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FOOTPRINT limited

Conservation, rehabilitation and recycling

rain garden

GREEN ENGINEERING CREATES

Rainwater harvesting at

A LIVING LABORATORY

University of Pretoria

One of the two permanent ponds in the rainwater harvesting project, in the background, with a portion of vegetated swale in the foreground.

The new Mining Engineering Study Centre at the University of Pretoria (UP) has a roof area of 1 700m² and provision had to be made for stormwater control from this large expanse, which would have put further pressure on the already overloaded stormwater infrastructure on this part of the campus. The site of the Study Centre falls within the Manie van der Schijff Botanical Garden. The university's residential landscape architect, Neal Dunstan, worked together with the curator of the botanical garden, Jason Sampson, to create the initial concept within tight timelines. The functional and aesthetic dimensions were based on the principles of a 'rain garden' serving as a water retention facility for the rainwater harvested from the roof and surrounding hard surfaces. Aside from the water collecting function of the pond system, the water is filtered through vegetated swales on the periphery of the ponds, and circulated through the aquatic and marginal plants in the ponds. The entire pond system with its peripheral landscaping is lined with a synthetic rubber geomembrane lining. The captured water is used for irrigating the botanical garden, while the entire facility – the habitat creation of which is a work in progress – was conceived as a series of ecosystems designed to serve as a 'living laboratory' to enable students to research wetland habitat.

Footprint Limited visited this highly innovative amenity and interviewed Dunstan and Sampson, along with Paul De Luca of Belgro who was responsible for the complex installation of the lining system.

"This is not a true rain garden," explains Dunstan, "as the term universally refers to the planting of vegetation in soil; usually in a manmade depression utilised for the collection and infiltration of stormwater. This system of ponds and landscaping, which envelopes three sides of the Study Centre, is lined and, therefore, although it is planted, the water doesn't infiltrate into the earth. The reason the choice was made to line the project at UP was that it would also serve as essential waterproofing for the underground lecture halls at the Centre, in conjunction with stormwater management. This meant that the traditional rain garden approach could not be fully adopted here."

Plants have their treatment functions but it is whole systems including soil and fauna that have the most effective bioremediation potential. The benefits of a rain garden which

One of the two tidal ponds, in the background, with reflections of plant species. These ponds are designed to be flooded in the wet season and to be partially dry in the winter season. If the decision is made to drop the water level, it will simulate natural seasonal changes and be useful for experimental purposes.

comprise a carefully chosen combination of plants along with soils and mulch, include collecting, retaining and cleansing rainwater that runs off impervious surfaces. The environmental benefits of rain gardens include habitat creation, pollution control, reduced energy use and the creation of microclimates; they are also visually and intellectually stimulating, and promote pride in projects while reducing maintenance requirements.

The landscaped area of the Study Centre is 4 500m² – comprising hard and soft landscaping including the ponds, the new western entrance to the university and the associated sidewalk, but excluding the building footprint. Dunstan comments that the ponds are roughly 1 150m² – including the swales, tidal ponds, permanent ponds and the associated flood zones; while the soft landscaping is about 1 000m² in extent. The building footprint is ± 2 750m², including the work done under the bridge, the new coffee shop and the merchandising shop. The total roof area of the Study Centre is 1 700m². The ponds and landscaping encompass the north, west and south sides of the building and about 150 aquatic and terrestrial plant species, including the cycads, have been planted in and around the system, thus far. The 'rain garden' has transfigured what was previously a degraded space of ± 60 year old roads, leaving behind very poor compacted soil conditions, into an attractive 'living' water retention facility.

Rainwater collection is largely from the roofs of the Study Centre where the system harvests about 17 000ℓ of water for every 10mm of rain that falls on the building's roofs. Water is also collected from pavement and road surfaces, with the adjacent Geology building roof contributing after refurbishment later this year. Dunstan says it is difficult to quantify the amount of water run-off from the paving but he estimates it to be three times that of the roof surfaces. The harvesting system is a hybrid system and can be topped up with borehole water if necessary. The water initially flows into the permanent ponds and then out into the 'tidal ponds'. Excess water flows into a 130m³ underground tank located under the staircase and ramps leading into the Study Centre. This stored water will be used to irrigate the botanical garden. The water circulates through the whole pond system on a continuous basis, and therefore is not so-called 'dead water'. It is also well-known that rainwater is more beneficial to plant growth because plants absorb it more easily. The tidal ponds are designed to be flooded in the wet seasons and to be partially dry in the dry seasons. This is to be achieved by means of a valve system.

