. To the north of the site is the residential development of Oakhurst suburb, as well as the Hanna reserve and a recreational area. To the west is the residential area of Habersham suburb and its public park and sport fields. To the south, a significant Plumpton regional park exits. Further south are the suburbs of Mount Druitt and Rooty Hill. To the east side with in the Plumpton area adjacent to the site is Alory park and Bell creek (which flows in a north-north easterly direction to join Eastern Creek). Further towards the east and adjacent to Plumpton suburb is Glendenning suburb with light industrial area and western Sydney parkland reserves area.

Source: Google Maps

Figure 36. Location of Plumpton Market Place

SITE ANALYSIS:

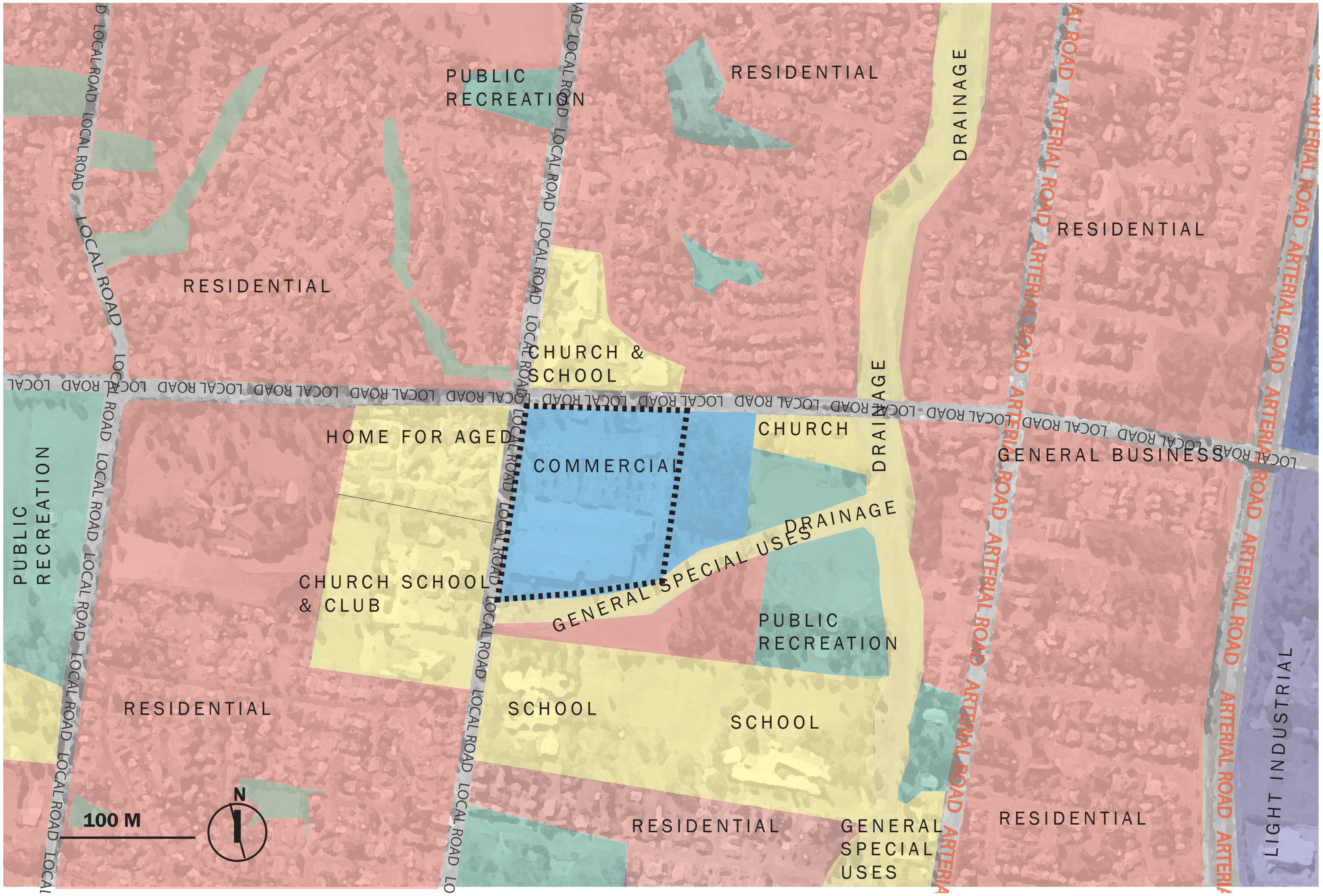
Land use:

The site is contained on the north and side by local roads, Jersey and Hyatt Road, respectively. Jersey Road is a comparatively high volume road with speed limits upto 60 km/h while the Hyatt Road is a low volume road with a speed limit of 40 km/h. The site is readily accessed from Western Sydney orbital road M7 motorway, which also forms the eastern border of the suburb. The site is also indirectly connected with M4 motorway through RootyHill North, which is also one of the main arterial roadS that runs in north south direction (Figure 37).

Circulation:

In addition to the main arterial roads (M7 and Rooty Hill North Road), the Jersey Road is the main four-lane traffic corridor running along the norther portion of the site. This road is intersected by Hyatts road which runs in a north south direction adjacent to the site. There are bus stops on the north side adjacent to the main pedestrian shopping centre entrance while others are located on the westside of Hyatts Road. There are three vehicular entrances or exit (depending on the vehicular movement) to the site, one is on the northeast side corner on Jersey Road and the other two are on the west side on Hyatts Road.

Pedestrian circulation within the site is limited to one informal unshaded pedestrian path through the parking lot that connects to one of the main entrances of the building. There are three main entrances into the



Source: Blacktown City Council, NSW, Sydney, Australia

Figure 37. Land use

building along the main facade and a fourth one on the west side of the building. The two main drop off and pickup zones are along the main building facade. The fast food businesses along the northside are connected with public sidewalks through minor entrances. In addition, a bicycle friendly lane runs along the western edge of the site and is a part of wider bicycle network. Within the parking lot two way vehicular traffic circulation exists between the 90° angled parking bays. Generally, the site has no formal pedestrian circulation paths connecting the main entrances with the existing sidewalks and bus stops (Figure 38).

Vegetation:

Eucalyptus is an integral part of the Australian identity associated with 'the bush' "From the children's song Kookaburra sits in the old gum tree, through to the distinctive smell of eucalypts to iconic paintings and photographs, eucalypts are an essential part of Australian culture, and are featured in art, music and literature" (Environment & Heritage, New South Wales Government, 2013 p.1). The most commonly found native Eucalyptus species are Lemon scented gum (*Eucalyptus citidora*) and Spotted gum (*Eucalyptus maculata*).

A dense Eucalyptus forest, dominated by above-mentioned species, is adjacent to the East site of the parking lot (Figure 40). There are also some Eucalyptus trees present along the north and west perimeter. The southside of the shopping centre is wide open, absent of a tree buffer. Within the parking lot, about 1.2m^2 planter beds, designed for trees, are present at a regular spacing. Observations indicate that most of the planters are empty with more than 80 percent tree mortality. This shows that the current designed pattern of plantation is problematic and likely not an efficient system to provide even basic ecosystem services.

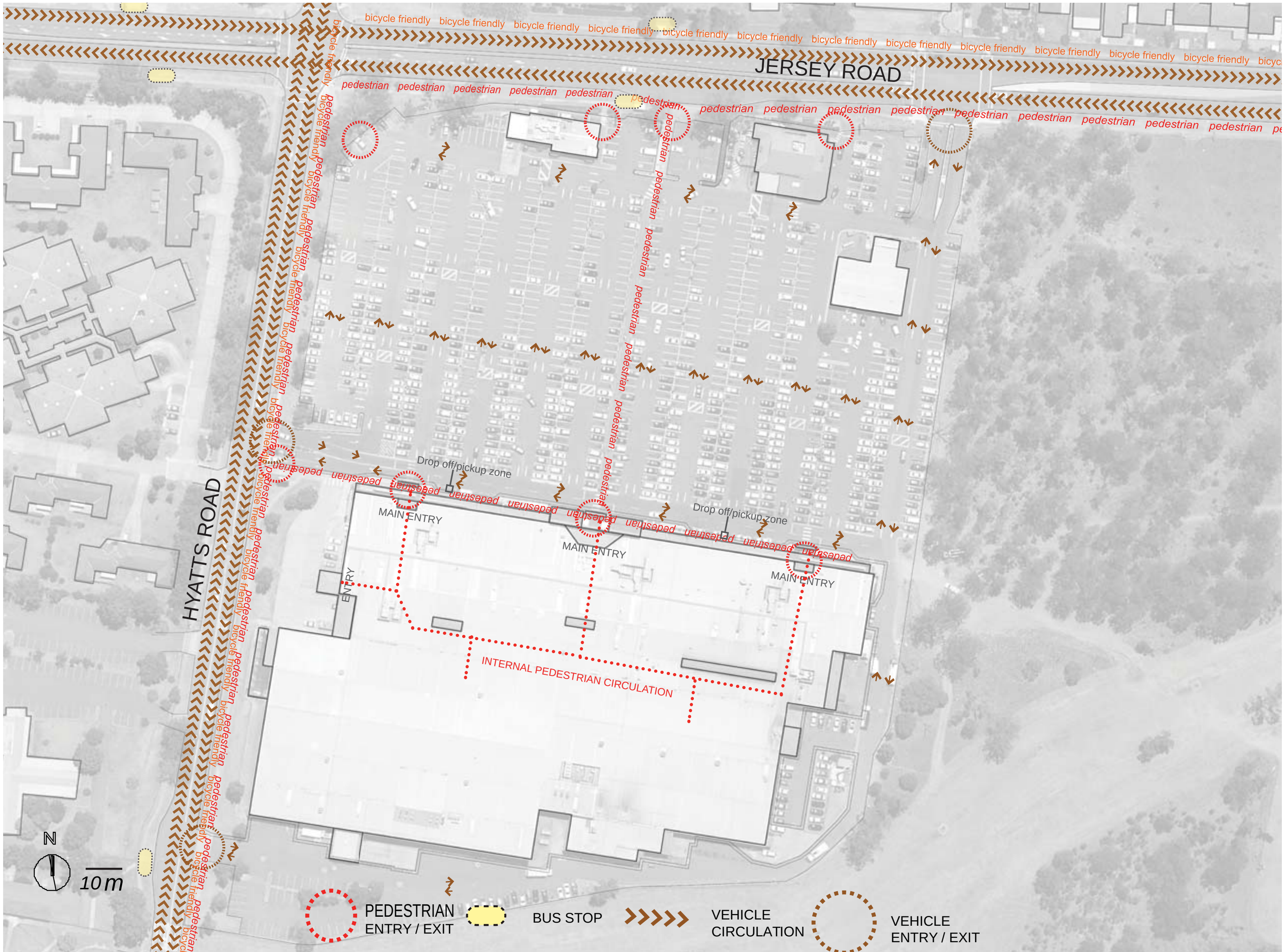


Figure 38. Existing vehicular and pedestrian circulation

Source: Google Maps

Visibility analysis:

