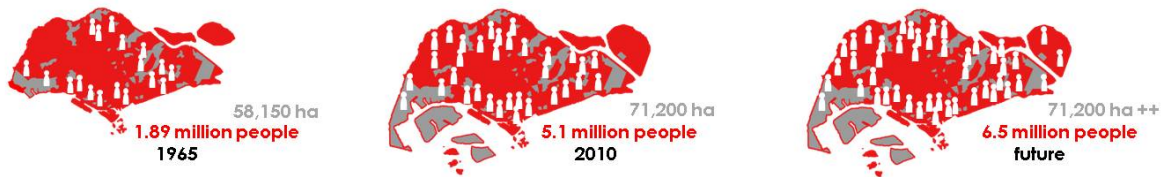


## **Transforming No-Go Zones in Singapore: Urban Liveability in an Industrial Park on a Landfill**

### **Creating Land for More People to Work, Live and Play**

Singapore is a Southeast Asian island city-state located south of the Malay Peninsula. Founded by the British as an entrepot port in the 19<sup>th</sup> century, the country later gained national independence in 1965. As a sovereign state, the island of Singapore alone houses the multitude of its land uses that contribute to the smooth running of the city-state, from military bases, water catchments to industrial, commercial and residential areas. As such, it was apparent very early on that more land beyond the island would be required to facilitate the nation's continued growth. Consequently, land mass in Singapore has grown by roughly 25% from 1965 to 2010 through substantial reclamation on offshore islands as well as on the coasts of the main island. Expectedly, the land increase has also been accompanied by a sharp population growth from 1.89 million in 1965<sup>i</sup> to 5.1 million in 2011, with another projected increase to 6.5 million over the next 40 or 50 years (Figure 1).<sup>ii</sup>



*Figure 1: (from left to right) Singapore's land area and population in 1965, 2010 and 2050 (projected). Singapore's land area will have increased by about 25% in under a century, and the population is projected to increase by 250% within the same time period. The grey areas represent industrial land use.*

*Sources: JTC Corporation; Department of Statistics, Singapore.*

With such a rapid population expansion comes the need to balance competing space demands for housing, transportation infrastructure, parks, waterbodies, reservoirs as well as industrial and commercial uses. As the larger population fuels a greater demand for land, Singapore has had to expand outwards, upwards and downwards to cater to the multitude of land uses.

Providing a steady supply of industrial land has marked JTC Corporation's land use planning from the beginning. Today, with industrial uses making up 18% of the island's total land mass<sup>iii</sup>, the importance of the industrial sector to Singapore is undisputed. Despite the rapid financialisation of the global economy during the later years of the 20<sup>th</sup> century, Singapore has carefully cultivated and maintained its manufacturing sector, with its share of GDP growing from 11% in 1960 to 27% in 2005<sup>iv</sup> to 26.6% share of national GDP in 2010.<sup>v</sup> Moving ahead, in order to perpetuate industrial growth, it will be imperative for us to prioritise industrial land demand and to maintain a sufficient land supply for such uses. However, as traditional means to increase our industrial land supply become less viable, JTC Corporation has repositioned itself as not just an industrial developer, but as an industrial infrastructure innovator to source for more creative solutions to alleviate our industrial space constraints.

### ***Land Reclamation***

Early endeavours to cope with the space crunch were mainly capital-intensive, major infrastructure efforts such as land reclamation. This was important in the 1960s and 1970s when the emerging Singapore economy was attracting very land-hungry, labour-intensive manufacturing industries to set up businesses in the city-state. As such, large parcels of industrial land were allocated to single-users who built factory facilities with low plot ratios and site coverage. However, as the ability to reclaim more land became increasingly limited, the nation has had to drastically intensify industrial land use patterns to keep up with the industrial demand for land.

