

Speech by Dr Vivian Balakrishnan, Minister for the Environment and Water Resources, at Brian Robinson Memorial Lecture at 5th International Contaminated Site Remediation Conference (Cleanup 2013), 15 Sep 2013, 3.30pm at Crown Centre, Melbourne
TOPICS : [biodiversity](#), [sustainability](#), [nature](#)

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1 A very good evening to everyone here. I need to begin with a confession that I am not an engineer. I am actually an ophthalmologist, an eye surgeon. But I like to believe that I have quite a lot in common with engineers, because I believe that we are all dedicated to applied science in order to solve real problems, in the real world, for real people. So when I said that I am on your side, I feel an instinctive sense of allegiance. I mean that in all sincerity.

2 I am also deeply humbled and honoured for this opportunity to be here, especially knowing that this lecture is in memory of the late Brian Robinson, who I understand played such a key role, not only in Australia, but just as importantly, in the careers and lives of all the people he had touched. I believe he had served for more than 30 years. I was listening to the list that he enumerated - he was promoting resource efficiency, talking about the delivery of sustainability in goods and services, financial drivers, and about getting the community involved. Immediately, the thought struck me, that in fact, these key narratives have really been foundational elements in the Singapore story, and elements of the environment and water in Singapore.

3 So I thought that I would like to take this opportunity to share some facets of the experience which we have in Singapore - both in remediating land, as well as to share from the political and administrative perspectives. How a proactive upstream climate, together with a political will, is critically important to make the necessary long-term investments. And I use the word 'political will' in the fullest sense of the word, because of the time horizon, which you need for such plans, and the willingness to dedicate huge amounts of capital expenditure. In the case of Singapore, we look at 50-year plans, to be honest, sometimes even up to a century. It is quite a challenge if your politicians have to worry about an election every three or five years, to get them to focus on 50 years and beyond. Fortunately for us, rightly or wrongly in Singapore, we had the luxury of political stability. And that meant that no problem was too remote in time and space that it could be ignored - we could not afford to do that. So that has been one of the key attributes of the Singapore planning process.

4 So to set the story in further context, let me provide some key statistics about Singapore. I am not sure how many of you have been to my little city island state - can I just get a show of hands, how many of you have been to Singapore? That is not bad. That is a majority. Well, if you have not been to Singapore, then you would know that from east to west is a grand total of 49 kilometres; from north to south, a grand total of 25 kilometres. This translates to a land area of 715 square kilometres. I asked my staff to check what this means relative to Melbourne. They told me that that makes us approximately one-fourteenth the size of Melbourne. So you can have fourteen Singapores in the space of Melbourne. But within this tiny fraction of Melbourne, lives 5.3 million people. I believe the population in Melbourne is 4.25 million. We have more people in Singapore than in Melbourne. That makes our population density 7,422 per square kilometre and according to the United Nations, the third highest in the world as far as population density is concerned. Only Monaco and Macau are more dense than Singapore.

5 But this is only part of the story, because for all of you who have been to Singapore and flown into Singapore, I hope you looked out of your airplane windows before it landed. You would have noticed that in fact, there is a disproportionate amount of greenery in Singapore. We have 350 parks, 18 nature areas and four nature reserves. And because we intend to keep as much of this native untouched greenery as possible, what this means is that the 5.3 million of us are in fact squeezed into an even smaller space that is available for development. So this gives you some idea of how severely land-constrained Singapore is. I would like you to hold this concept of severe land constraints in mind, because it explains the forces that led us to the decisions that I am going to explain.

6 Like all cities, Singapore also has to provide infrastructure for families and businesses to thrive, and that is a given. Another difference between Singapore and Melbourne is that we are a city-state. What that means is that within our limited space, we need to have homes for our people; we need to build for industry; we need reservoirs for water; we need transport infrastructure; we need airports; we need ports; we need landfills; we need parks; we need recreational spaces; and the list goes on. Imagine Melbourne being an independent sovereign nation, and having to do everything within the confines of the boundaries. That gives you again another idea and the enormity of the challenges that we face. So given our land constraints, in the case of Singapore, we could not simply build more. We could not keep building reservoirs; we could not keep building more roads, housing and factories, etc. to cope with the rising population and economic activities. We have to build more intelligently; we have to plan more carefully and more imaginatively, in order to make the equation work. Therefore, the Government and the agencies have had to discover new ways to stretch our resources, and the key thing is land. So again, we come back to this story of land.

7 I am going to start with a picture - an aerial photograph (*refer to image below*). This picture, I think goes back 30 to 40 years. And it is a picture of what we call the Lorong Halus landfill site. This site was established in 1970, and for 30 years, it was the primary dumping ground for all household, construction, industrial, and demolition waste. We closed this landfill in 1999, and opened up another off-shore landfill site, and that is the second story. Let me first complete the story of this particular landfill site because I think it is an interesting example of remediation. At the time we closed this site, it had spanned 234 hectares or more than 100 soccer fields. I am not sure how many fields that makes for Australian Football, because the Australian Football field is a bit larger. But in order to explain how and why we closed it, and how we remediated it, I need to take another detour. And that is the story of another scarce resource in Singapore, called water.