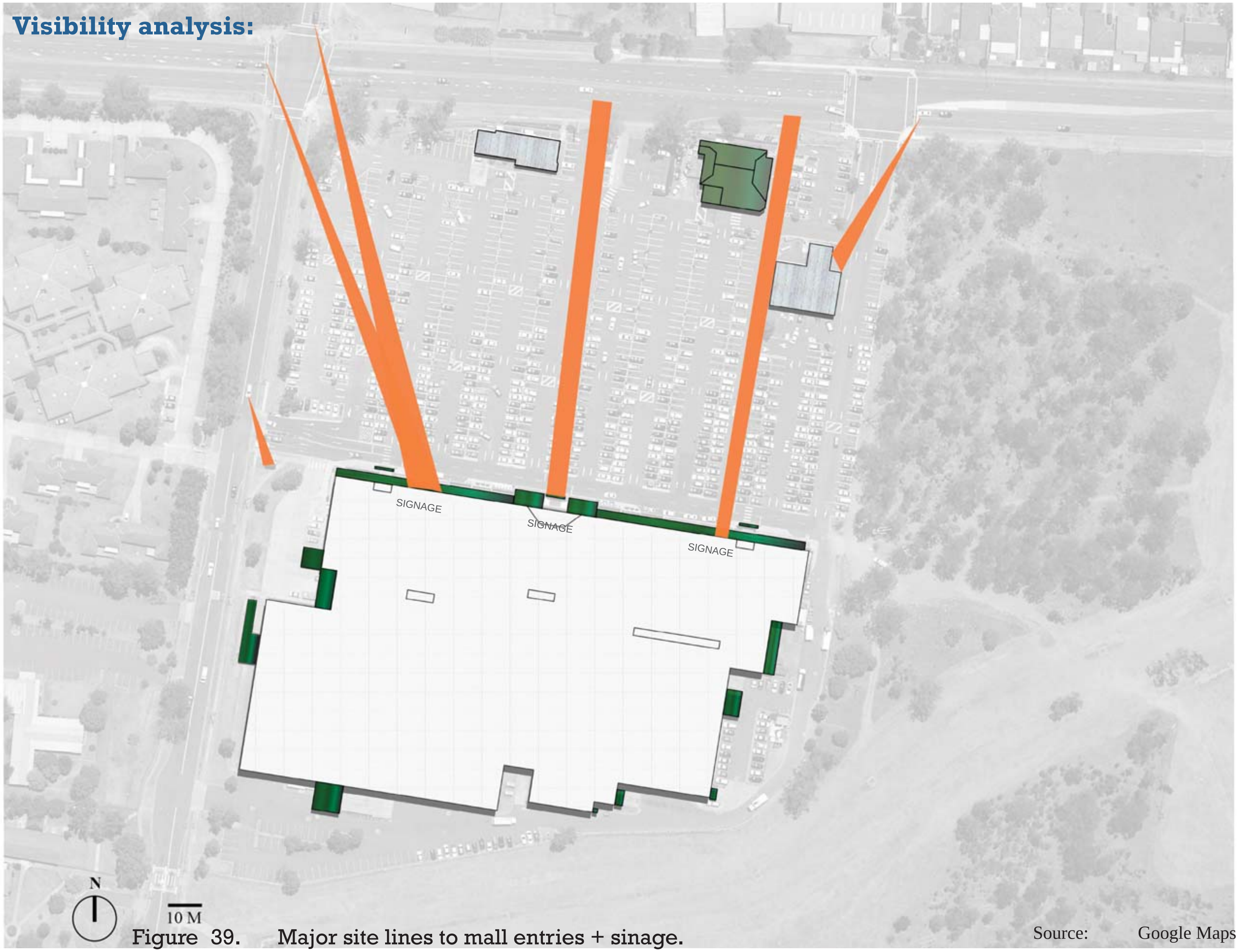


Figure 39. Major site lines to mall entries + sinage.

Source: Google Maps

Figure 40. Existing vegetation onsite and adjacent to the site.

Source: Syed, Adnan

Figure 41. Adjacent Eucalyptus forest (Looking north).

Source: Syed, Adnan

Figure 42. Adjacent Eucalyptus forest (east side).

Source: Syed, Adnan

Figure 43. Existing vegetation within the parking lot with about 80% mortality rate.

Source: Syed, Adnan

Figure 44. Looking south - Parking lot without any shaded canopy + impervious asphalt paving.

Source: Syed, Adnan

Figure 45. South side (one of the front main entrances)- without separate pedestrian path.

Source: Syed, Adnan

Figure 46. South side (one of the front main entrances + path) - with no shaded canopy for human comfort.

Source: Syed, Adnan

Figure 47. Looking southeast (service area parking) - with no shade structures for parked cars.

Source: Syed, Adnan

Figure 48. Looking south (service area parking) - with no shade structures + impervious asphalt surface.

PART FOUR

SITE DESIGN

The design (Plumpton Market Place):

The site analysis revealed Plumpton Market Place as a thriving shopping centre with an unattractive parking lot landscape providing very low ecological performance. The site has a limited pedestrian circulation system that is exposed to extreme temperatures during summer, a concentration of carbon emissions, poor air and water quality, low biodiversity and high stormwater runoff.

Given the extreme climatic conditions of this region, it is imperative that the parking areas such as at Plumpton Market Place provide a broad range of vital ecosystem services. The ecosystem services that can be improved through a redesign of the parking area include: providing generous shade during the summer to increase human comfort; reducing the level of carbon dioxide discharged to the atmosphere via increased tree planting; regulating temperature through shade and evaporative cooling; increasing biodiversity and habitat; returning precipitation to the groundwater strata; and replicating a natural drainage system to improve stormwater drainage problems (Figure 49).

Creating a comfortable microclimate with shade in the parking lot during the hot summer days is one

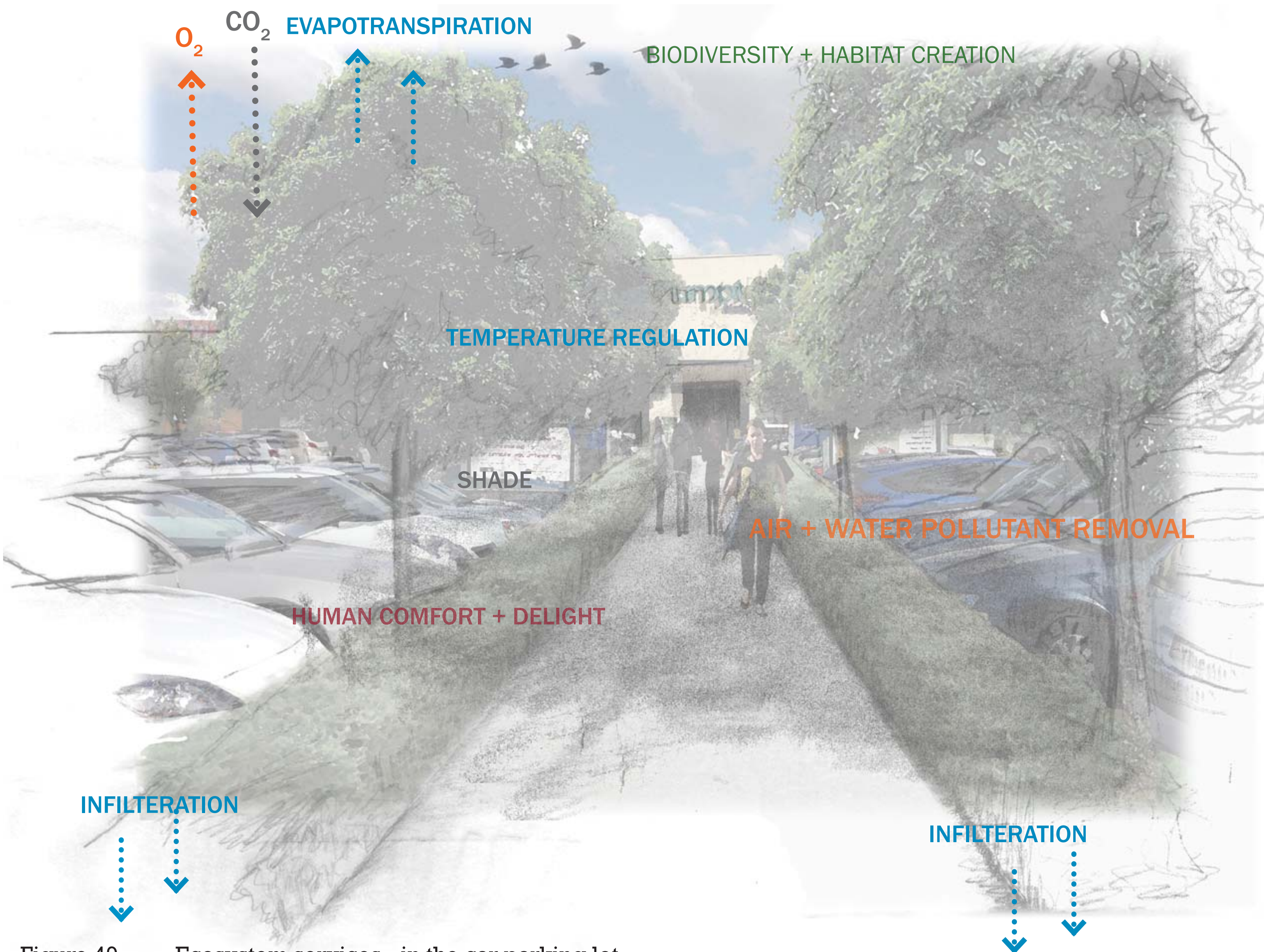


Figure 49. Ecosystem services - in the car parking lot.

of the priority ecosystem services for the users of Plumpton Market Place. Both the surface temperature and that of the air above the ground are extremely high during the daylight hours due to the expansive unshaded heat-absorbing paving surface. Therefore maximizing shade on the parked cars and pedestrian walkways, and increasing the evapotranspiration rate are critical to provide an appropriate level of human comfort.

Another human health and ecosystem issue associated with the site is the poor air quality as a resulting from vehicular exhaust, emissions and particulate matter present in the air. CO_2 is a main component of the automobile exhaust emissions and the open windy expanse of paving increases the particulate matter. Plants provide air cleaning service by stripping carbon from the air and absorbing other pollutants through their basic physiological functions (photosynthesis and water uptake) and slowing wind and associated dust levels.

Parking lots' large impervious areas result in low habitat quality, both on the surface and in the soil. This low quality habitat is directly associated with the loss of biodiversity, critical for an overall healthy ecosystem. Pervious areas with biodiverse vegetation within the parking lot can provide many services while providing food and cover for a diverse array of species.

The hydrological impact of impervious parking lots has a major negative impact on modification of surface water quality and downstream water quantity. The impervious surface is unable to absorb rainfall for groundwater recharge and generates higher runoff. Increase in the area having vegetation results in reduction of both the levels of pollution and the peak flow levels of the runoff that are conveyed into engineered stormwater facilities.

Concept:

As shade is one of the priority ecosystems services and Australians love outdoors and nature, this design proposes to create an open forest experience as a way to make the parking lot landscape of Plumpton Market Place a pleasant shopping experience. The open forest cover is the backbone of the ecosystem. It strips carbon and other airborne pollutants, releases oxygen through photosynthesis and water uptake, reduces air and surface temperature by providing shade and improves the overall evaporation process. Furthermore, the planting strategy with diverse vegetative species and increased planted cover form offers a living space, food and cover for many species and organisms.

This concept recognizes the importance of preserving the adjacent Eucalyptus forest and integrating it into the parking lot (Figure 50). The eucalyptus forest tree species, Lemon Scented Gum and Spotted Gum pay homage to the texture, color and smell of an Australian forest. The open forest concept is important to provide both the visual way finding and the shade necessary for greater human comfort in the summer. Palm trees, with their distinctive strong vertical form mark the entrances and announce the main northern gateway to Plumpton Market Place.

The proposed layout of the space facilitates both physical circulation and visual connections to the mall. It provides multiple paths and establishes clear and comfortable pedestrian corridors through the parking lot. A double allée connects the main mall entrances via a public walkway to the regional bus system (Figure 51). The garden on the west offers a place to sit and relax, supports the existing greenhouse retail operation, and creates a space to learn more about the native flora and ecosystem services (Figure 52,53).

