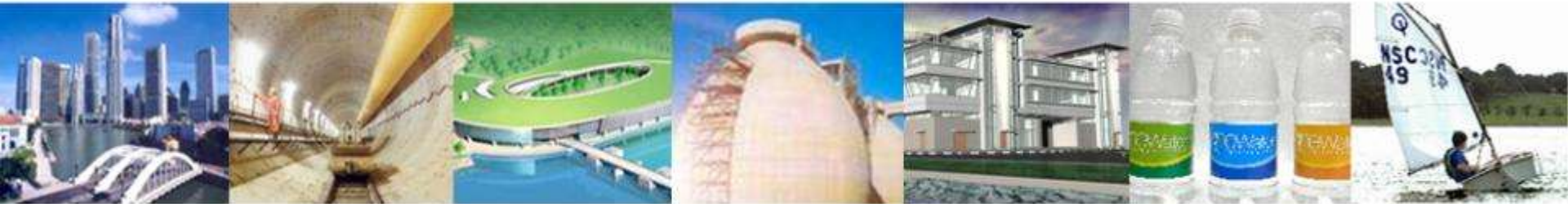


# Water for All Conserve, Value, Enjoy



## Singapore's Approach in Stormwater Management

*Presented by:*

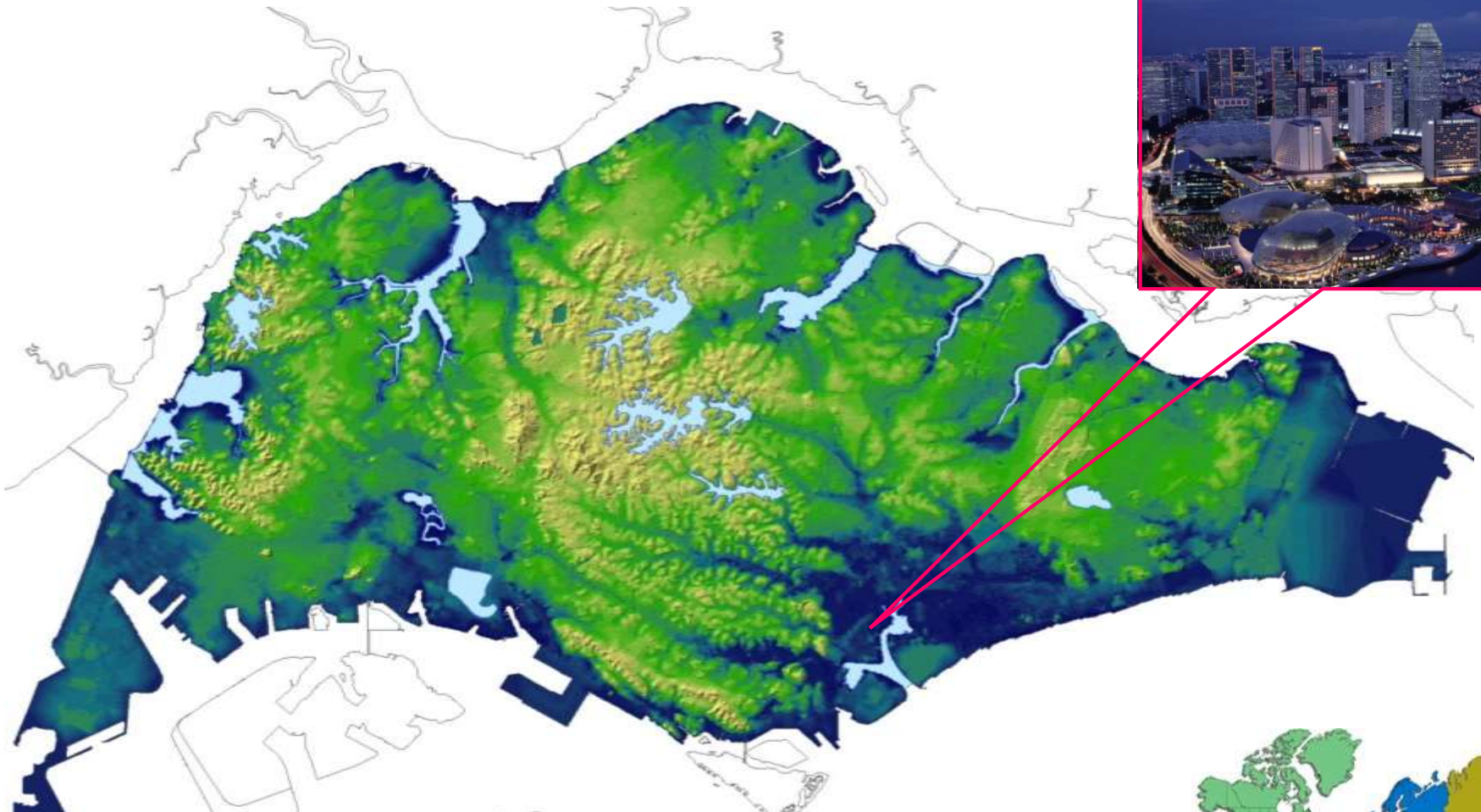
**Mr Ridzuan Ismail**

Director

Catchment & Waterways Department, PUB



# Topography of Singapore



- Surrounded by the sea, tidal range of about 3 m
- Over 3% of Singapore's land area is below 102mRL
- Average Annual Rainfall of 2400mm