### ***Industrial Clustering and Redevelopment***

Beginning in the 1980s, lighter and cleaner manufacturing activities were channeled into medium-rise flatted factory complexes with smaller land parcels. In addition, en-bloc redevelopment schemes<sup>1</sup> were also deployed to acquire land back from sunset industries and low value-add companies. Such reacquired land was then put to higher intensity use and reallocated to industrialists who could build factories with higher plot ratios and with higher economic productivity per unit of land. Furthermore, the goals of land reclamation became more specific – not just to add land mass to the mainland but also to provide highly specialised industrial land that was not readily available. An example of this is the reclamation and amalgamation of 7 offshore islands into one island – the Jurong Island petrochemicals and oil hub (Figure 2). Likewise, industrial clustering of various components of the economic value chain was also actively planned for to create business and land use synergies in a drive to save land.



*Figure 2: Aerial views of Jurong Island, a massive land reclamation project to house the burgeoning oil and petrochemicals industry in Singapore. The main feature of Jurong Island's industrial clustering are the shared facilities within the island i.e. jetties, utilities, services corridors.*

*Source: JTC Corporation*

### ***Land Intensification and Higher Plot Ratios***

To further save land, land intensification efforts were strengthened during the 1990s. In order to achieve the higher plot ratios instituted for industrial land uses, new and innovative building products were developed. For example, ramp-up factory facilities (Figure 3) ranging from 6 to 9-storeys tall were now replacing small terraced workshops and standalone factories. As a result, up to 90 of these small, land-based companies (averaging 0.2 to 0.4 ha each) could now be stacked up and housed in factory complexes that only took up 4.5 ha to 5 ha of land, generating significant savings.



*Figure 3: (left) Singapore's Jurong industrial area in the 1960s and 1970s was made up of large parcels of single-user, low intensity factories. (right) An example of Singapore's newer 7-storey ramp-up factories, with a ramp (right of picture) that allows container truck access and loading/unloading on every floor.*

*Source: JTC Corporation.*

However, such traditional measures of expanding the industrial land supply soon reached their limiting factors. Land reclamation was expensive and required long periods of planning and implementation. End-user resistance towards operating in high-rise facilities had also realistically limited how high industrial plot ratios could go. Similarly, en-bloc redevelopment schemes became too politically sensitive to be in constant use and had caused the permanent loss of several industries within the local economic value chain. Facing less viable methods of increasing land productivity, Singapore has had to turn to new frontiers to develop innovative industrial infrastructure to ensure optimal sources of industrial land for sustained growth. Moreover, such products are envisioned to give Singapore a competitive advantage in industrial real estate.

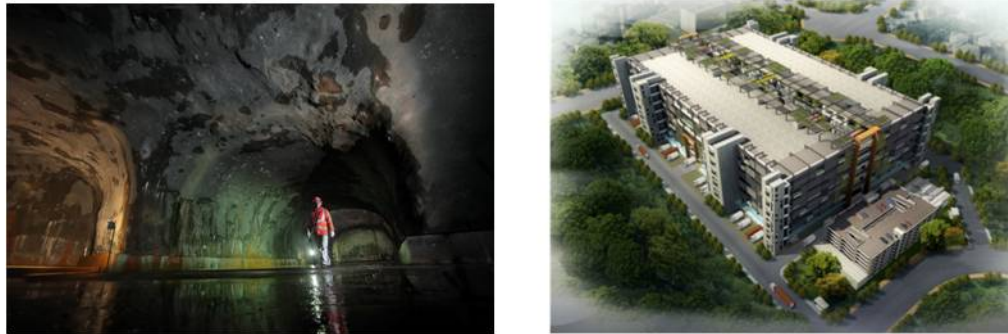
### ***Innovation through Sustainability***

As the leading industrial masterplanner and developer in Singapore, JTC Corporation has been at the forefront of breaking new ground in developing cutting-edge, unconventional industrial space solutions. By understanding that future land scarcity can only be resolved through sustainable land planning, JTC Corporation's move towards innovating new land products is the key to allowing our industrialists to grow their businesses.

One example of such leading-edge initiatives is the Jurong Rock Caverns (Figure 4), a series of undersea oil and petrochemical storage caverns excavated beneath the Jurong Island petrochemical hub in order to save approximately 60 ha of land that would have been sterilised had such storage taken place above ground. Another example is the Underground Science City at Kent Ridge Park, envisioned to be an expansion of the current science parks clustered around the National University of Singapore. By leveraging on its proximity to existing research centres, the Underground Science City will be developed into a fully self-sustaining underground data centre and R&D research hub.