The highly durable liner, which has solved both the stormwater and the waterproofing challenges simultaneously, also allows for marginal planting, and the only unlined portion of the soft landscaping is a 2m distance beyond the retaining walls. These walls were clad with concrete slabs recycled from the previous concrete walkways of the area, as it would have been costly to take the material off site. The walls were built by Belgro with gaps and crevices and have created good habitat for reptiles and amphibians, while also serving to hold the liner is place. The soil used in the rain garden was trucked in from another of the UP campuses – 1 000m² of rich clayey loam – that would otherwise have been dumped; while compost was acquired from the university's composting project; and mulch from felled eucalyptus trees was used prolifically.

After the liner had been carefully laid with needle-punched geotextile (Bidim) layers both above and below it and soil on top of the upper geotextile layer, second and third year landscape architectural students planted the aquatics that were placed by Sampson, while Dunstan planted the waterlilies, as an exercise in student and staff community involvement. The rest of the soft landscaping was done by Johann Niehaus and his team from Origin Landscapes.

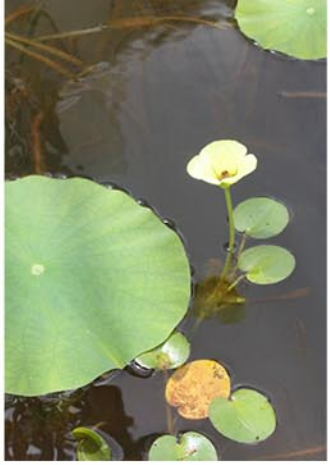
Virtually all the paving around the building is recycled in some way. The original concrete slab paving was retained and reused as permeable paving, as material for the retaining walls of the ponds and as energy breakers for the stormwater entering the system. One of the constituents of the new paving blocks from Bosun comprises waste material from platinum mining operations. All the rock used in the landscape was sourced from excavations on site and from a project in Groenkloof. Hand-carved facebricks from the '70s have been used along the edges to channel stormwater into the vegetated swales and to retain heritage value.

Custom designed pavers by Wilsonstone exhibit carvings of a cycad cone representing the botanical garden and a baobab as the

The exotic *Lobelia cardinalis* in one of the vegetated swales.

One of the varieties of the exotic Elephant Ear, *Colocasia esculenta*.

A magnificent hybrid of the Lotus family 'Mrs Perry D. Slocum'.



The Water Poppy, *Hydrocleys* sp, a non-invasive exotic aquatic species.

recognised symbol of the Plant Sciences Department. Infraset's plantable concrete retaining blocks have been placed in the ponds to provide different depths for the aquatic and marginal plants.

The professional team on the Study Centre project went through an interesting exercise to determine what Green Star rating could be achieved for the project, as part of a pilot study for public and educational buildings. It was established that the landscaping component, which addresses stormwater issues, reuse of a degraded (brownfield) site, water harvesting and conservation, and increase in planted areas, could contribute up to 35% of the points required for a 4 Star rating.

Sampson gives a very interesting account of the bioremediation properties of the plant, *Vallisneria aethiopica,* which is believed to be locally extinct in the wild and which is being grown in one of the tidal ponds at the Study Centre. The plant was donated to the university's rain garden by Ernst van Jaarsveld of Kirstenbosch, who collected it in the Moreleta Spruit some 30 years ago and wished to see it re-introduced to Pretoria. It is fully aquatic and the whole plant is submerged, serving as an absorption agent and water conditioner. It is able to remove pollutants easily because it has a very thin lamina, and the plant has a strong affinity for phosphates...it is a so-called "phosphate sponge". The water in the rain garden ponds is never stagnant and sediments move with the current and settle on the strands of *V. aethiopica*.