# Urbanisation



1980  
Population 2.4M over ~600 km<sup>2</sup>



1990  
Population: 3M over 650 km<sup>2</sup>

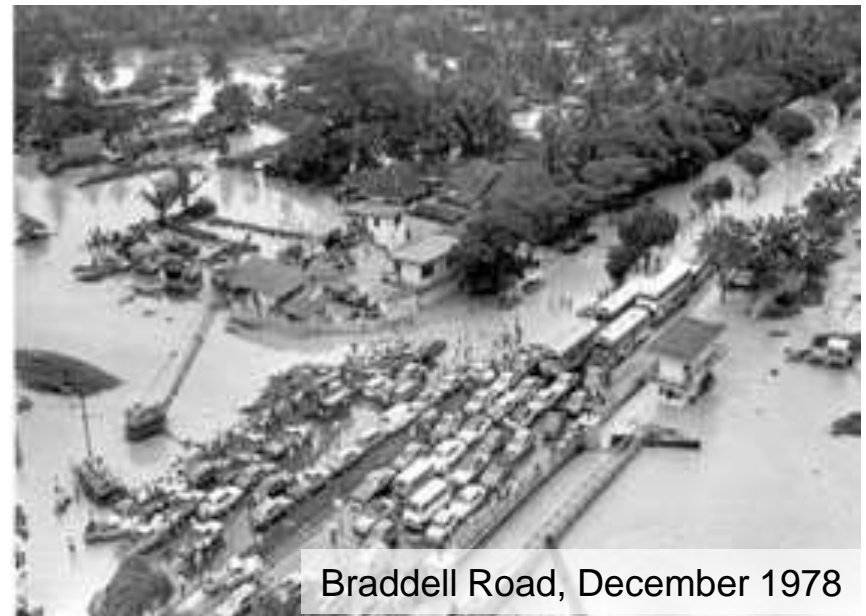


2000  
Population: 4M over 680 km<sup>2</sup>



Present – 2015  
Population: 5.54M over 719 km<sup>2</sup>

# Historical Floods



# Today's Floods

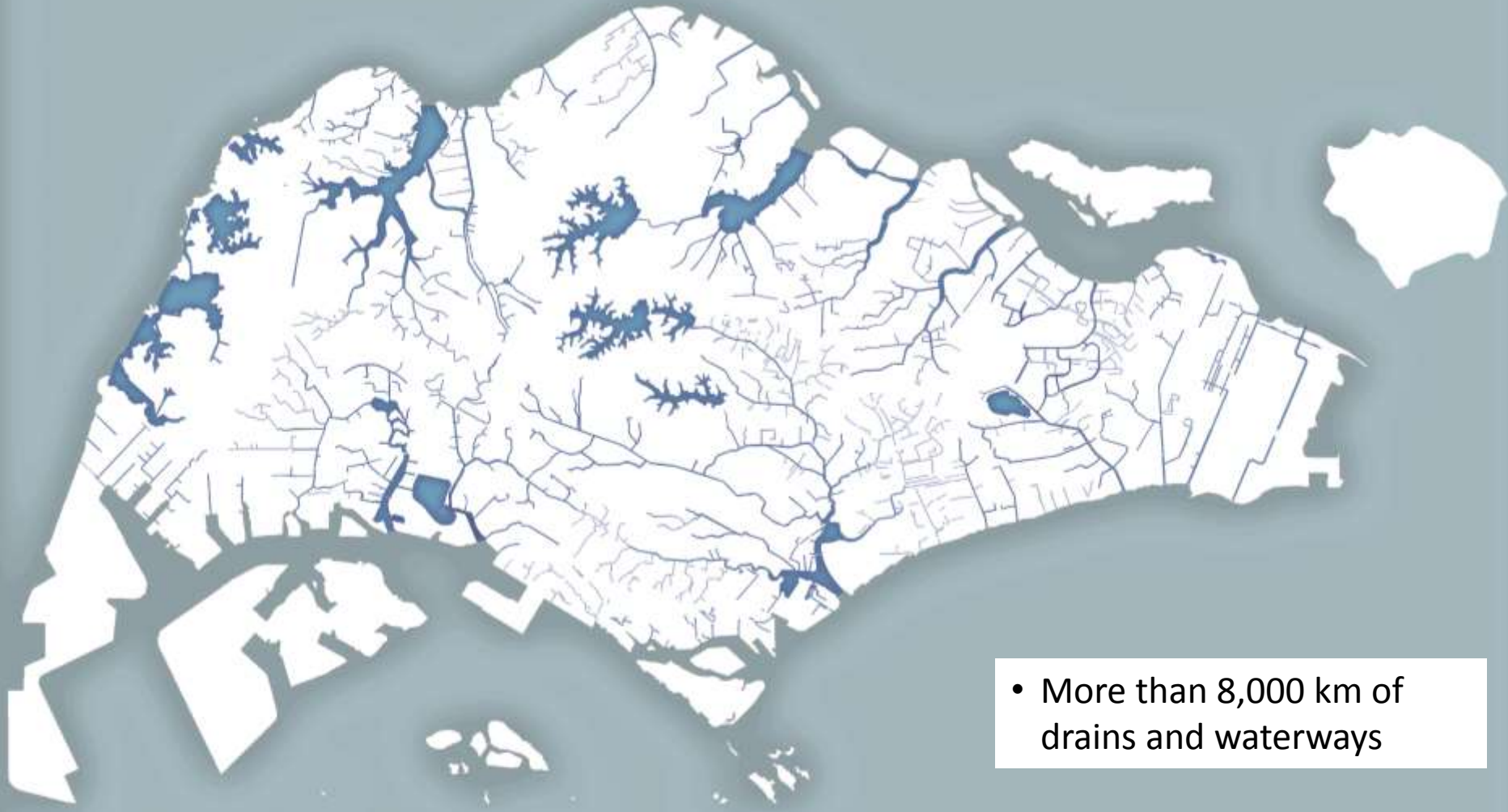


Localised and usually subside within an hour...



# INFRASTRUCTURAL PLANS AND DEVELOPMENT CONTROL

# Blue Map of Singapore



- More than 8,000 km of drains and waterways

# Singapore's Waterways and Drains



## Major Canals

Large waterways that lead to the reservoirs or sea



## Outlet Drains

Tributaries that discharge to major canals



## Roadside Drains

Drains along the sides of roads



# PUB's Stormwater Management Strategies



1

Providing adequate drainage ahead of new developments.