To manage stormwater, the design offers a series of bioswales, pervious landscape areas and walkways. The overall system moderates runoff rates, promotes infiltration, increases evapotranspiration and optimizes the existing inground stormwater infrastructure (Figure 54).

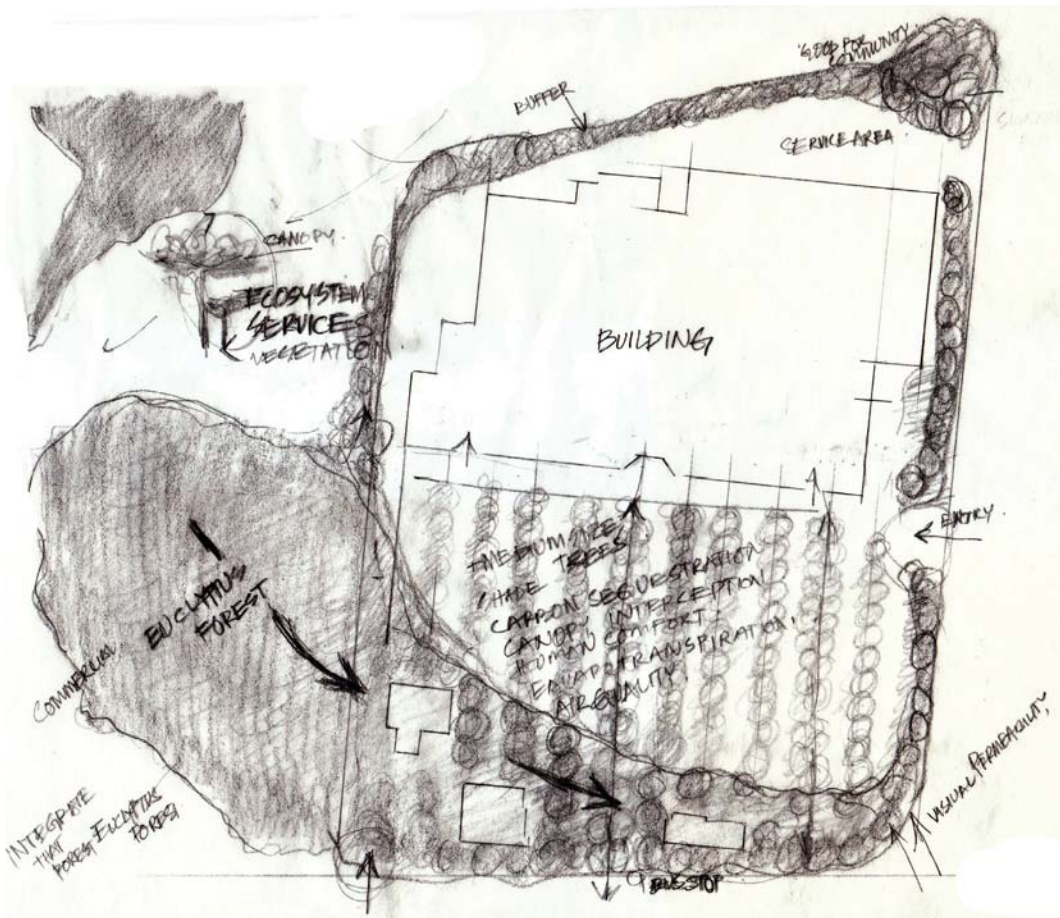


Figure 50. Concept plan - open forest.

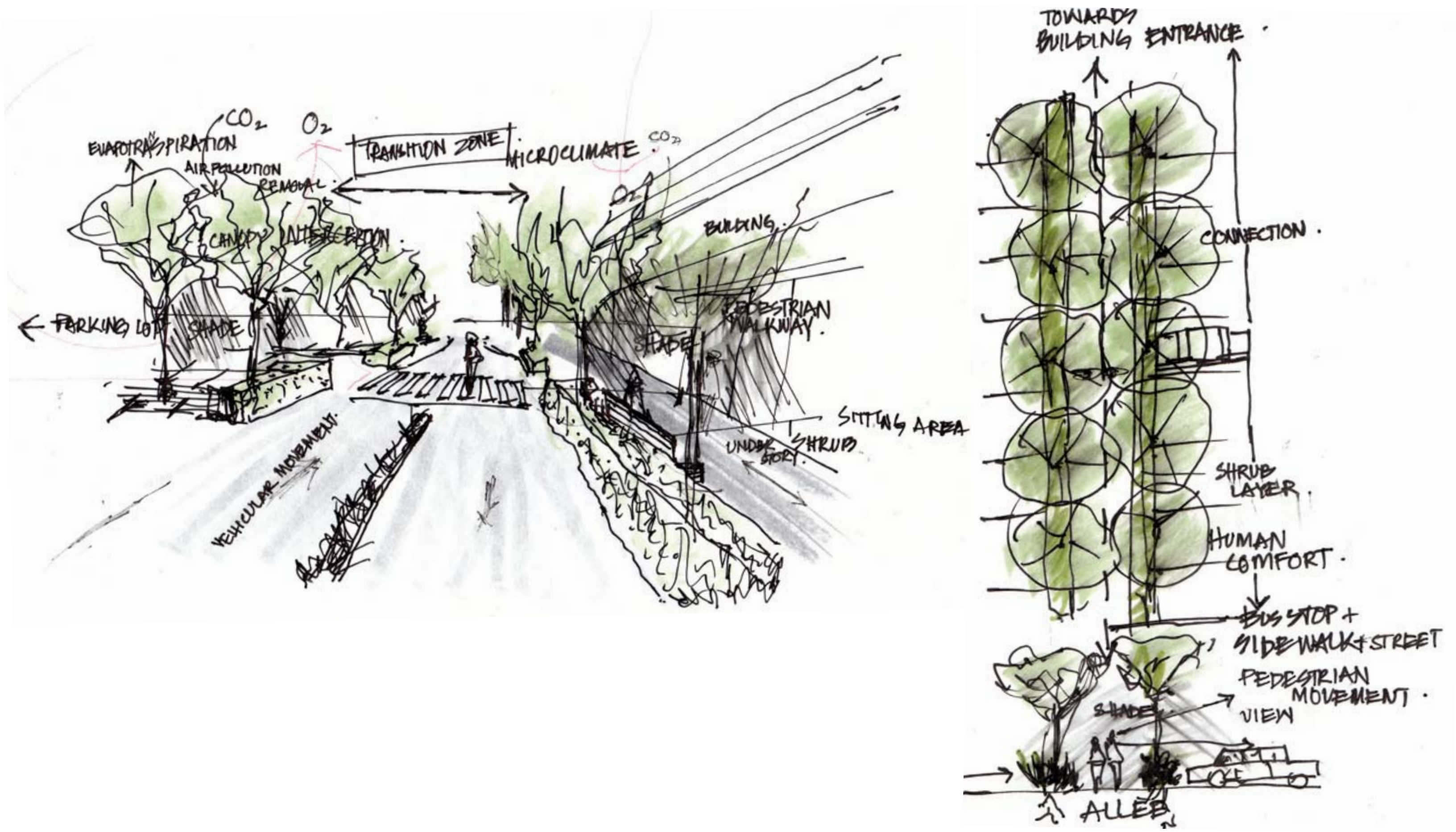


Figure 51. Concept sketch (Building transition zone) + concept plan and section (allée).

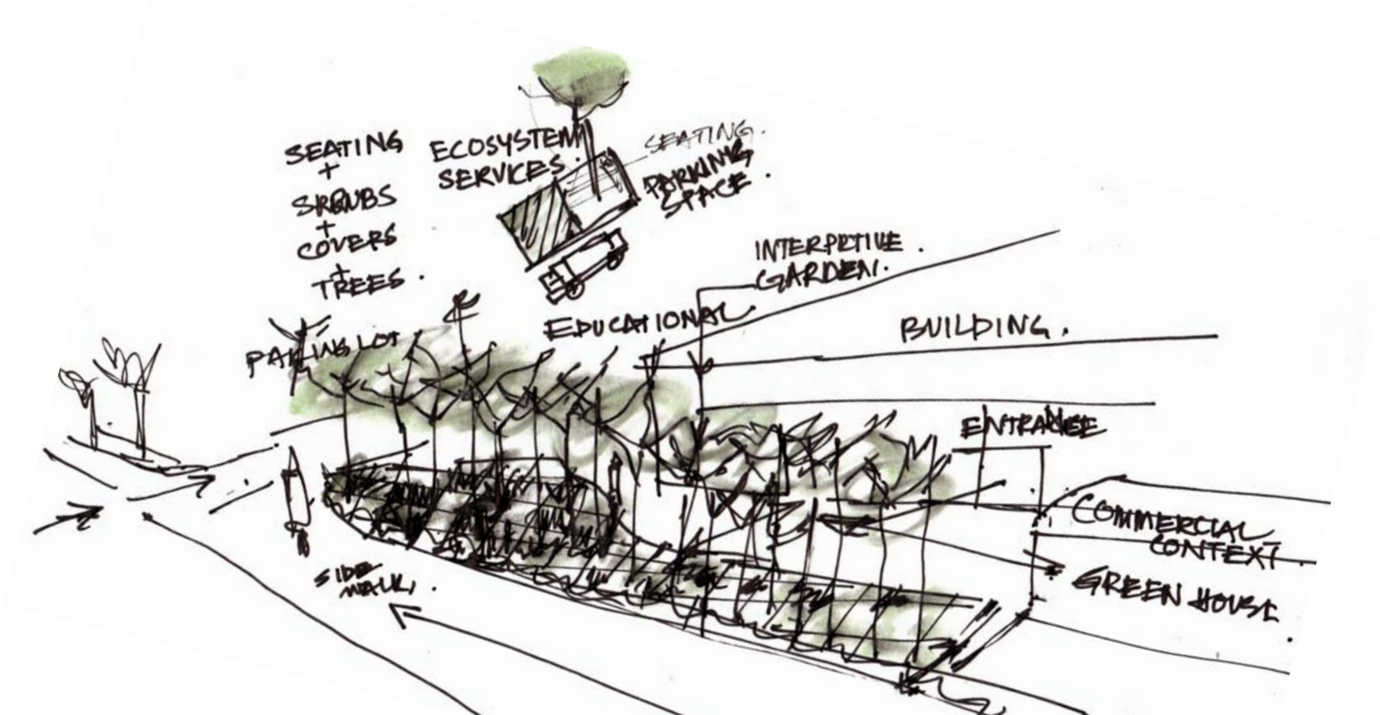


Figure 52. Concept sketch of garden.

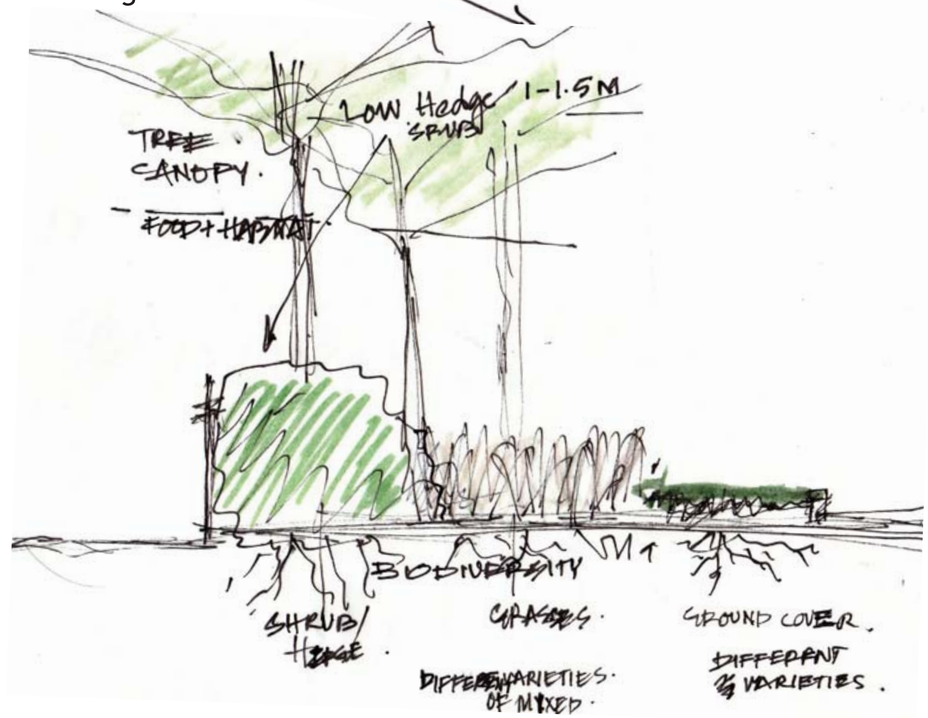


Figure 53. Concept of increasing biodiversity by using different type of vegetation for food + habitat.