8 Water has always been an existential issue in Singapore. Even since the Second World War, when the British troops surrendered to the Japanese forces, which were only one-third the size of the surrendering Allied forces (which unfortunately included a significant number of Australians who were marched off the boats, became Prisoners-of-War, and marched into Changi). Ever since then, water has been an existential issue, because even until this day, the majority of our water is imported from Johor in Malaysia, which is the state to the north of Singapore.

9 Even today, the catchment area for the water that we receive from Malaysia is twice the size of Singapore. So, this has always been an existential constraint and obsession for us, because it has everything to do with our independence and sovereignty and with long-term viability. We have no fresh water lakes in Singapore and you would probably call our rivers streams down here. We have no mountains, and we depend entirely on surface capture for our reservoirs. It still only accounts for tiny fractions of what we need.

10 The irony of it all is that we also happen to be one degree north of the equator, and in fact, there is plenty of rainfall. On average, we receive 2,400 millimetres of rain a year. So in theory, if we could capture every single drop, we would have more than enough water. But, we cannot. And the reason we cannot is because we do not have enough land. Because even when it rains - and in Singapore when it rains, it really pours - I do not have enough space to store that water. So it is a kind of existential treadmill for us with water.

11 When Singapore became independent, we inherited three reservoirs from the colonial government. And since independence, we have deliberately built as many reservoirs as we

can. Let me explain that. Today, we have four sources of water in Singapore. The first source, I have already explained to you - imported water from Malaysia. This is subject to an agreement between the two sovereign countries. We have two agreements - one signed in 1961 and 1962. The 1961 agreement has lapsed. Today, we have the second agreement, which will expire in 2061. That provides for about half our current water supply. That is the first tap.

12 The second tap is our own local catchments. As I said, we started off with three reservoirs, and now we have 17 reservoirs - but that is still only a minority of our supply. There are two other national taps, which have become available only within the last decade, because some engineers somewhere invented reverse osmosis using the latest technology of semi-permeable membranes.

13 In the last 10 years, it became viable to desalinate water and to recycle used water at a price that we could afford. And my deal in the case of Singapore - we do not subsidise water. In fact, every consumer pays full price, including the conservation tax for every drop of water out of the tap. So, making it viable and cost-effective is not an idle challenge. Because our people pay for it, and if we mess it up, we do not win elections. So we are focused on that.

14 Now the PUB, which is our water agency, has dammed up almost all the major streams in Singapore, and effectively transformed them into estuarine reservoirs. Estuarine reservoirs are basically reservoirs that are practically at sea-level. All we do is dam the river at the mouth, and that has enabled us to increase the number of reservoirs to 17. Even then, as I said, that would be a minority.

15 Having explained our obsession with water, reservoirs and estuarine reservoirs, let me come back to the landfill site. If you look at the area in this picture (*refer to image below*) - which I think was taken about a year or two ago - that was the previous landfill. Remember I told you we closed it in 1999. The reason I wanted to share the story is that we have converted that landfill into a reservoir park. Think about it - a landfill is now directly adjacent to or abutting a reservoir. Fresh water reservoirs from which, we are treating water and drinking water from. If you think about the fact that we only closed it in 1999 - if we had not remediated it properly, we will all be drinking toxics.



Serangoon Reservoir

16 So the question then is how did we achieve this, and I wanted to emphasise that the remediation of this landfill was not a trivial exercise. It was not just about making the land available, though that was important, but making sure the water in the reservoir was safe enough. That meant we had to eliminate the risk of leachate from the landfill polluting the water, and we had to put in place extensive measures to remediate the site. This included the installation of a pipe network to extract the methane and channelling it into a flare station for burning. The clamping of landfill with a layer of clay and soil is obviously to address the issues of smell and public hygiene. But more importantly, when we decided to dam up the river and make it into a reservoir, we also had to make sure we dealt with the leachate appropriately. The landfill site was already in an advanced state of decomposition, so you could argue that the leachate was kind of weak. But if you think about the passage of time, that is not a very long period. We could not afford to have contaminated rain or groundwater leaked into the reservoir.

17 So we did two things. First, we built a barrier between the landfill site and the reservoir. We constructed an underground wall consisting of Betonite, soil and cement. This wall is 0.8 metres thick, 18 metres deep, and 6.4 kilometres long. It is not the Great Wall of China, but is a significant wall. Secondly, we established a network of wells and pumps to collect the leachate due to rain - the water that was percolating through the old landfill site, and then channelled it into a system of tanks and lagoons for treatment. We secured a 9-hectare site to treat the leachate, and I think our innovation here was to implement a bio-remediation wetland system. Basically, we were using plants as super filters to extract the contaminants from the leachate from the water in the wells (*refer to image below*).