2

Implementing flood protection measures by stipulating requirements such as minimum platform levels and crest levels in the Code of Practice on Surface Water Drainage.

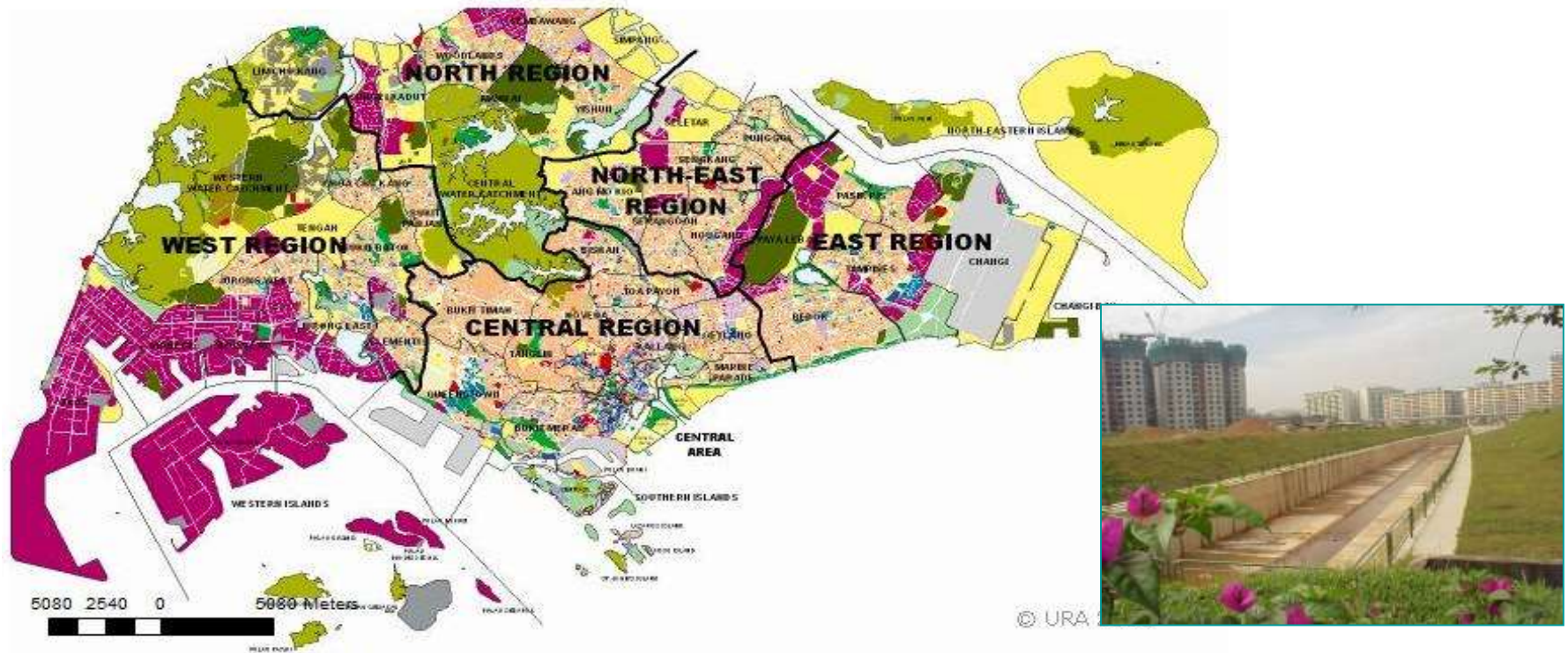


3

Improving drainage in flood prone areas continually by widening or deepening drains, and/or by raising low-lying roads.