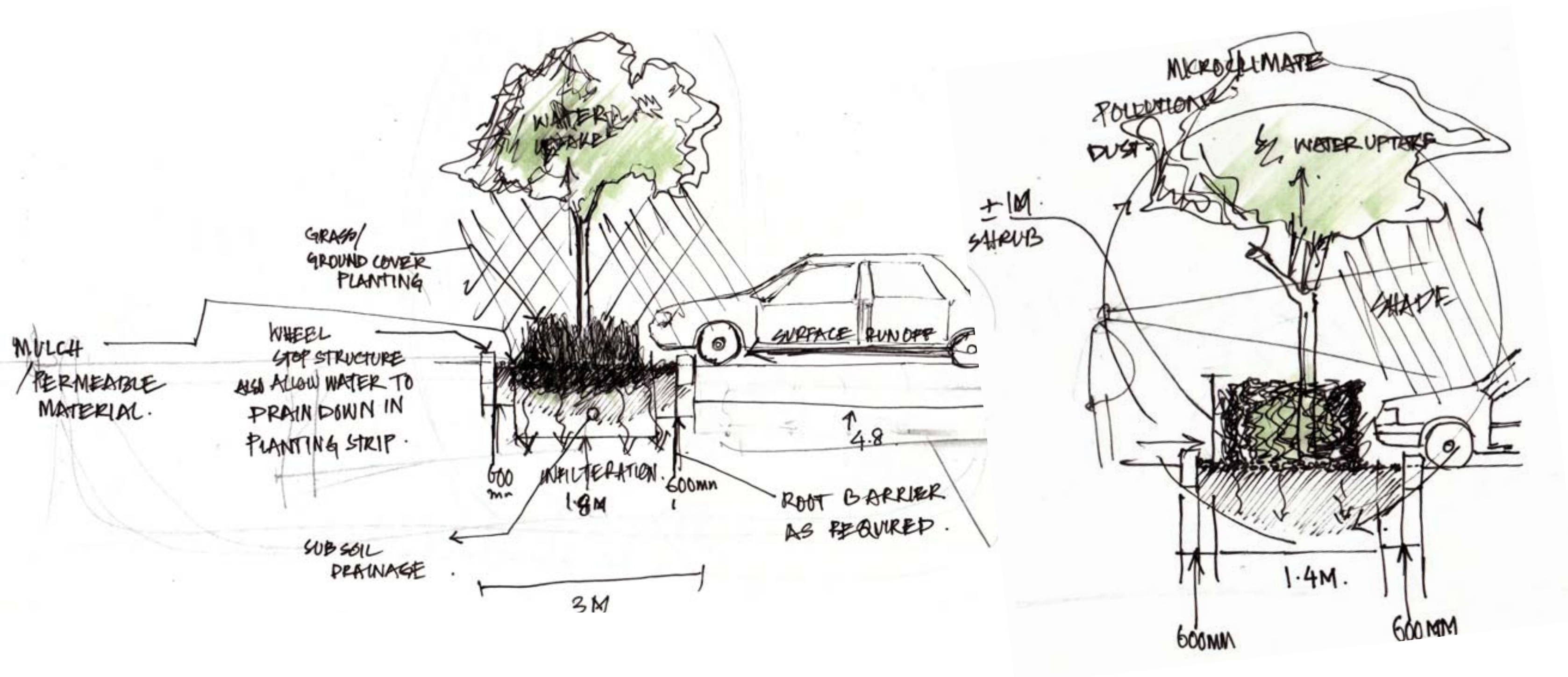


Figure 54. Drawings of storm water retention concept + infiltration

Design detail:

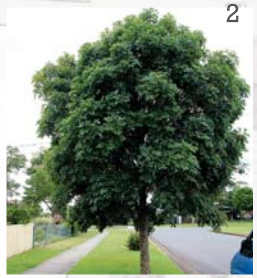
Vegetation:

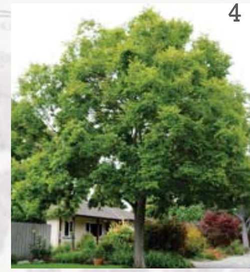
The concept for the planting strategy is to create of overlapping levels of vegetation, from an open forest down to biodiverse nutrient-absorbing ground covers. The plants selected for Plumpton Market Place are primarily a mix of natives but also include adapted exotic species. Palms, with their distinct vertical form, highlight the entries. Tall evergreen Eucalyptus species (Lemon scented gum *Eucalyptus citidora* and Spotted gum *Eucalyptus maculata*) with their asymmetrical forms were selected because of their wide canopy, cultural significance and their dominant presence in the adjacent existing forest. The species (Tuckeroo *Cupaniopsis anacardiodes),* Australian teak *(Findersia australis),* Chinese Tallow *(Sapium sebiferum)* and Chinese Hackberry (*Celtis australis*) are hardy medium-sized trees that are appropriate to both human scale and shading of cars. When mature, these trees will provide a dense canopy of shade throughout the parking lot as well as provide physical benefits of shelter and food sources for birds and insects. All shrubs are small to medium evergreens selected for their foliage, form and height relative to pedestrian sightlines. They require little maintenance and provide year round interest and screening. The bioswale areas include tufted species such as Nobby Club-rush (*Isolepis nodosa*), Mat rush (*Lomandra longifolia*) and Tussock Grass (*Poa* spp.) as they maintain their biomass through vigorous vegetative growth. The Mat rush is the workhorse for stormwater management system. The upright growth structure slows water flow and captures pollutants while the deep penetrating roots facilitate water absorption (Figure 55 a,b).

Figure 55. (a) Planting plan

Medium Trees

A

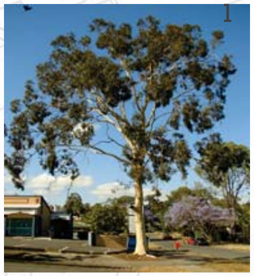





1	*Cupaniopsis anacardioides*	Tuckeroo
2	*Flindersia australis*	Australian teak
3	*Sapium sebiferum*	Chinese Tallow
4	*Celtis australis*	Chinese Hackberry

Large Trees

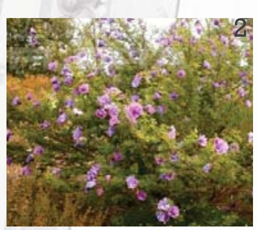
B



1	*Eucalyptus citidora*	*Lemon scented gum*
2	*Eucalyptus maculata*	*Spotted gum*
3	*Phoenix dactylifera*	*Date palm*

Small to Medium Shrubs

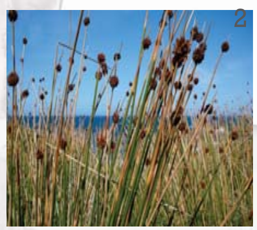
D


1	*Syzygium australe*	Tayla
2	*Alyogyne huegelii*	West Coast Gem
3	*Correa pulchella*	Pink mist

Tufts and Grasses

E


1	*Isolepis nodosa*	Nobby Club-rush
2	*Lomandra longifolia*	Matrush
3	*Poa spp*	Tussock Grass

Groundcovers

F



1	*Adenanthos pungens*	Coral
2	*Acacia aculeatissima*	Snake Wattle
3	*Acacia cognata*	Mini Cog

Figure 55. (b) Planting species Source : flicker.com

		HEIGHT & SPREAD		FORM	ATTRIBUTES / FEATURES
A	1)	10-12 m	8 m	Single straight trunk with stable branch structure. Rounded shape with dense widely spreading crown.	Native, evergreen, ideal as a street / shade tree. Provides food and shelter for wildlife.
	2)	10-12 m	8 m	Single straight trunk with stable branch structure. Rounded dense crown.	Native,evergreen, hardy, ideal as shade /street tree. Bird and butterfly attractive tree.
	3)	10-15 m	8 m	Single straight trunk with stable branch structure. Dense rounded / conical crown.	Deciduous, broad leaf, ideal as shade / street tree. Provides food and shelter for wildlife.
	4)	10-12 m	8 m	Single straight trunk with stable branch structure. Dense rounded crown.	Deciduous, hardy ideal as shade / street tree. Provides food and shelter for wildlife.
B	1)	16-20 m	16 m	Asymmetrical in form with open and wide canopy.	Evergreen, fast growing, very hard, attractive bark and scented foliage
	2)	16-20 m	16 m	Asymmetrical in form with open and wide canopy.	Evergreen, fast growing, very hardy ideal, attractive bark and scented foliage
	3)	16-20 m	10 m	Strong vertical form with feather fronds.	Evergreen, very hardy ideal, commonly used in clusters to identify key nodes or axes.
C	1)	1.5-2.0 m	1.5-2.0 m	Small to medium compact shrub.	Native, evergreen, ideal for hedging or screening.
	2)	1.5-2.0 m	1.5-2.5 m	Small to medium compact shrub.	Native, evergreen, attractive flowers and foliage ideal for hedging or screening.
	3)	1.0- 1.5 m	1.0- 1.5 m	Small compact, shrub.	Native, evergreen, attractive flowers and foliage ideal for hedging or screening.
D	1)	0.5- 0.5 m	0.5-0.5 m	Rhizomatous perennial.	Native, evergreen, very hardy.
	2)	0.6 - 0.1 m	1.0-1.0 m	Rhizomatous perennial.	Native, evergreen, deep rooted.
	3)	0.8 - 1 m	0.8 -1.0 m	Rhizomatous perennial.	Native, evergreen, provides food for birds and insects.
E	1)	0.1- 0.5 m	1.0-1.0 m	Low growing compact form.	Native, evergreen.
	2)	0.1 - 0.5 m	1.0-1.5 m	Low growing compact form.	Native, evergreen.
	3)	0.8 - 1 m	0.8 -1.0 m	Low growing compact form.	Native, evergreen

source: (Bush land flora, 2013).
(Landcom, street tree design guidelines, 2008).
(Tree species selection, City of Sydney, 2011).

Allée:

To create a pleasant pedestrian environment with connectivity to the major street, the regional bus system and the public sidewalks, an allée creates clear direct links between the parking lot and the building entrances to provide enhanced pedestrian corridors. Trees on this pedestrian walkway will provide shade cover at maturity while understory perennials beneath provide partial visual and physical screening to the parked vehicles without blocking the pedestrian view. The perforated curbs curtail auto traffic outside of the individual rows yet allow the movement of water into the vegetative strips where it can be absorbed and percolate into the soil. The broad canopies of the trees will also enhance evapotranspiration cooling in hot summer (Figure 56,58, 59,60 a,b).

