

CASE STUDY

Building an Offshore Nature Haven on Trash



Landfills are associated with toxic environments, yet the offshore landfill in Singapore has thriving marine life that people come to explore during low tides. Photo credit: Ria Tan.

Singapore built an offshore landfill on Pulau Semakau primarily for waste management, but it also ensured that marine life would thrive and it could serve as a public park.

Overview

As a fast-growing island city-state, Singapore has little space on its mainland for the rubbish its residents generate. Its innovative solution was to build one of the world's earliest and cleanest offshore landfills—an island that today harbours flourishing ecosystems from mangroves to coral reefs.

This case study was adapted from Urban Solutions of the Centre for Liveable Cities in Singapore.

Challenges

In 1992, one of Singapore's last two landfill sites, a dumping ground at Lim Chu Kang in the north western region of the mainland, reached its maximum capacity and was closed. The other landfill, a 234-hectare site at Lorong Halus in the northeast, was expected to fill up by 1999.

Singapore, like any small country or city with a burgeoning economy, faced a trash problem. As it grew, it generated increasing amounts of waste. In 1970, about 1,300 tonnes of solid waste was disposed of each day; by 1992, this had ballooned to about 6,000 tonnes a day. This was despite the fact that Singapore had been incinerating its trash since the late 1970s to generate energy and minimise the land required for dumps. At the same time, more and more land was urgently needed for other uses such as housing and industry. In fact, planners had already approved a new landfill site in the northern farming area of Punggol, and government agencies had begun to engage local farmers to acquire their land, when the area was abruptly earmarked for housing instead.

So Singapore had to find alternatives, and quickly. An offshore landfill was one possibility. The island-state already had expertise in land reclamation, which it had carried out along its coastlines since the 1960s. But in order to deposit incinerated waste offshore, it would need to ensure that pollutants would not leach into the surrounding seawater. The government was also aware that converting islands into landfills encroached on precious natural space. It therefore aimed to find a solution that would not only fulfil the need for a landfill, but also preserve the natural environment and enable the space to be open for public recreation.

Solutions

After the conclusion of feasibility studies, the government approved a proposal to construct an offshore landfill in 1994, making it one of the world's earliest. This would involve enclosing the sea space between two islands south of mainland Singapore, Pulau Semakau to the west and Pulau Sakeng to the east. The 350-hectare landfill would take in the sludge and ash left over from incineration, as well as waste that could not be burned. Work began in 1995.

To contain pollution and protect nature, engineers, academics and contractors had to work together to come up with innovative solutions in the design, building and operation of the landfill.

A seven-kilometre perimeter bund was built to enclose part of the sea between the islands to create the space required for the landfill. The bund was lined with impermeable membrane, marine clay and rock layers to keep leachate in and the surrounding waters free of pollution. Any leachate generated would be treated at a plant on site.

The landfill's original design kept a narrow channel between Pulau Semakau and Pulau Sakeng, but experts determined that the channel's hydrodynamics meant all the mangroves on the eastern side of Pulau Semakau would not survive the resulting tidal changes. So engineers constructed the perimeter bund, and replanted 13.6 hectares of mangroves to replace those that had been removed to build it. The replanted mangroves would serve as biological indicators of leaking waste.

The replanting was an effort on an unprecedented scale. But that effort was nearly scuppered after an oil spill in 1997 released 28,000 tons of oil into the surrounding waters. The team of engineers, experts and contractors considered various options, including washing each leaf with detergent. In the end, they decided to let nature take its course—and more plants survived than expected.

During construction, screens were also installed to avoid smothering nearby seagrass and corals with silt. And after a study trip to the world's largest landfill, Fresh Kills Landfill in New York, it was decided that waste should be transported in an enclosed system to minimise dust and windblown waste.

At first, a container system was considered, but it would have cost too much. The project team eventually designed a 3,000-tonne covered barge—a method that was more costly upfront but cleaner and more efficient in the long run. The incineration ash and non-incinerable waste from the barge are unloaded in an enclosed building, then dump trucks transport the refuse out to be discharged and compacted in landfill cells pumped free of seawater. When filled, the cells are covered with a layer of earth, allowing grass and trees to take root naturally over time.

Phase I of the landfill began operations on 1 April 1999, enabling the last mainland landfill at Lorong Halus to be closed after it was filled. On 11 July 2015, Phase II was completed, comprising a single, 157-hectare landfill cell into which ash is directly discharged. Corals from the development site were transferred to a marine park at Sisters' Islands, while fish there were released into the open sea.

Results

Today, more than 2,400 tonnes of incineration ash and non-incinerable waste are transported on barges to Pulau Semakau each night.

Besides being a clean and odour-free landfill, Pulau Semakau also harbours flourishing natural ecosystems like mangroves, seagrass meadows and coral reefs, as well as rich biodiversity ranging from sea stars to herons. Knobbly Sea Stars—large, colourful sea stars once common to Singapore waters but decimated by habitat loss and the aquarium trade—are now a common sight again in Pulau Semakau. Meanwhile, the National Parks Board has reintroduced fireflies, seldom seen on the mainland, to Pulau Semakau's wetlands.

Since 2005, Pulau Semakau has been open to the public for recreational activities such as guided nature walks, sport fishing tours and stargazing. It is also a test-bed for innovations, such as a floating wastewater treatment plant and renewable energy solutions like a micro-grid that integrates multiple energy sources.

The landfill has received international acclaim. In a 2007 story for *New Scientist* magazine, journalist Eric Bland even dubbed it the "Garbage of Eden".

At current waste disposal rates, Pulau Semakau is expected to last at least till 2035. But Singapore is not resting on its laurels. Instead, the government urges people to reduce and recycle, to extend the landfill's capacity as far as possible into the future.

Resources

Grace Chua. (2016). Pulau Semakau: Growing the "Garbage of Eden". *Urban Solutions, Issue 8: Building with Nature*. Published Feb 2016. The Centre for Liveable Cities, Singapore. Available at <https://www.clc.gov.sg/publications/urban-solutions-issue-8-building-with-nature.htm>

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