



Managing Water Quality in **Gardens by the Bay**

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The Gardens by the Bay occupies 101 hectares of prime land by the water at Marina Bay. At the heart of Singapore's next phase of development as a global city, Gardens by the Bay is an integral part of Singapore's "City in a Garden" vision, in which the island-state is woven into a floral tapestry and infrastructural development is nestled within a green oasis. Under this plan, Gardens by the Bay will capture the essence of Singapore as the premier tropical City in a Garden with a quality environment to live, work, and play in.

Comprising three gardens interconnected across waterways around Marina Bay, Gardens by the Bay will have links to several urban nodes, offering a variety of activities, recreational opportunities, and entertainment options in a garden setting. Each of the three gardens will have its own distinctive design and character.

Bay South Garden is one of the three waterfront gardens that make up Gardens by the Bay. Located in the heart of Singapore's new downtown and with an area of 54 hectares, it incorporates: two cooled conservatories covering around two hectares; Supertrees, which are 25-to-50-metres-tall steel structures clad in vertical green and floral displays; a series of horticultural themed gardens; and a lake system. The lake system is about five hectares in surface area and two kilometres in length, and circulates around the eastern, southern, and western boundaries of Bay South. Given the integration of the lake to the adjacent Marina Reservoir, maintaining water quality is a critical consideration in the design of the lake system.

Bay South Garden Lake System

The Bay South Garden lake system comprises the Kingfisher Lake and Dragonfly Lake, and encircles the perimeter of the garden. The lakes are not only landscape features but also provide a waterfront view for developments alongside the garden. They form part of the water catchment in Bay South and are integral to the garden's water-sensitive landscape design.

Water catchment

With Bay South occupying the entire foreshore of the Marina Reservoir, a concerted effort was made to direct all rainwater within the garden to the lake system. This is achieved by a network of drains that also collects rainwater from the roofs of the various buildings within the garden.

The lake system is further integrated with the Marina Reservoir. Water is pumped from the reservoir into the Kingfisher Lake to ensure water is circulated to the Dragonfly Lake. When the water in Dragonfly Lake rises after rain, it overflows into the reservoir.

Water from the lakes is also used for irrigation within the garden. This keeps the water level within the lakes constant for aesthetic amenity and minimises the onset of alga bloom. To maintain the level of dissolved oxygen, aeration systems were installed in the lakes.

Water-sensitive landscape design

Aquatic planting was incorporated into the design of the lake system for the purpose of water filtration and treatment. The planting is contained in filter beds (a series of cascading bioretention systems) and reed beds (bioretention systems along the edge of the lakes) to treat runoff from the garden's catchment. This helps to reduce the levels of suspended solids, nitrogen, and phosphorous in the runoff before it enters the lakes. To further treat the water, floating islands with aquatic planting were created within the lakes. By incorporating the islands and configuring the lake with a high length-to-width ratio, maximal contact between the water and aquatic planting is maintained. Additionally, two marginal wetlands were incorporated at each end of the lake system, one in the form of a bog garden and the other in the form of a freshwater wetland. In particular, the freshwater wetland serves as a pre-treatment system for water taken in from the Marina Reservoir.