Bioswales:

To manage the stormwater effectively, a number of bioswales are proposed to offer onsite infiltration and to reduce excess surface runoff (Figure 61 b, 62). Bioswales are located to complement the existing catchbasin system, reinforcing the existing drainage of the lot. Water runoff from impervious asphalt surface is directed to the bioswales (trees with understory plantation) through curb cuts. The vegetative soil media attenuates and treats the majority of water onsite and allows retention and infiltration during average rainfall events. Perforated overflow pipes connected to the existing underground stormwater infrastructure helps to manage stormwater runoff during large storm events (Figure 61 a,b).

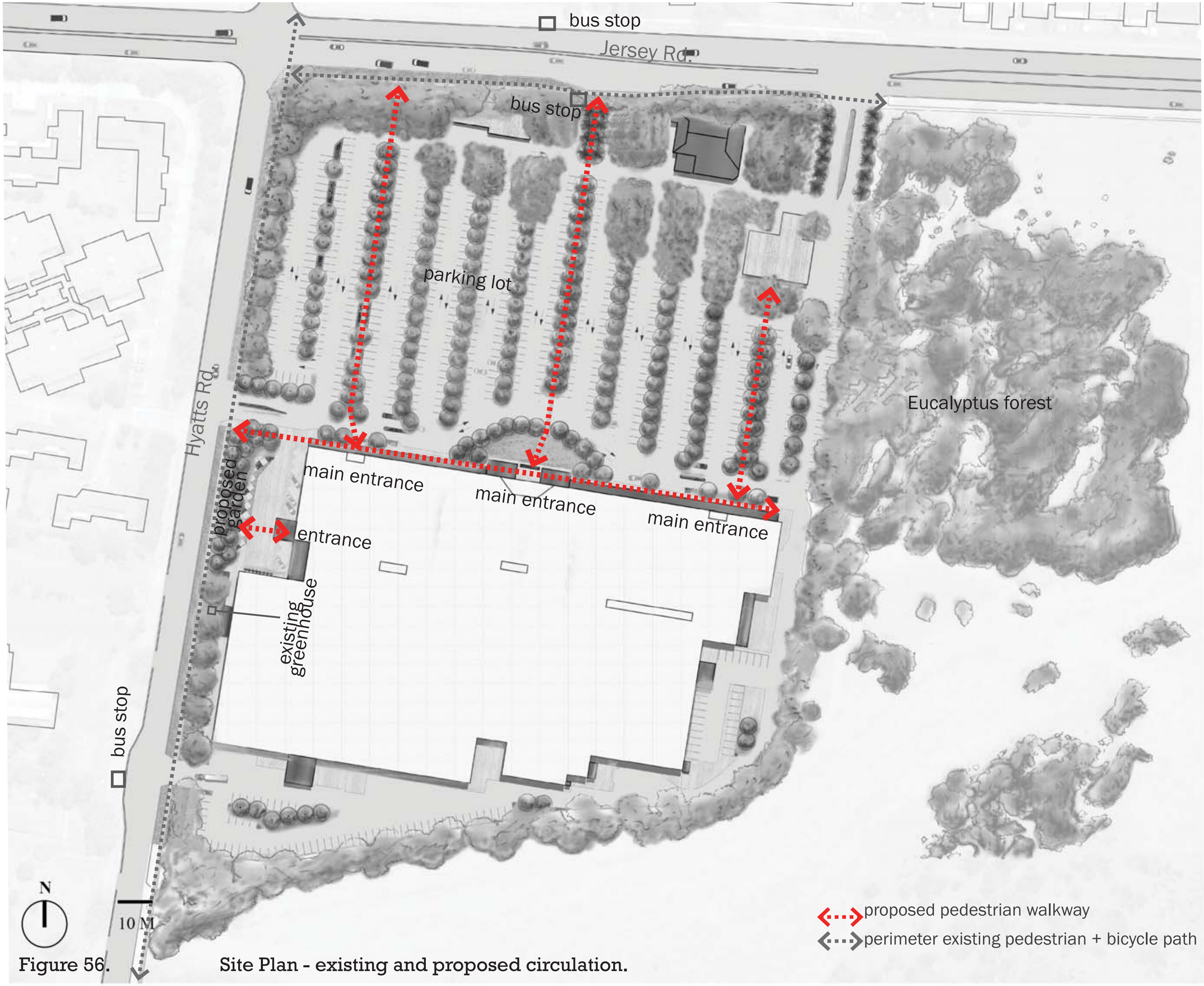
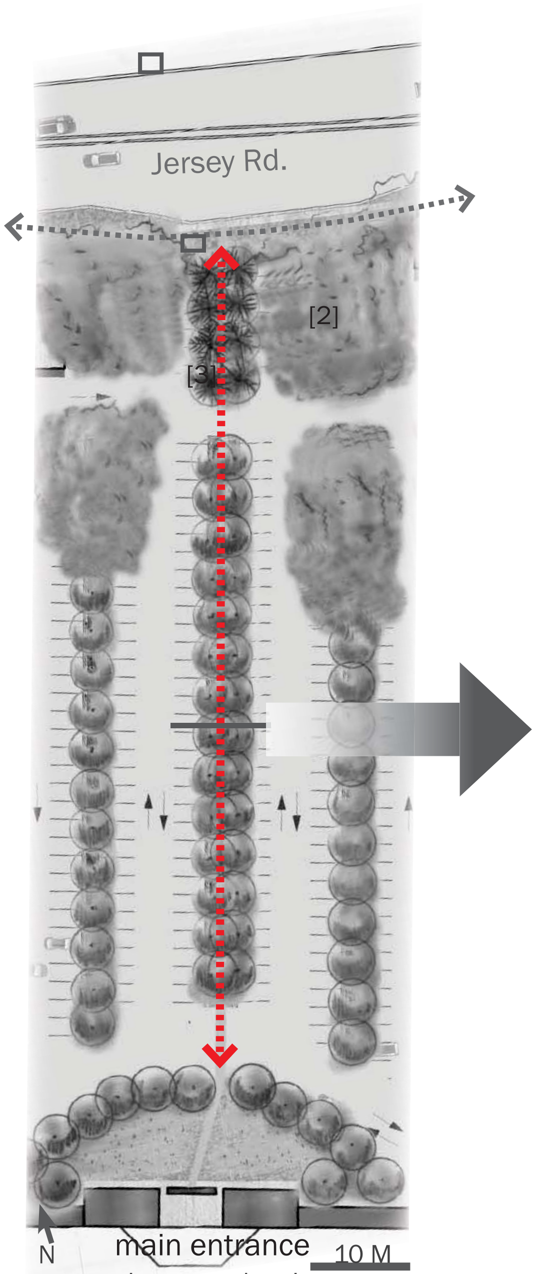


Figure 56. Site Plan - existing and proposed circulation.

Figure 57. Site Plan showing bioswale system + flow within the parking lot.

Figure 58. Pedestrian entrance into the site (allée).

Figure 59. View within the parking lot.



perimeter pedestrian walkway
[allée]proposed main pedestrian walkway
bus stop
[2] eucalyptus open forest
[3] allée of palm trees at the entrance

Figure 60. (a) Site Plan central allée / proposed main shaded walkway.

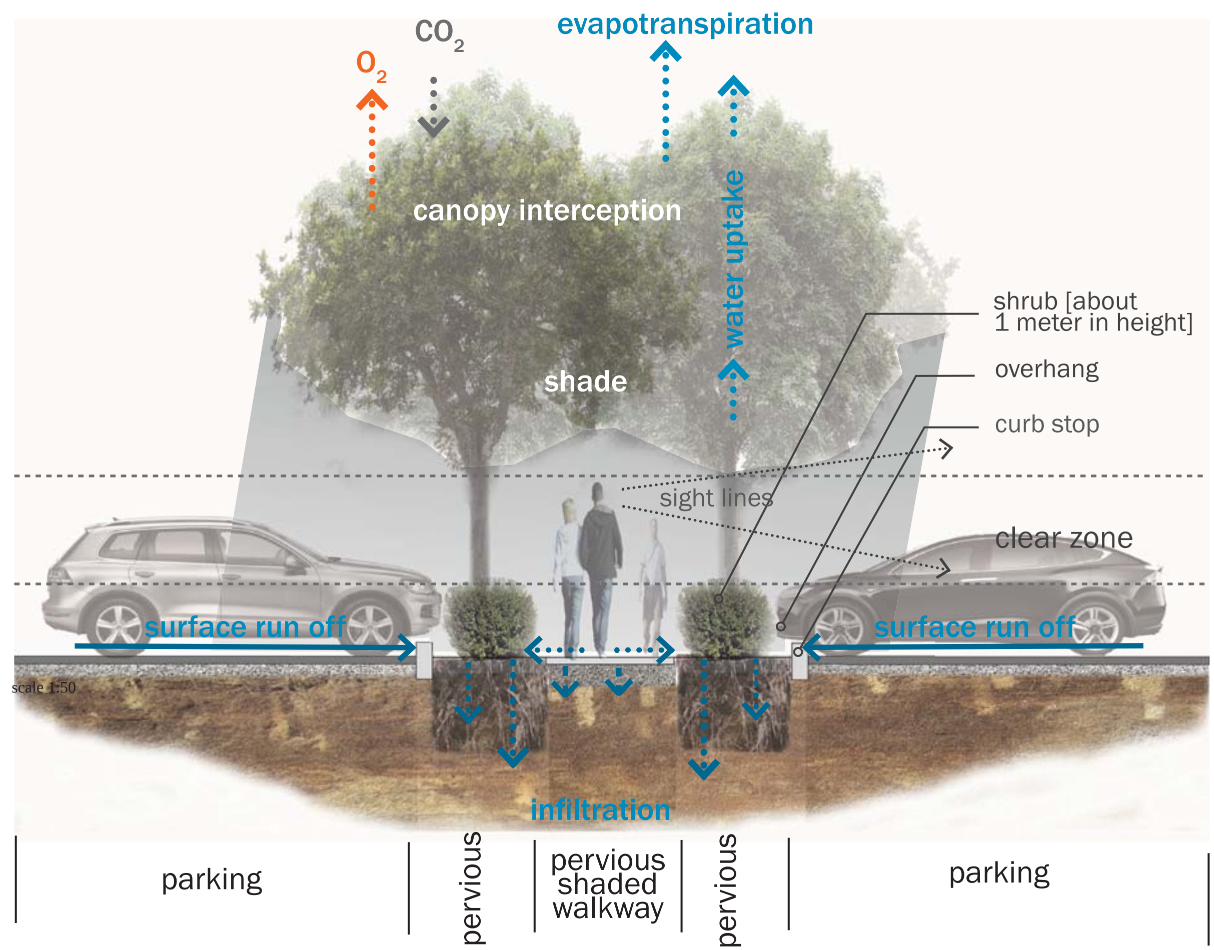


Figure 60. (b) Right - Allée section showing in detail.