Yet, there are still newer space frontiers to explore. In the future, vehicle ramps in our factory complexes will give way to mega-hoist material handling systems, allowing containerised goods to be delivered to the doorsteps of each factory unit (Figure 4). Without the vehicle ramps, the land take by each factory complex is likely to be further reduced. Thinking ahead, future

Singapore may be home to multi-level aircraft hangars and airspace developments decked over roads and utilities.



*Figure 4: (left) Undersea Jurong Rock Caverns developed for the storage of oil and petrochemicals, a use which would have sterilised and underutilised a large amount of land on ground. (right) The Cluster Industrial Complex with Megahoist facilities saves additional land by replacing multi-storey ramps for container trucks with a shared mega-hoisting mechanism to directly transport containers from the ground floor to the end-user's doorstep.*

*Source: JTC Corporation*

Indeed, it must be acknowledged that such blockbuster initiatives to create more land require long lead-times for planning and development and are very expensive. In fact, a lot of the effort in the creation of more industrial space is balanced with the need to provide affordable industrial real estate to continue attracting industrialists to invest in Singapore. As the country maintains a substantial manufacturing sector within its economy, such space constraints will continue into the foreseeable future. Without a hinterland to expand into, industrial space needs in Singapore will remain at the forefront in the search for more land. One of the ways to make this quantum leap towards providing more land more cheaply is to recycle the land we already have.



## **Even Landfills Have Development Potentials**

As Singapore's growing urban fabric is put to higher intensity use, landfills have been identified as potential brownfield sites that can be feasibly transformed and recycled for productive use. JTC Corporation has identified a 110 ha site in northeastern Singapore that will be the test-bed for the first industrial park built on an existing landfill. Lorong Halus (a historical Malay name meaning 'smooth path') is a lush, forested area with greenery and wildlife thriving even on the 29 ha portion of the site encumbered by a landfill (Figure 5). Bound by the Serangoon River on the west and highways on the east, Lorong Halus is currently unused and disconnected from adjacent residential and industrial estates. The site has been identified as a potential major employment generator for residents living away from the city's central business district and a suitable site for an industrial park catering to knowledge-based and high value-add industries.



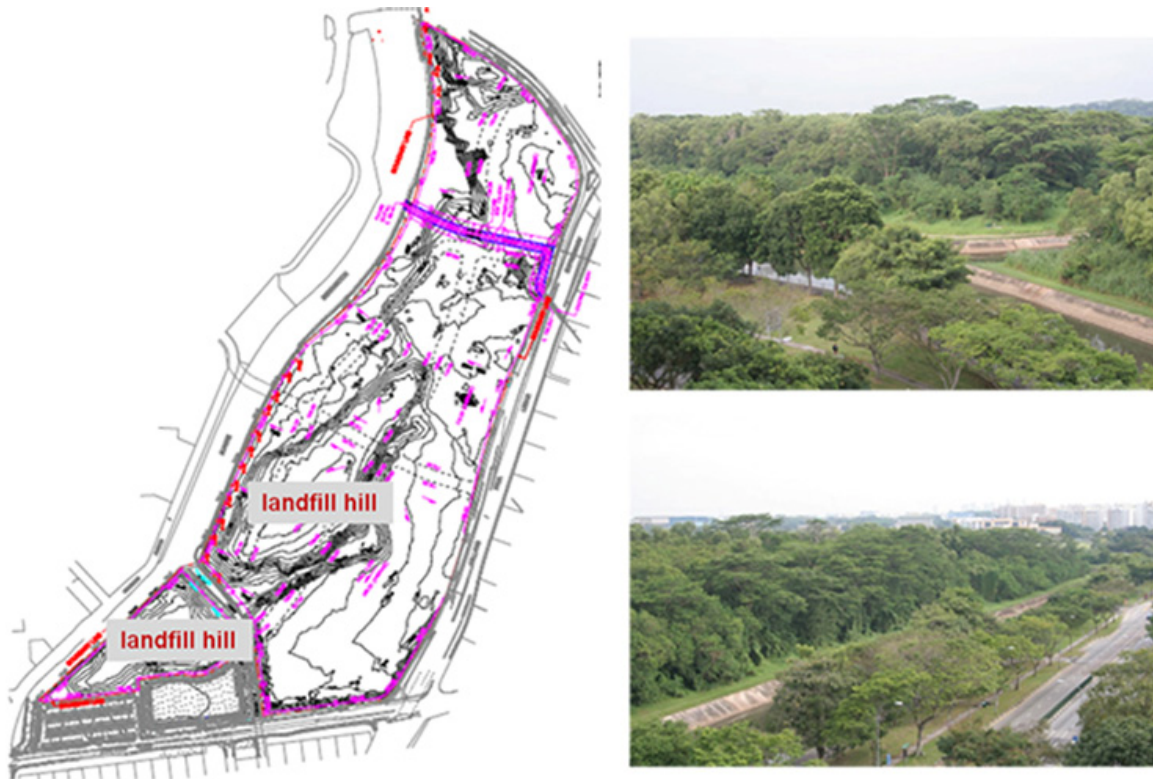
*Figure 5: Location plan and aerial view of Lorong Halus across the Serangoon River.*