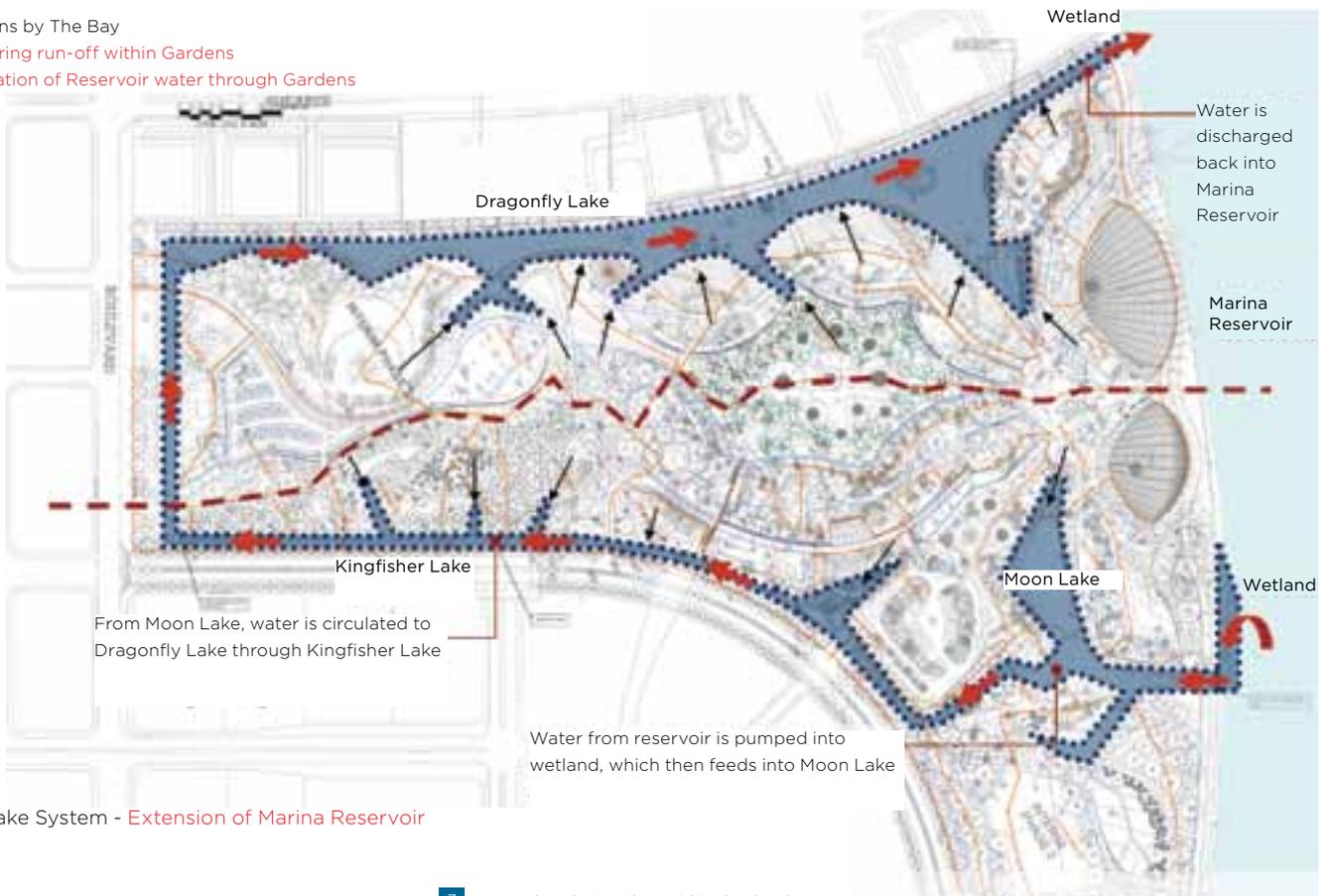
Water-sensitive modelling applied to the design of the lake system showed that the aquatic planting effectively reduced the levels of suspended solids, nitrogen, and phosphorous by, on average, 85 percent, 45 percent, and 65 percent respectively.

The planted islands, filter beds, reed beds, and wetlands within the lake system provide refugia for urban wildlife, especially birds and dragonflies.

Gardens by The Bay

Capturing run-off within Gardens

Circulation of Reservoir water through Gardens



GB Lake System - Extension of Marina Reservoir



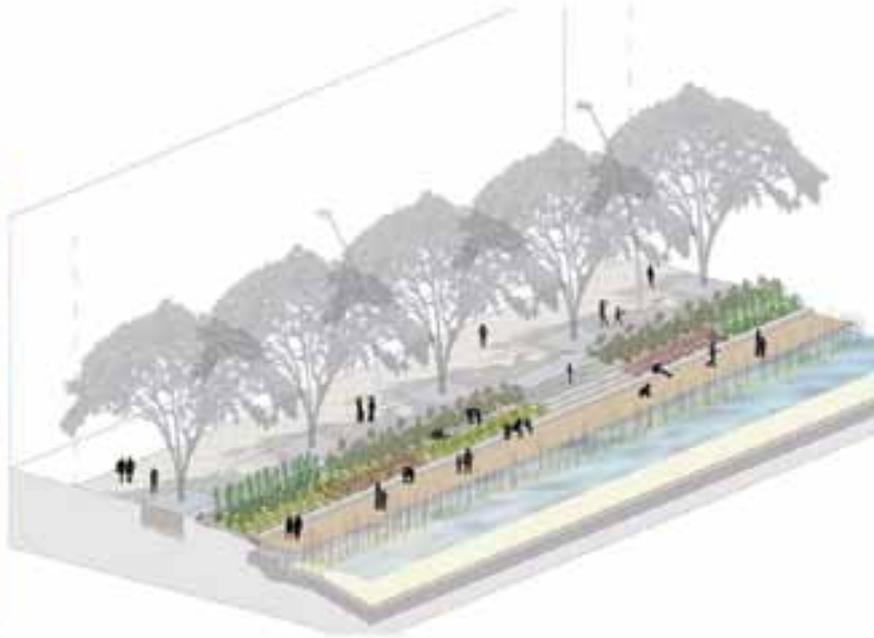
Along the boardwalk is a series of aquatic gardens that will showcase the diversity and forms of aquatic plants in the tropics.