18 We had tanks and lagoons to first remove the suspended particles, introduce oxygen in order to remove organic matter and then break down the nitrogen compounds to make it easier for the plants to absorb the materials. The leachate was then channelled into five reed beds, with three types of plants –Cattails, **Vetivers**, and Papyrus, which were used to filter out remnant contaminants such as heavy metals. And mind you, we are still finding traces of heavy metal, mercury, lead and cadmium in the leachate. So we could not just allow that to flow to the reservoir. The treated leachate is then channelled again into a polishing pond for final filtering by water lilies before being channelled into the sewers for conventional wastewater treatment.

19 There were multiple challenges in implementing this innovative bio-remediation system. We had to identify the right plants based on their abilities to thrive in our tropical climate, as well as the composition of the leachate that we were extracting. So for example, we found that Vetivers were the most effective filters, but initially we found them wilting because there was too much salt and too little phosphorus. So we planted more Cattails to address this problem. The point that I am trying to make is that we needed not just water engineers, but also biologists and people who understood plants.

20 Today, our efforts had succeeded. Lorong Halus - remember I told you we set aside nine hectares - has become an open park for Singapore families to enjoy. In the design of the remediation system for the landfill, we could have opted for a chemical remediation (*refer to image below*). But I think choosing to use a biological method, to use plants to in fact, create an attractive park –an open park for Singapore families to enjoy - I think that was the genius of what we achieved for this place.



21 Since the opening of the park in March 2011, we have attracted many families and just last year alone, we saw 3,500 visitors join in organised events at the wetlands. We do not keep track of people who just wander in on their own with their kids running around to look at and enjoy the plants and the views. But more than that, (*refer to images below*) these are some of the other visitors we have had - the birdlife, which is proof that this is perfectly compatible with biological plants.



22 The wetland does not function in isolation. Remember the reservoir next to it? Well, it actually connects via another man-made channel that we made, to another reservoir that is further to the west. So we created a waterway out of water which we were confident was safe and good enough to drink. The original concept of reservoirs was to keep people out because they can pollute it. But we have changed this idea about a decade ago. In fact we want to open up all our waterways and reservoirs for our ordinary citizens to come and enjoy. Because if they enjoy it, they will take back a sense of ownership. They will now become stakeholders in championing keeping our waterways clean and open and available to all.

23 So this was the plan, and this has been completed. So you see (*refer to images below*), this was an artificial channel, this was the water from the reservoir next to the remediated landfill. It is open to the public, people can go in and have a great time in that place. And we have other plans for the remaining areas to be opened, because we have over 200 hectares, and we only took 9 hectares for the bio-remediation plant. The rest of it will now be available for other things like industrial parks; maybe residential in the long run. Because it is completely re-mediated and available for use; and in Singapore's context, because we are so short of land, this is a successful concept of recycling land back. The point I wanted to make is, it is possible, and to remediate not only to use the land, but to get it to that quality where you dare to have a reservoir abutting a former landfill site. I am not sure where else in the world people have the guts to trust their engineers to pull it off, but we did it.



*Green Lung in Punggol
Photo Credit © HDB*



24 Let me now switch to an island in the south. I told you we closed Lorong Halus in 1999 - that meant we needed another site. Because we were short of land, we picked an offshore island. You need to understand how tiny the whole of Singapore is, so when we say offshore island, basically we mean a rock. So, it is very tiny. Now, my purpose of sharing this second story is to illustrate the concept of “remediation *ab initio*”. That means planning for remediation at the point of conception of the project. So you do not contaminate and then remediate it. You plan *ab initio* - right at the beginning.

25 Let me illustrate what I mean by this. The offshore landfill that we created measures about 350 hectares. We achieved this by combining two islands. Their original names were Pulau Semakau and Pulau Sakeng. (*refer to image below*)



26 So you can see that I literally meant two rocks in the sea. By the process of reclamation, we built these (*refer to image below*) you can see two islands, but the rest of it was reclaimed. So we ended up with 350 hectares.



Semakau Island – prior to land reclamation

27 This opened in the late 1990s, and basically what we have been doing in the past two decades is to progressively fill this area (*refer to image below*). Because we knew we only have one landfill site, we wanted this to last for decades, because we are thinking in terms of 50-year plans.



Former Sakeng Island

Semakau Island – cell structure

28 We switched to incinerating almost all our waste, because the process of incineration reduces landfill requirements by about 90%. But having said that, not everything can be incinerated, so there are still some waste streams which have to enter into this in their raw form. So it is still a fully functioning landfill site by anyone's definition.