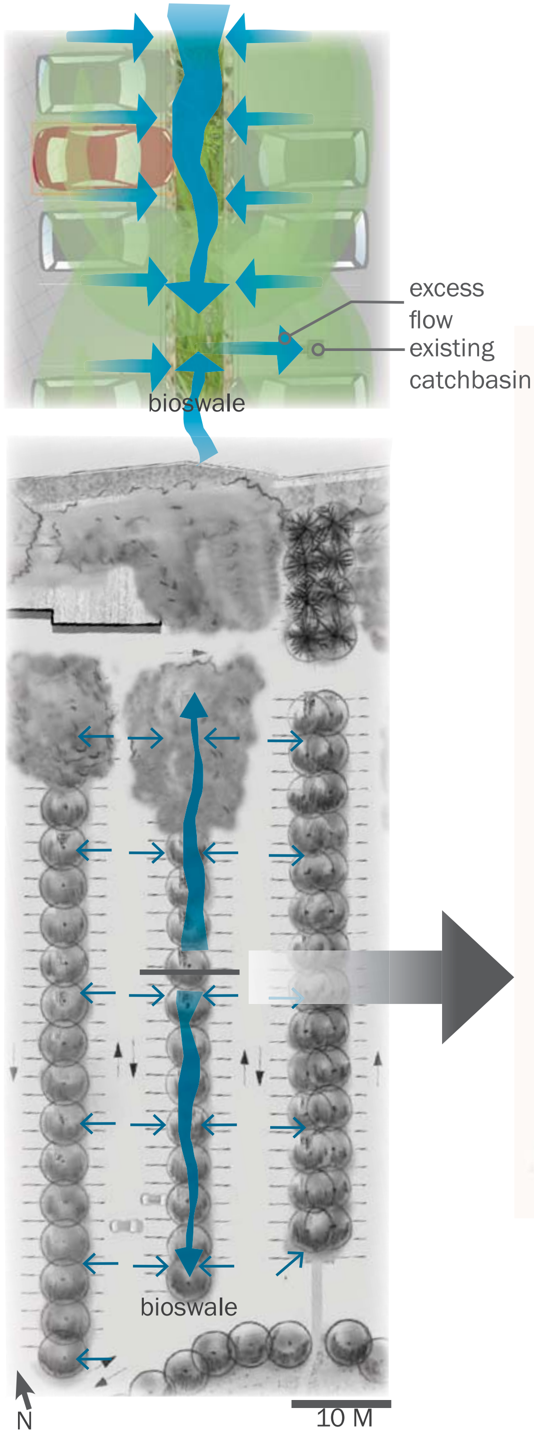


Figure 61. (a) Top - Flow detail
(b) Bioswale system.

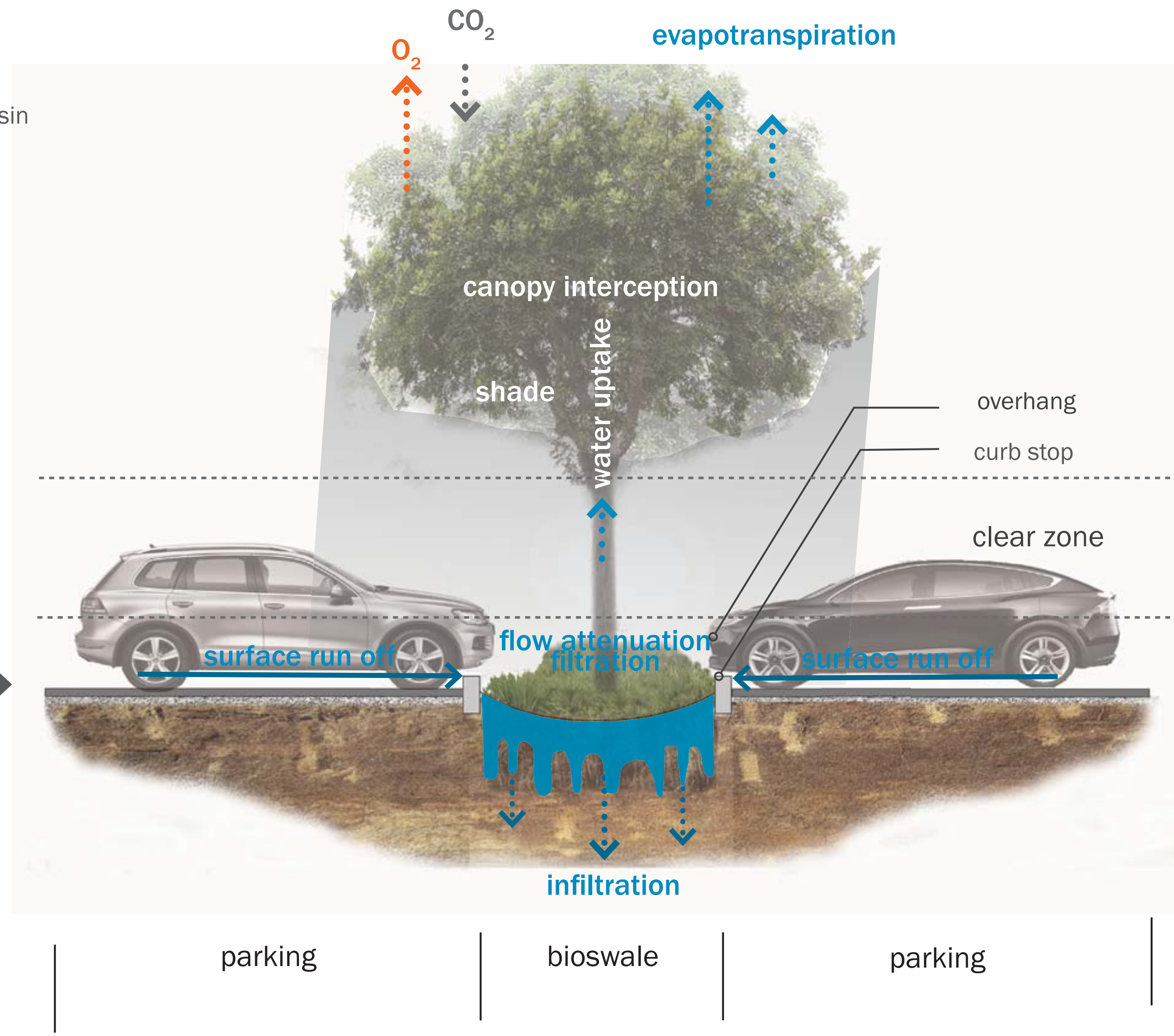


Figure 62. Section through Bioswale.

Biodiversity:

The planting plan was designed to increase habitat and biodiversity and to restore the degraded ecosystem system existing onsite. Different biodiverse levels - from the canopy down to the ground cover layer - creates habitat for many species of organisms. Diverse varieties of woody and herbaceous plants were selected because of their ability to adapt to local conditions and habitat enhancement value.

Transition zone:

The design provides a visual and physical transition zone from the parking lot to the shopping centre. Planting here extends the existing architectural pedestrian canopy and enhances the drop off points and the visual importance of commercial signage on the building. Shade trees with low understory perennials occupy contiguous pervious strips throughout the parking lot to break the large expanse of the parking lot. The understory perennials supplement the trees to enhance biodiversity and habitat, promote evaporative cooling and improve air and water quality. This overall scheme of planting creates a comfortable transition from the shaded parking lot to the building (Figure 64).

To experience this new way of shopping and to achieve a long-term gain of higher ecological performance, the entire parking site was reconfigured to accommodate bioswales, shaded pedestrian walkways and increased vegetative/pervious areas. However with these modifications, the site did compromise with only a minimum loss of 5% of total parking stalls.

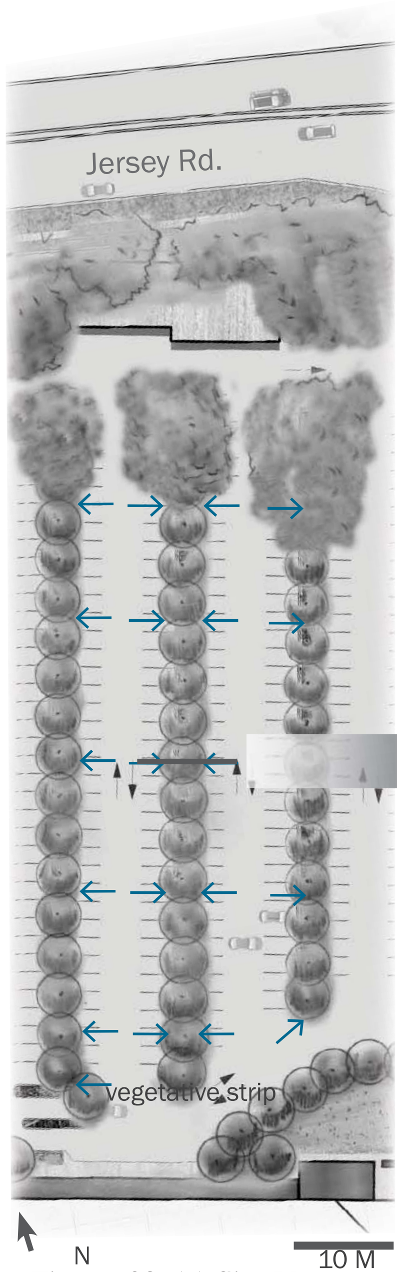


Figure 63. (a) Site Plan - vegetative strip between parking rows.

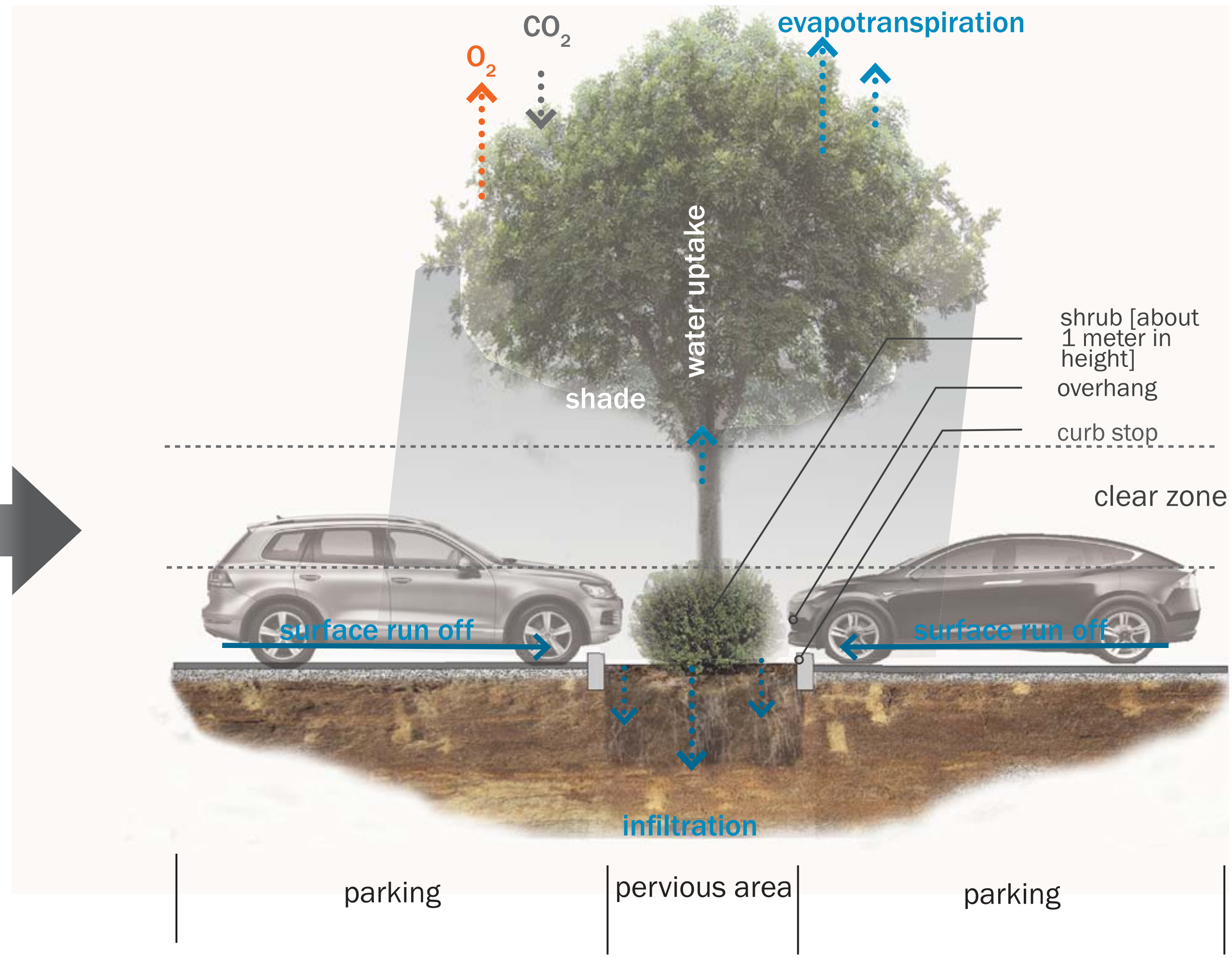


Figure. 61 (b) Section through vegetative strip between parking rows.