4. View of Dragonfly Lake.



Floating islands

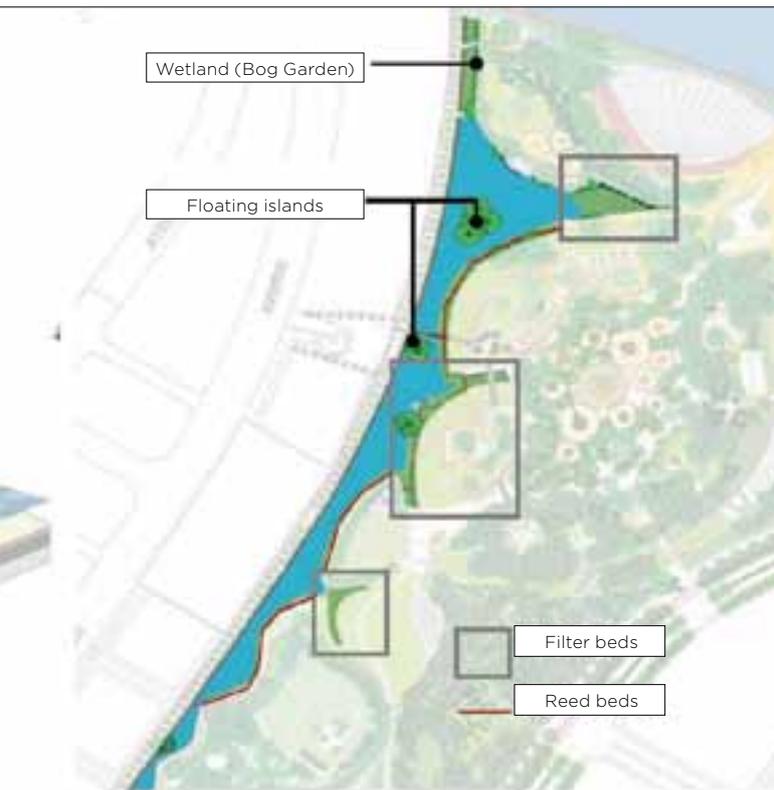


Reed beds integrated with waterfront promenade

Island type A



Section showing reed beds



Dragonfly Lake



Access to the Lake System

Other than its hydrological and ecological functions, the lake system presents opportunities to educate and create awareness of the importance of clean water and the value of aquatic plants as natural filters.

To facilitate this, a two-kilometre-long boardwalk around the Dragonfly Lake was constructed to bring people closer to the water, along which will showcase the diversity and forms of aquatic plants found in the tropics.

In addition, surrounding the edge of the Dragonfly Lake is a series of interpretative media to illustrate the water cycle and highlight the key features of the lake system. Storyboards with enhanced features support multimedia interpretation on smartphones and tablets, while viewing devices with augmented reality features allow visitors to visualise the ecology found around and below the lake's surface.

The digital interpretations were made possible through a sponsorship of two million dollars from ExxonMobil. This sponsorship also includes the development of educational materials and guidebooks to support the Gardens' school outreach programmes and guided tours.

Conclusion

Bay South Garden's lake system, integrated with the adjacent Marina Reservoir, emerges a key feature of Bay South Garden. In designing the lake system, consideration was given from the onset to ensure that the lakes cater to the garden's water catchment and that a set of water-sensitive landscape design strategies was incorporated to maintain water quality. To further enhance accessibility to the lakes, a boardwalk was constructed to draw people closer to the water and to bring out the key features of the lake system via interpretative media. 