The plant also provides an excellent habitat for fish, amphibians and insects. It has a rosette of loose leaves and these do not tangle with each other even though the plant can produce strands of up to 1–2m in length. The plant grows vegetatively by means of stolons. It is presumed that the plant has been choked out of local rivers, pans and dams by invasive plant species and hence no longer occurs locally. Sampson comments that if the decision is made to drop the levels of the tidal ponds at the facility in conjunction with seasonal cycles, *V. aethiopica* will dry out as it does naturally and then reshoot from buried rhizomes when the water levels rise again.

Sampson explains that the plants selected for the rain garden were chosen for three reasons: for ecosystem functioning, aesthetic appeal and educational purposes – teaching along with research. These reasons slot in well with the objectives of botanical gardens worldwide which include scientific and horticultural research, conservation, display, along with providing a recreational and educational facility for the community. The Manie van der Schijff Botanical Garden comprises about 3 000 plant species, both indigenous and exotic, in an area of 3,5ha (including buildings). There is a legal obligation for the parent institution to maintain and develop an internationally recognised botanical garden.

The garden at UP also has an excellent collection of tropical African cycads for horticultural research and safe-keeping. It is reputed to be one of the best collections in

Lining the pond system

Dunstan said the original intention was to line the pond system with plastic but that this had been rejected because of the likelihood of damage to the liner with garden tools. The decision was made to line the entire pond system with an EPDM synthetic rubber geomembrane liner. The choice of the Firestone product was made because of its durability and flexibility.

Paul De Luca of Belgro, the distributor of Firestone Lining Systems, undertook the installation at the Study Centre with Gift Mahachi, the Company's technical representative. The installation was particularly challenging due to the combination of geometric and organic shapes. This necessitated a hybrid installation that involved loose placement of the membrane over the organic shapes and full adherence to the geometric shapes and vertical walls. The very nature of the rain garden added some complications during construction, because of the large quantity of water deposited from the roof into the work area even after the slightest shower.

De Luca commented that the EPDM liner was chosen due to its exceptional durability and UV resistance, proven in the field, with project references of over 40 years lifespan; where the liner was still in use and still in its original chemical state. Of particular advantage to this unique site was the property of the EPDM liner which allows 300% stretch enabling it to tolerate ground movement that other materials would not accommodate. From an aesthetic point of view, the flexible nature of the material enables the designer to incorporate both organic and geometric shapes with no compromise to the integrity of the lining system.

The liner is cheaper and more reliable than a concrete liner and damage which did, in fact, occur due to the overlapping of different contracts on the site, resulting in showers of pop rivets, knife blades and shards of aluminum sheeting landing on the liner, was a constant problem. De Luca added that this damage was, however, quick and easy to repair with no compromise at all to the integrity of the membrane.

The project, considered to be an exemplary one, is to be used in Firestone's training manual illustrating a combination of 'loose laid' over organic forms and 'fully adhered to' geometric forms. The way it is structured means the liner also serves as waterproofing for the building.

The rainwater that comes off the Study Centre roof is collected in box gutters. These gutters have slots to allow the water to enter the ponds with less force. Dunstan says when it rains there is a 'dancing effect' on the water from the slots and the sound is musical.

the world of the *Encephalartos* genus (with only one species missing), from places such as south Sudan, the banks of Lake Victoria, the DRC, Uganda and the Chimanimani Mountains in Zimbabwe. A representative sample of these cycads has been moved from UP's experimental farm to the outer areas of the rain garden, which is suitable because the microhabitat alongside the vegetated swales is warm and humid.