*Source: JTC Corporation*

Operated as a municipal waste landfill from the early 1970s up till the late 1990s, the Lorong Halus landfill today consists of two hilly mounds, where the depth of landfill waste ranges from 5m to 19m below ground, and 10m to 15m above sea level (Figure 6). Not only does the landfill

waste pose developmental constraints, the hilly and uneven topography also comes into conflict with the need for large, flat parcels of land for industrial development.

Environmental studies conducted by Singapore's government agencies in the 1990s had assessed that the landfill waste was already in an advanced state of decomposition and the leachate (contaminated ground water) was considered generally weak. However, the relatively high levels of methane being produced by the landfill on the site would still pose fire hazards if the gases were not properly channeled.



*Figure 6: (left) Ground topography of Lorong Halus industrial park indicating the location of two landfill hills in the southwestern corner of the site and the Serangoon River running down the western edge. (Upper Right) Aerial view of the upper landfill hill. (Lower Right) Aerial view of the lower landfill hill.*

Two methods of land rehabilitation were then assessed: first, the complete removal of the landfill via incineration of waste; and second, the capping of the landfill. While the first method was deemed more costly, it was evaluated as being able to achieve a high level of rehabilitation such that the site could be put back to a somewhat greenfield state. Although this option was considered, one of the implications of removing and incinerating the waste from Lorong Halus was the need to store the remaining ash at another landfill. Given Singapore's land scarcity, even national landfills are heavily rationed and transporting the waste from one landfill to another at such high cost was not deemed the most efficient solution.

Consequently, the environmental studies recommended that leaving the landfill waste on site and treating it in situ with a clay capping layer was the most cost-efficient method of land rehabilitation. Such landfill-encumbered land was then recommended to be put to use as parks and golf courses for the next 30 to 60 years while methane levels fell to an acceptable and safe threshold. Thereafter, such land could be converted to other uses. Notable examples of this

method of land rehabilitation can be found at the Millennium Parklands of the Sydney Olympic Park and the South Korea World Cup Park where landfill waste was excavated, sorted, incinerated, consolidated and reburied under newly-built recreational parks (Figure 7). Unfortunately, converting 29 ha of Lorong Halus into a park for the foreseeable future was not considered a sound, productive use of the land within Singapore's land constrained context.



*Figure 7: (left) Part of the Millennium Parklands of the Sydney Olympic Park. (right) Panoramic view of the Seoul World Cup Park.*

*Sources: Wikimedia Commons/Adam J.W.C; <http://www.flickr.com/people/seoulkorea/>*