# Strategy 1: Providing Adequate Drainage Ahead of Developments

- Involves working with Developing Agencies (e.g. LTA, HDB, JTC, URA) to:
  - identify future/ upcoming major developments
  - secure **Drainage Reserves (DR)**
  - Put in place drainage systems ahead of developments



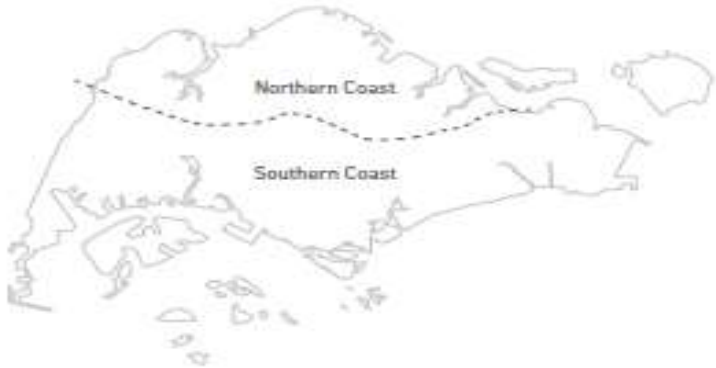


## Strategy 2: Stipulating Flood Protection Requirements

- All developments (including redevelopments and addition & alteration works) are required to make **Development Control** submissions to the various technical agencies, including PUB, to seek technical clearance before commencement of works.

Area Served by Drainage System	Design Return Period (years)
Catchment of less than 100 ha	10
Catchment of 100 to 1000 ha	25
Catchments of more than 1000ha or critical installations	50 to 100

- PUB's Code of Practice on Surface Water Drainage also specifies:
  - Minimum platform level (MPL)
  - Minimum crest level for openings to basements
  - Reclamation Levels
  - Flood protection measures
  - Pumped drainage systems

# Minimum Platform Level (MPL)

FACTOR	MINIMUM PLATFORM LEVEL REQUIREMENTS FOR:	
<p>location</p> 	<p>Developments in catchments discharging to the:</p> <ul style="list-style-type: none"> <li>• <b>Northern Coast:</b> 104.5 mRL</li> <li>• <b>Southern Coast:</b> 104.0 mRL</li> </ul>	
<p>development typology</p> 	<ul style="list-style-type: none"> <li>• <b>General developments:</b> 300 mm above the adjacent road/ground level</li> <li>• <b>Commercial/Multi-Unit Residential developments with basements:</b> 600 mm above the adjacent road/ground level</li> <li>• <b>Special facilities and developments with linkages to special underground facilities:</b> 1 m above the adjacent road/ground level</li> </ul>	
<p>flood history</p> 	<p><b>Areas with Flood History</b></p> <ul style="list-style-type: none"> <li>• <b>General developments:</b> 600 mm above the highest recorded flood level</li> <li>• <b>Commercial/Multi-Unit Residential developments with basements:</b> 600 mm above the highest recorded flood level</li> <li>• <b>Special facilities and developments with linkages to special underground facilities:</b> 1 m above the highest recorded flood level</li> </ul>	

# Minimum Crest Levels

- Additional crest protection is provided at entrances to basements or underground facilities
  - Stairs/road humps
  - Flood barriers
- Applies to all points of flood water intrusions, incl ventilation shafts



# Flood Barriers

For developments with constraints, flood barriers and gates to provide at least the same level of flood protection that the minimum platform and/or crest levels would provide for the building

Tanglin Mall flood gates - *flat*



Tanglin Mall flood gates - *activated*



Lucky Plaza flood gates - *flat*



Lucky Plaza flood gates - *activated*



# Strategy 3 – Improving/Upgrading Our Drainage Systems

- PUB has an island-wide drainage improvement programme.
- Drainage improvement works include widening and deepening, constructing diversion canals and catchment level detention systems