Plants such as the exotic *Lobelia cardinalis* (Cardinal Flower) is one of many used in the BSc Hons practical to identify and ascertain more about plant families. It also produces particularly attractive flowers. The indigenous marginal plant, *Gunnera perpensa* (River Pumpkin), is important because of its medicinal properties and the students use it for experimental purposes to extend the work already done on this plant. The aquatic *Nelumbo nucifera* hybrid 'Mrs Perry D Slocum' of the Lotus family was chosen largely for the exquisite beauty of its semi-double flower, deep pink, aging to creamy yellow; and its horticultural achievement – it is a hybrid between the North American Yellow Lotus (*Nelumbo lutea*) and the Red Caspian Sea Lotus (*N.nuciferassp caspica*). *Dichromena colorata* (Star Rush or White-topped Sedge) was also selected for aesthetic reasons. *Vallisneria aethiopica* and the exotic *Typha minima* (Dwarf Bulrush) were selected for their ecosystem functions – bioremediation capabilities and habitat creation. The varieties of the exotic *Colocasia* (*Alocasia*) *esculenta* are of great interest as this is a tropical Asian food plant, which produces taro that serves as a staple food in Polynesia and other areas of the Pacific. *Marsilea schelpiana* – the Cut-leaved Clover – is an indigenous water fern which produces spores around its roots; and Sampson explains its ecosystem value in that it shades the water preventing algal growth.

Sampson comments that Dunstan provided the canvass for the rain garden, ensuring appropriate depths and habitats that would accommodate the plants that he selected; while De Luca advised on the design of the pond system and this influenced the planting design. The teamwork was responsible for the favourable end result.

The shape of the roofs of the Study Centre are such that every drop of water goes into the rainwater collection system.

Project team

Client: University of Pretoria
Funders: Exxaro, Anglo American Chairman's Fund and UP
Architects: ARC Architects
Quantity surveyor: Pentad
Civil and structural engineers: Aurecon Group
Electrical engineer: Claasen Auret
Mechanical engineer: Spoormaker & Vennote
Landscape architect (resident): Neal Dunstan
Curator of Botanical Garden: Jason Sampson
Building contractor: Robenco Construction
Pond system lining contractor: Belgro
Soft landscaping contractor: Origin Landscapes

Neal Dunstan

***Nymphaea lotus* (White Waterlily or Sacred Lotus) is indigenous to lakes, ponds and dams in KZN and up through tropical Africa.**

***Vallisneria aethiopica* with its submerged fronds and *Nymphoides thunbergiana* (Small Yellow Waterlily) are both indigenous to Gauteng.**

The indigenous Cut-leaved Clover, *Marsilea schelpiana*, shades the water, preventing algal growth.

***Cyperus papyrus*, (Papyrus) – the largest sedge in Africa – is indigenous to coastal marshes north of KZN.**

"Neal was responsible for the aesthetic elements; I selected the ecosystems – a different set of plants for each pond; while Paul linked the two together with his practical knowledge," maintains Sampson.

Students in landscape architecture and plant science are already making use of the rain garden, while one of the intentions of the zoology students is to help create habitat appropriate for reed frogs. The Raucous Toad has been seen on the periphery of the tidal ponds, along with sightings of the Red-backed Toad and Common River Frog. Several species of Tilapia along with Southern-mouth Brooders and River Sardines have been released in the ponds. Sampson and Dunstan comment that this is a work in progress and with time they, along with the students, have realised how much potential the new project holds.

Dunstan comments that the rain garden's experimental function is part of the role that is being pioneered internationally in converting university grounds into living laboratories... the 2025 vision of the university is one of progress. This structure is distinctive in that the landscape and building are merged, as a single entity, with the ponds as examples of green engineering right on the doorstep of a building which accommodates engineering students.

"The rainwater harvesting is part of the structure of the building. The only technology used for the rain garden is the pumps: one of which is used to circulate and aerate the water in the system and a second pump connects to the irrigation system for the botanical garden. Once fully stabilised, the pumps will not need to run on a 24 hour basis...and they are borehole pumps with low energy usage. A full weather station will be installed at the Study Centre with sensors to determine soil moisture, leaf wetness and evapotranspiration rates... this data will be used for calculating irrigation schedules....and to facilitate research work," concludes Dunstan.

Article and photographs (except where otherwise acknowledged) by Carol Knoll

Retaining walls clad with recycled paving from previous walkways – the gaps inbetween provide habitat for reptiles and amphibians.

Grooved clay bricks that were previously used as wall cladding have been retained and used as edging for funneling stormwater into the planted landscape.

The cycad cone (top) symbol of the botanical garden and the Baobab (above) which is representative of the Plant Sciences Department.