### **Living 'With' and 'Above' the Landfill**

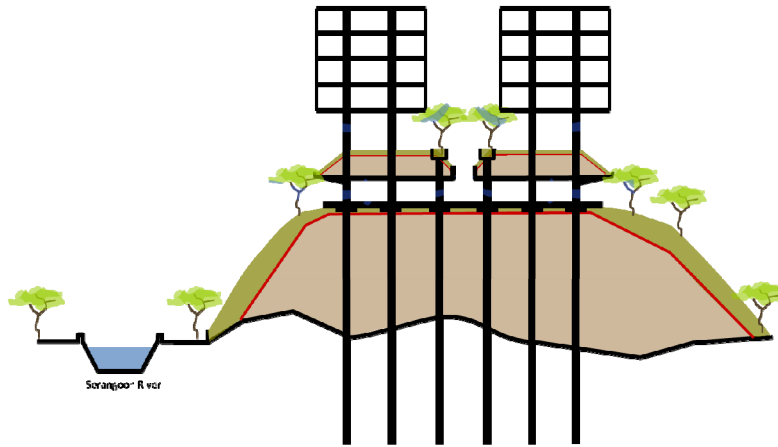
To proceed with building an industrial park over the Lorong Halus landfill without removing the waste, we would have to overcome the challenges posed by hazardous industrial activities that may trigger fires or explosions from the high concentration of methane in the air. As such, we developed creative building solutions that would have to be adopted by the industrial facilities built on the landfill-encumbered parcels: developments could not have basements, ground floors could not be fully enclosed and an estate-wide gas migration monitoring and mitigation system would have to be put in place. While the methane gas detection systems can be built into the infrastructure of the industrial park, we recognise that strict building design guidelines such as basement-less, partially-open building envelopes would impose developmental constraints on any future end-user of these sites.

Additionally, the topography of the landfill hills, containing an estimated 4.3 million cubic metres of landfill waste, also required creative infrastructure solutions. One option was to undertake a balanced cut-and-fill and to rebury the landfill waste from both hills in the lower-lying areas within the site, which would have resulted in expanding the landfill-encumbered area by half. This would mean contaminating the parts of the site that were virgin land and imposing developmental constraints on even more land parcels. Ultimately, this option was dropped in favour of an alternative containment strategy. The landfill waste would be kept and capped over in the form of its two existing hills, with the hills flattened slightly into plateaus suitable for development. Environmental decks above the plateaus will then hold the landfill waste displaced from the top of the landfill hills, further intensifying the land for industrial development as well as landfill storage.

One of development scenarios JTC Corporation is exploring for the landfill-encumbered parcels is the development of an integrated heavy vehicle park under a factory complex or workers' dormitories (Figure 8). By building a heavy vehicle park on the first level of the landfill plateau, we would be bringing in a use that could be implemented on an open surface. Above the heavy vehicle park would be an environmental deck storing the displaced landfill waste, which will in turn form the landscaped open area of the development above it, which could potentially be



high-rise blocks of workers' dormitories or a multi-tenanted factory facility. Indeed, it is envisioned that 'land' at every level of the landfill parcel would be put to productive use.



*Figure 8: Cross-sectional view of the proposed industrial development on the landfill hill. After removing the top of the hill to create a flat plateau for building foundation works, the displaced landfill waste can be stored on an environmental deck above the plateau level. Both the plateau and deck level can be landscaped to provide green areas within the land parcel. Note the importance of air circulation to prevent the build-up of methane gases.*

*Source: JTC Corporation.*

Although the slopes of the landfill hills will not be developable, they will be turfed and landscaped to provide an unique identity to Lorong Halus, and to recall as much of the pre-existing natural elements on the site as possible. By exploiting the natural virtues of the site as a verdant urban sanctuary, small trails leading to F&B corners can be tucked into the sides of the hill to enhance vibrancy and use of the hillside parks. It is envisioned that the landfill hills will become placemaking elements for Lorong Halus industrial park, actively challenging the common notion of landfills as contaminated, no-go zones.

The surrounding non-landfill encumbered parcels will house light and general manufacturing companies (Figure 9). Some of the potential industries that could be sited at the larger parcels in Lorong Halus are food manufacturers, precision engineering and logistics companies. Many of the smaller parcels along the riverfront could then be allocated to smaller and lighter manufacturing companies such as those producing lifestyle goods and fashion products. Many of these companies will be encouraged to create product showrooms facing out into the Serangoon River, inviting the visual interest of pedestrians walking along the river, as well as residents living across the river.