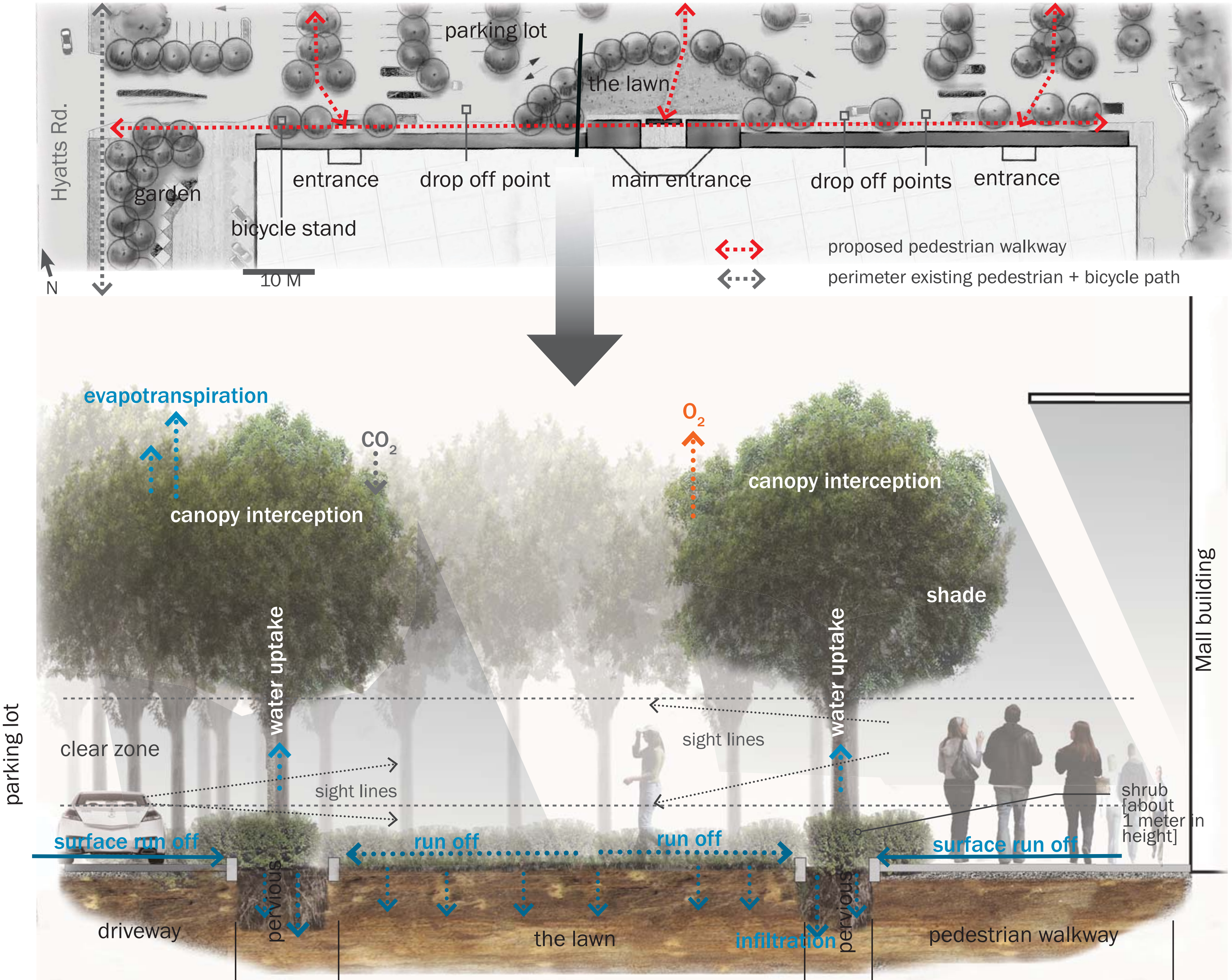


Figure 64. Top- Site Plan, Bottom Section - through proposed pedestrian walkway + transition from parking lot to building entrances.

The proposed layout of the parking lot also provides smooth and safe vehicle access and circulation. Clearly defined street access, driveways and internal vehicle routes allow the driver to enter and move through the open forest parking lot and park the car under shaded cover. The shade provided by open forest can keep the automobiles cooler and thus decrease the unpleasantness of overheated parked vehicles. The parking lot's unique open forest experience of a comfortable modified microclimate and shaded pedestrian circulation system then provides the user a pleasant walk from the auto to the building and back again specifically during the hottest part of the year.

Garden:

A garden on the west side of the mall entrance adjacent to the greenhouse (Figure 65,66)provides a place to relax, socialize. It provides interpretation of the parking lot's ecosystem services and also displays the plants that are for sale in the greenhouse. The garden design is an abstraction of the existing pattern of the parking lot. The lines establishing the parking layout rotated at an angle of 45° and fragmented into blocks filled with trees and perennials. This allows the planting to be visually dynamic and to create a structure for ecological interpretation. The vegetation consists of medium-sized shade trees with designed seating and blocks of perennial shrubs and diverse ground covers, each selected to provide both a pleasant experience and educational component. The extension of the linear arrangement of vegetation along the northside connects the garden spatially with the main building entries and the parking lot through this transition zone. The uniform use of pavers serves to connect the garden with the western entrance.

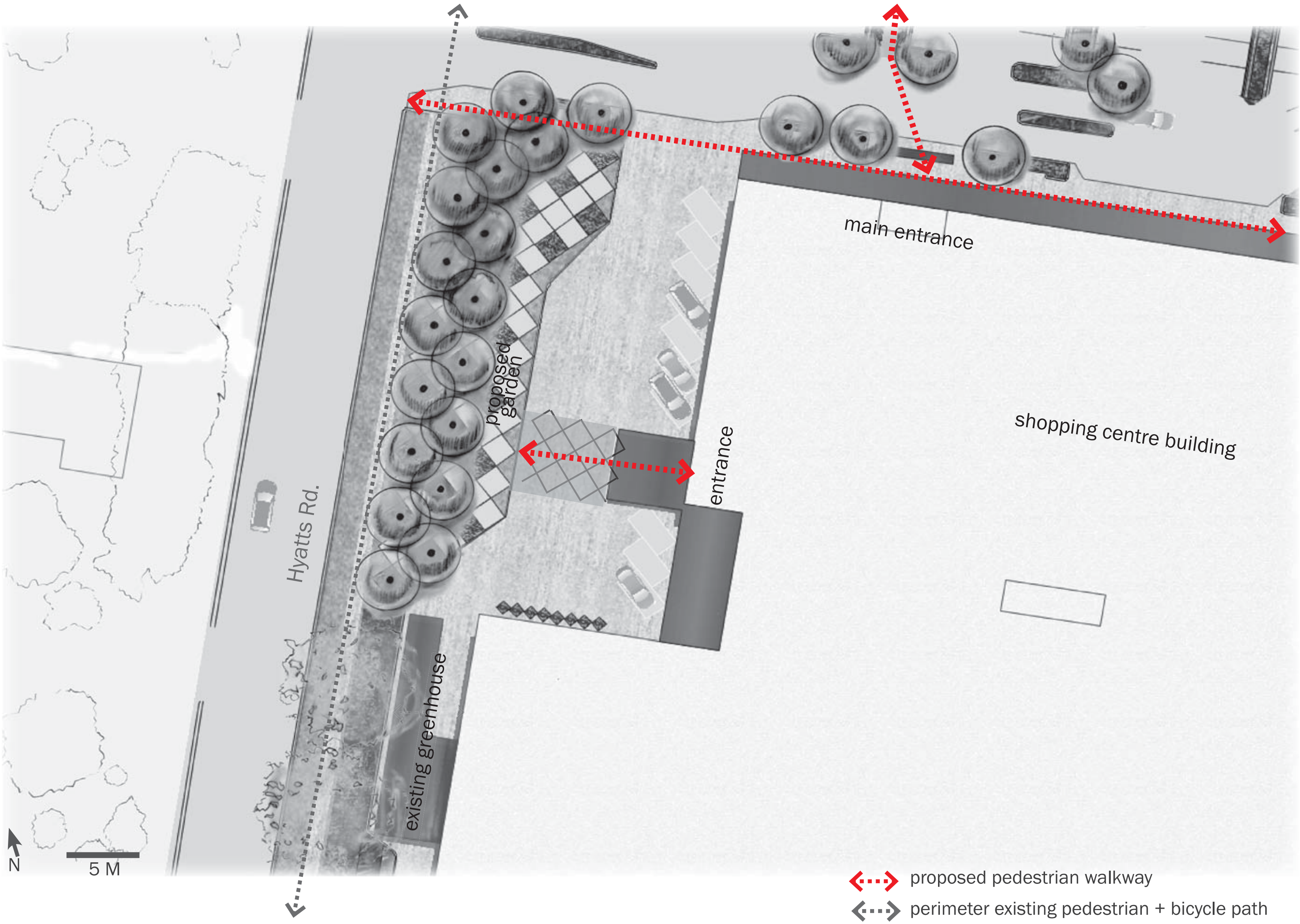


Figure 65. Site Plan - proposed garden adjacent to the existing green house.

Figure 66. Perspective of garden area.

Ecosystem services analysis:

The redesign is an attempt to combine multiple ecosystem services to enhance ecosystem service functions on the site. Shade, evaporative cooling, biodiversity, air quality, water filtration and ground water infiltration are all positively affected.

Shade:

The redesign reduces the area of solar reflective hardscape surface by using solar absorptive vegetative stratas of various vegetation types (trees with understory, shrubs, mixed perennials and groundcover). Closely planted canopy trees species will provide 100% shade cover in the summer for parked cars within 30 years (Figure 67). Furthermore, the design creates shaded corridors through the parking lot for comfortable pedestrian movement. The shaded pavement design strategy will help reduce potential urban heat island impacts at the site.

Evaporative cooling:

In addition to providing shade, the design offers an increase in evapotranspiration rates as a result of an increase in vegetative biomass. This increase as a result of the layered strata of vegetation and the increase of the pervious area by 5,300 m^2 . This should have direct correlation with the cooling of the surrounding environment and ambient air temperature.

Air quality:

The increased vegetative area is also directly proportional to an expected improvement in air quality. The design open forest concludes approximately 400 tree species supplemented with understory shrubs and perennials. This will result in improved air quality performance through plant physiological functions of photosynthesis, water uptake and air filtering. Carbon capture and other pollutants capture will also be higher as the trees increase in size and age.

Biodiversity:

The redesign offers a significant increase in the number of different species of trees, shrubs and ground covers. The design creates an open forest with different stratas of vegetation will significantly increase the quantity and quality of food, cover and habitats for different species of organisms. The 5,300 m^2 permeable pavement enhances habitat quality, both on the surface and in the soil. The design strives to provide as much connectivity between planted areas as a parking lot will allow in order to enable animal movement.