29 The combined island was divided into 11 cells, you can almost see the cellular structures - each of these would be a cell (*refer to image below*). Progressively, they will be filled, and as the cells are filled, we will cap them with a layer of soil, and plant vegetation over them. That is why you can see that it is beginning to be quite green. And not only that, we also surrounded the entire combined island by a geo-membrane - basically, it is a polymeric membrane. So I guess I will call it a landfill in a plastic bag. Again, we are very cautious that we do not want any leachate to pollute the seas around us. We actually have active coral alongside the island and we want to make sure we do not kill the coral by having other metals and leachate in the sea. We also have a leachate treatment plant on the island, and again, the concept was that your footprint is confined to the land that you have and you do not pollute the surrounding seas.



30 Now, the next thing which I wanted to show about this island was that we actually been able to maintain its biodiversity. So for instance, we had to remove some mangrove swamps in the process of reclaiming the land. But we replanted more than what we removed so we repaid our debt as far as the plants are concerned. But really, what is even more interesting, is the fact that we have been able to maintain biodiversity on that island. So you see, there are butterflies, more butterflies, spiders, dragonflies, birds, crabs, and starfishes.



Semakau Island – thriving biodiversity



Semakau Island – thriving biodiversity
Common Tit Butterfly (Hypolycaena erylus teatus)



Semakau Island – thriving biodiversity



Semakau Island – thriving biodiversity



Semakau Island – thriving biodiversity



Semakau Island – thriving biodiversity
Malaysian Plover



Semakau Island – thriving biodiversity



Orange Fiddler Crab



Semakau Island – thriving biodiversity



Semakau Island – thriving biodiversity
Dorid Nudibranch (mollusk)



Semakau Island – thriving biodiversity
Snaky Bornella nudibranch (mollusk)

thriving biodiversity



Semakau Island – thriving biodiversity



Semakau Island – thriving biodiversity



Semakau Island – thriving biodiversity
Euretaster insignis starfish



Semakau Island – thriving biodiversity

31 All these pictures are real. I took this one (*refer to images below*). The Prime Minister and I were on site, and we found some starfishes and decided to arrange the five into the shape of the stars we have on our flag. That is the Prime Minister and the sea urchin he and his wife found. They are not allowed to eat it. You know we Chinese eat everything. In nature, we can put it back. The five starfishes I have pointed out - they were quite big specimens and really what I wanted to show in these example was we can plan on remediation *ab initio*, and you can have a fully functioning landfill site that preserves all the biodiversity.



31 And today, we market this as perhaps the world's only functional landfill, which is also concurrently an eco-tourist attraction. The Prime Minister went there not because I asked him to, but he asked to go and see, as he was getting a lot of stories from people who had gone there and had a great time. That is why we brought him to the island.

32 We also took the opportunity therefore to open up the island to the public, so that anyone can hire a boat and visit the island. In 2012 alone, we had about 10,000 visitors and we believe that apart from just being an attraction, it also has an educational role for our students and for young Singaporeans to really understand that in Singapore, because we are so small, we do not have the luxury which I think many bigger countries like Australia has, in believing that you have external sites where you can just dump stuff. We do not have that luxury. Every landfill site that we use would either have to be reused or in this case, concurrently used and that means applying sufficient imagination and the latest scientific engineering expertise in order to make it happen.

33 So let me conclude by saying that necessity is the mother of invention. Both these projects that I have shown you came about because we were forced to experiment and innovate due to our critical lack of land and water. We had to apply imagination and creativity in order not to be tied down by our constraints. As shown in Lorong Halus, a brown-field site has to be transformed and recycled for higher value land use. Even better, in the second example, that if integrated comprehensive plans are instituted early on or at the beginning, you can have a thriving eco-system in the landfill site.

34 So in planning Singapore's land use, we are not just looking at solutions to increase our urban density. We understand instinctively that everything is a cycle. What you throw away, is some other systems' inputs. And if you do not take care of the cycle, it will come back to life. The only difference between us and many other places is that we are so small and so vulnerable, we learnt those lessons early on; and we had a founding Prime Minister who put the equivalent of the Environment Protection Authority (EPA) in the Prime Minister's Office. That is how the Ministry of Environment and Water Resources started as a department in the Prime Minister's Office. So it had the big advantage of having political attention at the highest level for five decades.

35 So those are two stories which I wanted to share with you, I hope you found them useful and the next time if you are in Singapore, come and check out these sites so you know I am not just telling long stories. They are real and they are there for you to check. And if you got other crazy ideas, which you might have difficulties convincing regulators in other countries, who have the luxury of space and land and water, pitch your crazy ideas to us. Anything which will allow us to save our land, reuse land, recycle land, create water, and make it compatible with life in a very densely populated city, we will be keen to get from you.

36 Thank you all very much, and I wish you all the best.