*Figure 9: The envisioned masterplan for the redevelopment of Lorong Halus industrial park.*

*Source: JTC Corporation.*

In addition, land along the eastern banks of the Serangoon River have also been safeguarded for a park connector to support cycling and other pedestrian activities, which will complement the planned damming of the river into a closed reservoir for water-based recreational activities. It is envisioned that the injection of such activities into an industrial park could bring in vibrancy and vitality to the area. Since this activity zone will front the western side of the industrial park, many of the smaller industrial parcels along the riverfront will enjoy a view of the river and be part of this activated zone. With the added premium of the riverfront view, many of the industrialists facing the riverbanks will be encouraged to design their buildings to open up seamlessly into the activated river frontage as well as to introduce retail and other F&B amenities to further attract pedestrian activity, especially from the adjacent residential neighbourhoods. The ultimate vision of Lorong Halus is one of an industrial park within a park-like setting, with a strong emphasis on green and blue elements, bringing liveability into an urban, industrial context (Figure 10).



*Figure 10: The vision of Lorong Halus industrial park as a vibrant and dynamic riverfront industrial park.*

*Source: JTC Corporation.*

## **A New Generation of Industrial Parks for the 21<sup>st</sup> Century**

As land gets scarcer in Singapore, each land use will become denser and closer in proximity to each other. We foresee that our industrial spaces will start getting closer to residential neighbourhoods, water catchments as well as parks and recreation areas. It will not be feasible to continue to segregate industrial parks away from other land uses; indeed, a new mindset towards re-incorporating these industrial elements into our urban fabric is crucial and necessary to sustain a thriving urban environment. As industries become cleaner and less pollutive, industrial parks need to be environmentally sustainable, green, cool, pedestrian-friendly, with aesthetic qualities that help them blend into the neighbouring vicinity.

By employing land recycling as a viable approach to maintaining land supply for economic growth, Singapore is attempting to redefine what is considered developable land by recycling landfills and other sensitive areas not traditionally deemed as having development potential. With our land scarcity as a major constraint, landfills and other brownfield sites cannot remain no-go zones for development.

Planning for Lorong Halus industrial park has been an attempt to challenge the mindsets of industrialists into accepting development on constrained, brownfield sites, as well as to test the receptivity of the local real estate market towards such innovative infrastructure solutions. As new areas are being opened up for industrial development over the next 40 years, Lorong Halus will be a forerunner in instructing the market on working with site constraints rather than ignoring them. As shown at Lorong Halus, we will indeed turn the constraints of the landfill on its head by transforming the landfill into a landscaped hill park overlooking a riverfront – the anchoring feature within our strategy for industrial park placemaking.

The new generation of Singapore's industrial park will not be a place of pure functionality. Green and blue features to soften the hardscape of an industrial environment will be key to making our industrial parks places, not spaces. Activated zones that will bring in pedestrian traffic and recreational activities will liven up the area and ensure the use of the industrial park by different populations at different times. The next generation of industrial parks will be integrated with the surrounding urban fabric, and not be set apart from it. At Lorong Halus, we anticipate an industrial park demonstrating the features of urban liveability – a place transformed from a no-go zone into a dynamic community for work and play.

Estelle Chan

JTC Corporation

Singapore

## Notes

---

<sup>1</sup>En-bloc redevelopment schemes are a variation of the concept of eminent domain as employed by government authorities. In Singapore, en-bloc redevelopment schemes are based on the 'willing buyer, willing seller' principle.

## References

---

- <sup>i</sup> 'Time Series on Population (Mid-Year Estimates)', 2010, Department of Statistics, Singapore, [online] Available at: <http://www.singstat.gov.sg/stats/themes/people/hist/popn.html>
- <sup>ii</sup> Mah, Bow Tan. 2007, 'Why we need 6.5 million people', *Petir March/April 2007*, People's Action Party, Singapore.
- <sup>iii</sup> 'Land Availability Statistics', 2011, *Land Stock Management Database*, JTC Corporation, Singapore.
- <sup>iv</sup> Nah, Seok Ling. 2006, 'Singapore's Manufacturing Sector: 1991-2005', *Statistics Singapore Newsletter March 2006*, Economic Development Board
- <sup>v</sup> 'Gross Domestic Product by Industry', 2010, Department of Statistics, Singapore, [online] Available at: <http://www.singstat.gov.sg/stats/themes/economy/ess/essa11.pdf>