**Before**



**After**



*Bukit Timah Canal*

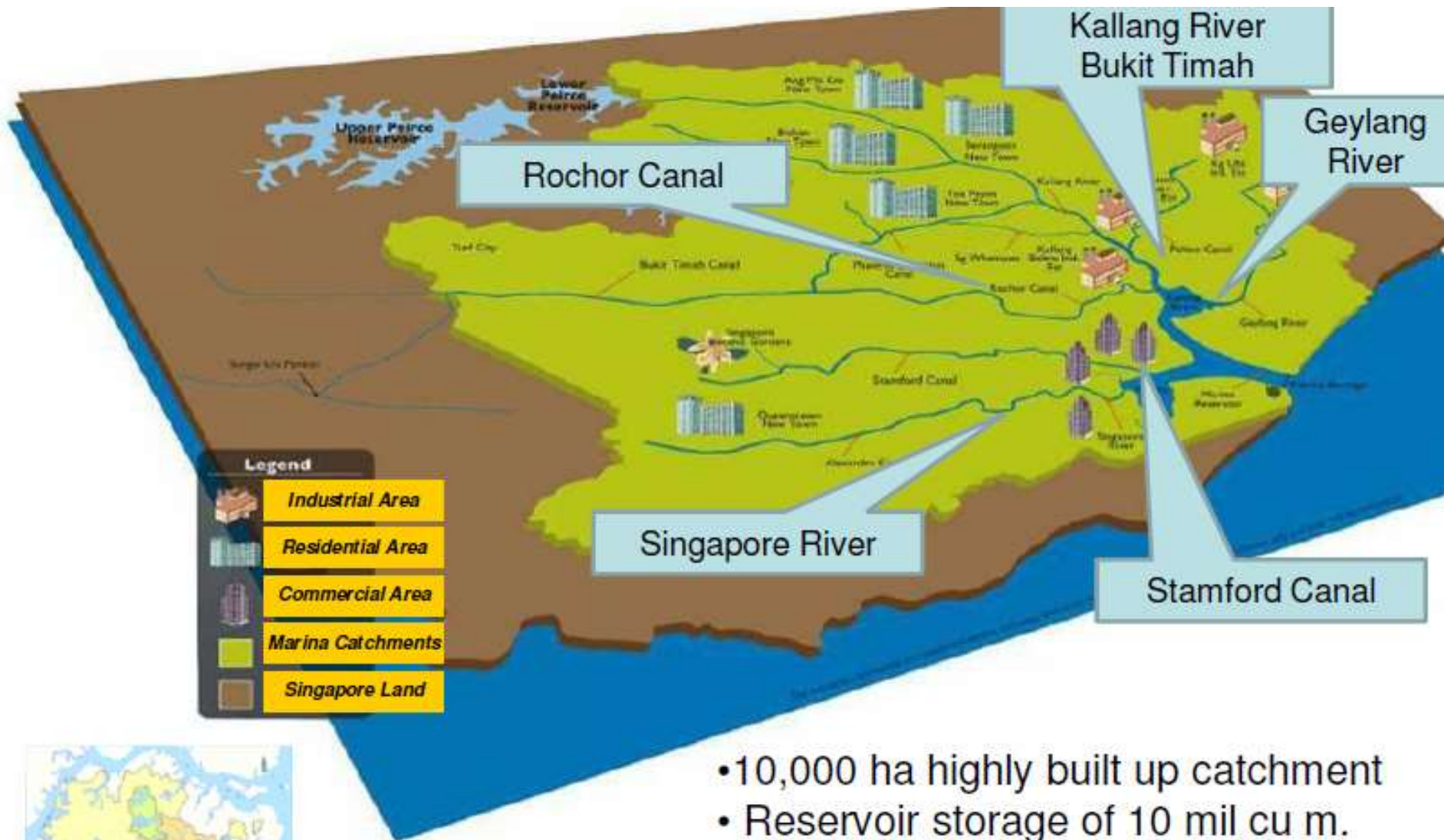
*Sunset Drive*

*Lorong Sarina*

# MARINA BARRAGE: 3 IN 1 SOLUTION



# Marina Barrage Overview



# Marina Barrage: 3-in-1 Benefits

**Completed in 2008 at a cost of \$226mill**

## **Flood control**

- Acts as a tidal barrier to keep seawater out and alleviates flooding in the low-lying city areas such as Chinatown and Little India