Stormwater management:

The proposed series of bioswales throughout the parking lot have a combined surface area of 719m^2. They will minimize the overall reliance on the existing storm sewer system and capture, cool and treat contaminated runoff from asphalt surfaces, close to the source. They will enable existing stormwater infrastructure to better handle peak flow of large storm events maximizing the filtering capacity of the stormwater system within the tight spatial context of the parking lot.

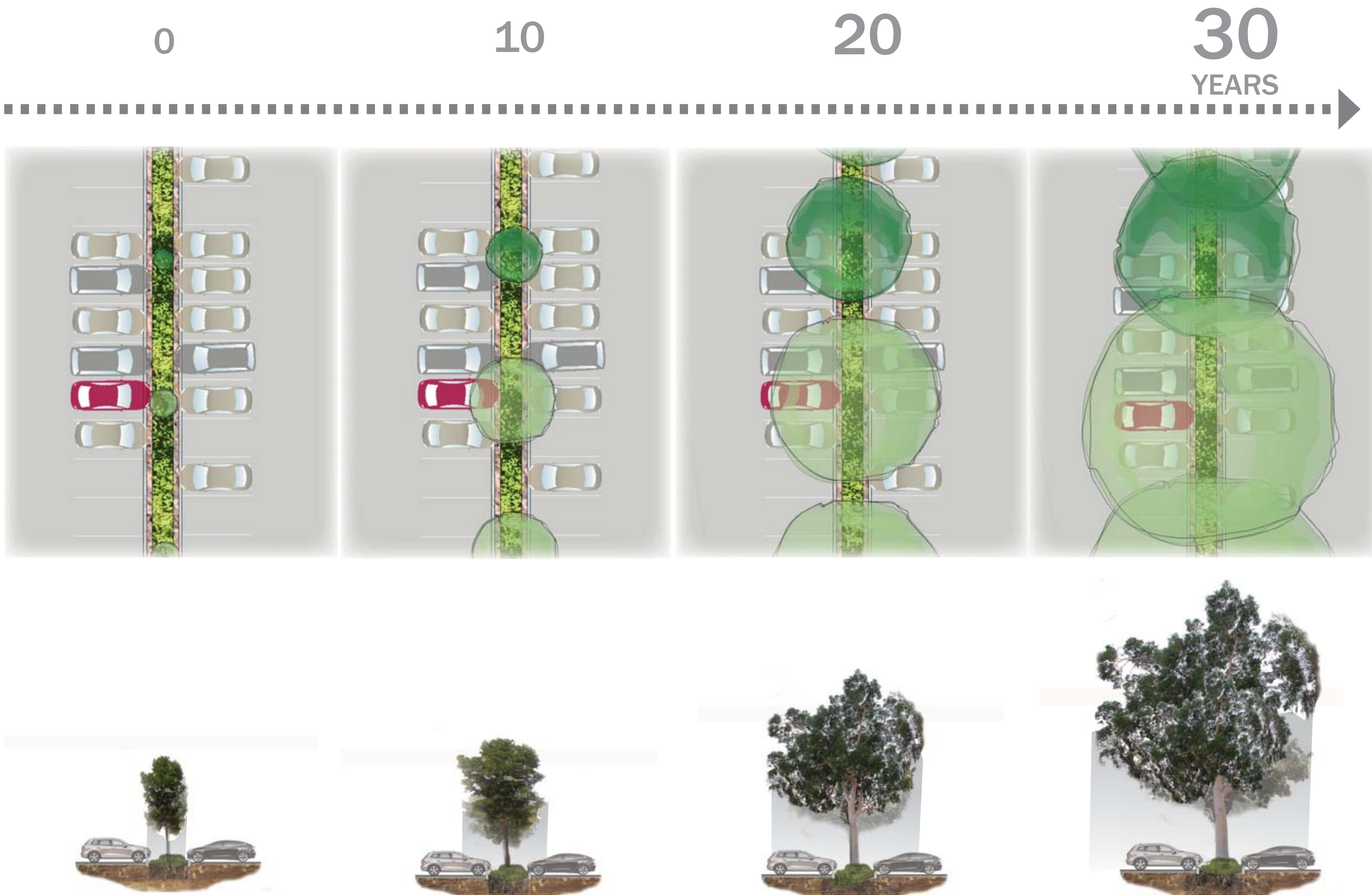


Figure 67. Temporal process over the years; maturity of trees and size of canopy at different levels based on best growing condition assumptions. (Increase in size of canopy is directly related to the increase in % shade and evapotranspirative cooling and better air quality).

Conclusion:

Although the reconfiguration of the parking lot would result in a loss of number of parking stalls, this design demonstrates how ecosystem thinking and a quality commercial environment can work together to support both business and the environment.

Parking lots, if conscientiously designed with a focus on priority ecosystem issues, can contribute to a healthy community in a similar way to parks, gardens, eco-boulevards and greenways. The redesign proposal for the Plumpton Market Place parking lot in Sydney is an attempt to achieve the objectives of reducing carbon emissions, stormwater runoff, improving air/water temperature and quality, and enhancing human comfort and delight within a commercial business context. This design creates shade for comfortable pedestrian movement, a system of drainage, and a level of biodiversity that supports the region while enhancing the commercial experience of the shoppers.

In both a northern and a southern climate, the proposed design decisions were very similar with the exception of vegetation type, seasonal hydrology and different soil conditions. The main difference was the temporality of the northern climate with its frozen period, snow storage and accumulation and high water flows in the spring. This design exploration reflected upon these differences while applying similar landscape design concepts.

An overall shift in thinking is required to consider the parking lot as a pleasant pedestrian environment. With enhanced ecological performance, parking lots can serve as civic assets rather than environmental liabilities.

REFERENCES

Australian Government Bureau of Meteorology. (2013). Retrieved March 20, 2013 from http://www.bom.gov.au/index.shtml?ref=hdr

Ben-Joseph, E. (2012). Rethinking a lot: the design and culture of parking. MIT press.

Brown, C. and Grant, M.(2005). Biodiversity and Human Health: What Role for Nature in Healthy Urban Planning Built Environment, 31(4), 326-338.

Bushland Flora- Australian native plant nursery. (2013). Retrieved June 10, 2013 from http://bushlandflora.com.au/

Calkins, M. (2012). The sustainable sites handbook : a complete guide to the principles, strategies, and practices for sustainable landscapes. Hoboken, N.J. : John Wiley & Sons.

Dia Art Foundation. (2012). Introduction. Retrieved June 15, 2013 from http://www.diaart.org/exhibitions/introduction/84

Donovan. G., Butry, D., Michael, Y., ScD,Prestemon, J. and Liebhold, A. (2013). The Relationship Between Trees and Human Health. (Am J Prev Med 2013;44(2):139 –145). Retrieved June 10, 2013 from http://www.ajpmonline.org/webfiles/images/journals/amepre/AMEPRE_3662-stamped_Jan_8.pdf

Environment Canada. Retrieved September 12, 2013 from http://climate.weather.gc.ca/

Environment & Heritage, New South Wales Government. (2013). Retrieved March 20, 2013 from http://www.environment.nsw.gov.au/

Government of Alberta. (2011). Ecosystem Services Approach Pilot on Wetlands. Retrieved June 10, 2013 from http://environment.gov.ab.ca/info/library/8493.pdf

Government of New South Wales, Environment & Heritage. (2013). Retrieved June 18, 2013 from

http://www.environment.nsw.gov.au/surveys/CumberlandPlainVegetationMappingProject.htm

Landcom street tree design guidelines. (2008). Retrieved June 18, 2013 from http://landcom.com.au/downloads/uploaded/2008_Street_Tree_Design_Guidelines_50b9_2965.pdf

Mitchells, J.(n.d.). The big Yellow Taxi. Retrieved June 10, 2012 from http://jonimitchell.com/music/song.cfm?id=208

Millennium Ecosystem Assessment.(2005). Living beyond our means: Natural Assets and Human Well-being. Retrieved June 15, 2012 http://www.millenniumassessment.org/documents/document.354.aspx.pdf

National Climate Centre of the Bureau of Meteorology. (2012). Retrieved March 20, 2013 from http://www.bom.gov.au/climate/

Oxford Dictionary. Retrieved June 10, 2013 from http://oxforddictionaries.com/definition/english/park

Rosenberg, Norman J. (1983). Microclimate : the biological environment. Wiley Press.

Sustainable Sites. (2002). Sustainable Tourism Online. Florida Aquarium Parking lot and Queuing Garden. Retrieved June 15, 2013 from http://www.sustainabletourismonline.com/29/publicinfrastructure/sustainable-sites-florida-aquarium-parking-lot-and-queuing-garden

The Sustainable Sites Initiative.(2009b). The Case For Sustainable Landscapes. Retrieved June 10, 2013 from http://www.sustainablesites.org/report/The%20Case%20for%20Sustainable%20Landscapes_2009.pdf

The Sustainable Sites Initiative.(2009 a). The Case For Sustainable Landscapes. Retrieved June 10, 2012 from http://www.sustainablesites.org/report/Guidelines%20and%20Performance%20Benchmarks_2009.pdf

Tree Species Selection, Part B. (2011). City of Sydney. Retrieved June 10, 2013 from http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0017/130238/PartB-TreeSpeciesSelection.pdf

Turnbull, A. (2007). The Lingotto Building. Retrieved June 15, 2013 from

http://googlesightseeing.com/2007/07/the-lingotto-building/

The Urban Heat Island Effect and Western Sydney. (2012) Retrieved March 20, 2013 from http://www.greeningaustralia.org.au

Windhager S., Grederick F., Simmons and Heyman D. (2010). Towards Ecosystem Services as a Basis for Design Landscape Journal 29:2-10

Images:

Figure 1: Drawn by author. Diagram abstracted from Millennium Ecosystem Assessment. (2005) Living beyond our means: Natural Assets and Human Well-being. Retrieved June 15, 2012 from http://www.millenniumassessment.org/documents/document.354.aspx.pdf

Figure 2 & 3: Drawn by author.

Figure 4: Google maps.

Figure 5,6: Ekistic design studio. Copyright permission granted June 19, 2013. Retrieved from http://www.ekisticsdesignstudio.com/site/?p=223

Figure 7: Google maps.

Figure 8-9: The Parking Lot as Public Space. International Urbanism. Retrieved June 19, 2013 from http://www.interculturalurbanism.com/?p=1132

Figure 10: Drawn by author.

Figure 11: Google maps.

Figure 12-14: Retrieved June 19, 2013 from http://www.flickr.com/creativecommons/

Figure 15: Drawn by author.

Figure 16: Drawn by author. Map obtained from Google maps.

Figure 17-18: Taken by author

Figure 19-23: Drawn by author.

Figure 24: Drawn by author.

Figure 25-26: Syed Adnan. Plumpton, NSW, Sydney, Australia. Copyright permission granted November 18, 2013.

Figure 27: Drawn by author. Map obtained from Google maps.

Figure 28-33: Drawn by author. Information obtained from Australian Government Bureau of Meteorology. Retrieved March 20, 2013 from http://www.bom.gov.au/index.shtml?ref=hdr

Figure 34-35: Syed Adnan. Plumpton, NSW, Sydney, Australia. Copyright permission granted November 18, 2013.

Figure 36: Drawn by author. Map obtained from Google maps.

Figure 37: Drawn by author. Information obtained from Blacktown City Council (2013). Retrieved March 20, 2013 from http://maps.blacktown.nsw.gov.au.

Figure 38-40: Drawn by author. Map obtained from Google maps.

Figure 41-48: Syed Adnan. Plumpton, NSW, Sydney, Australia. Copyright permission granted November 18, 2013.

Figure 49-57a): Drawn by author

Figure 55 b): Retrieved June 19, 2013 from http://www.flickr.com/creativecommons/

Figure 56-67: Drawn by author.