## **Water Supply**

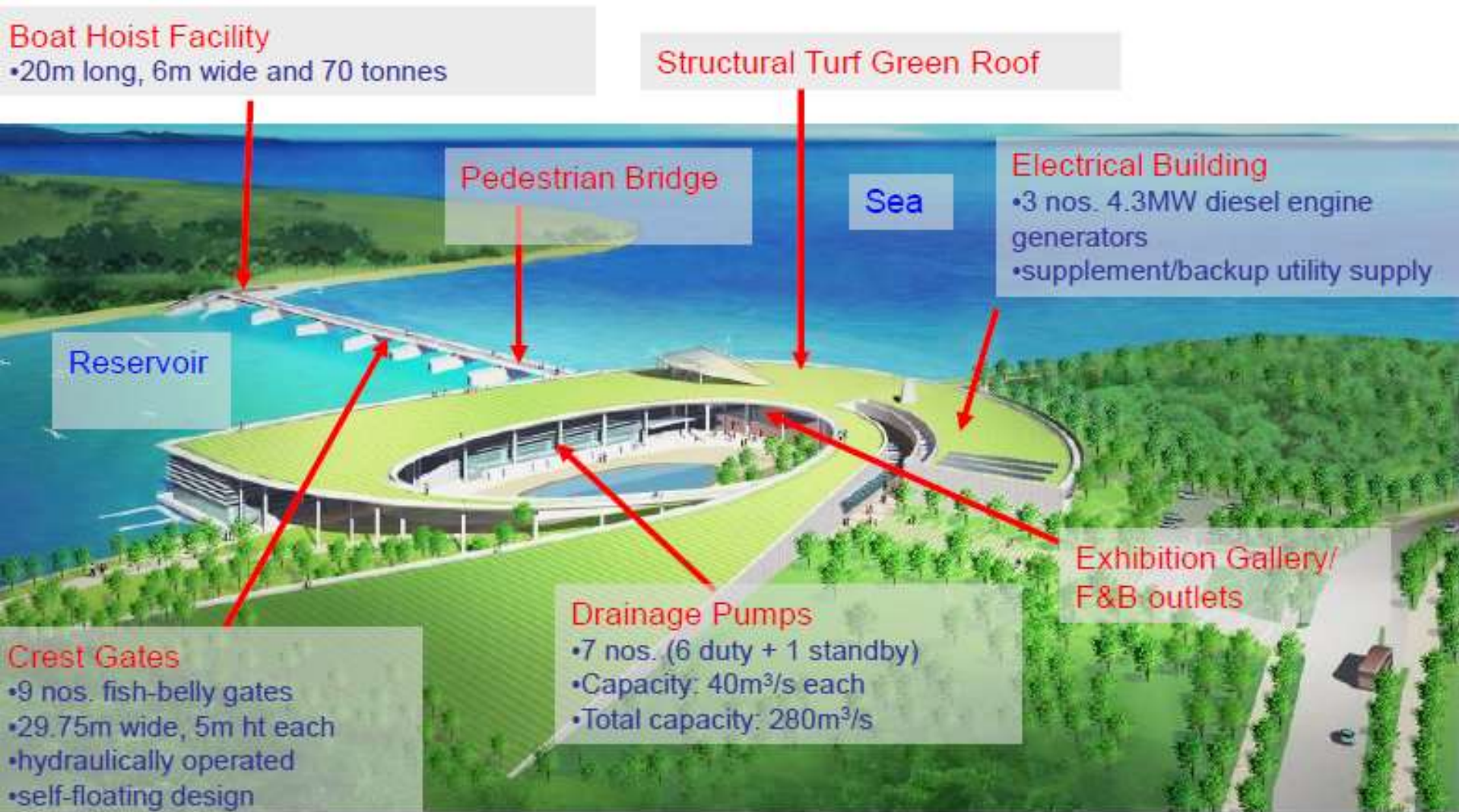
- Boosts Singapore's water supply by creating Singapore's 15th reservoir and its first reservoir in the city

## **Lifestyle attraction in downtown Singapore**

- Hotspot for recreational activities and one of Singapore's iconic landmark

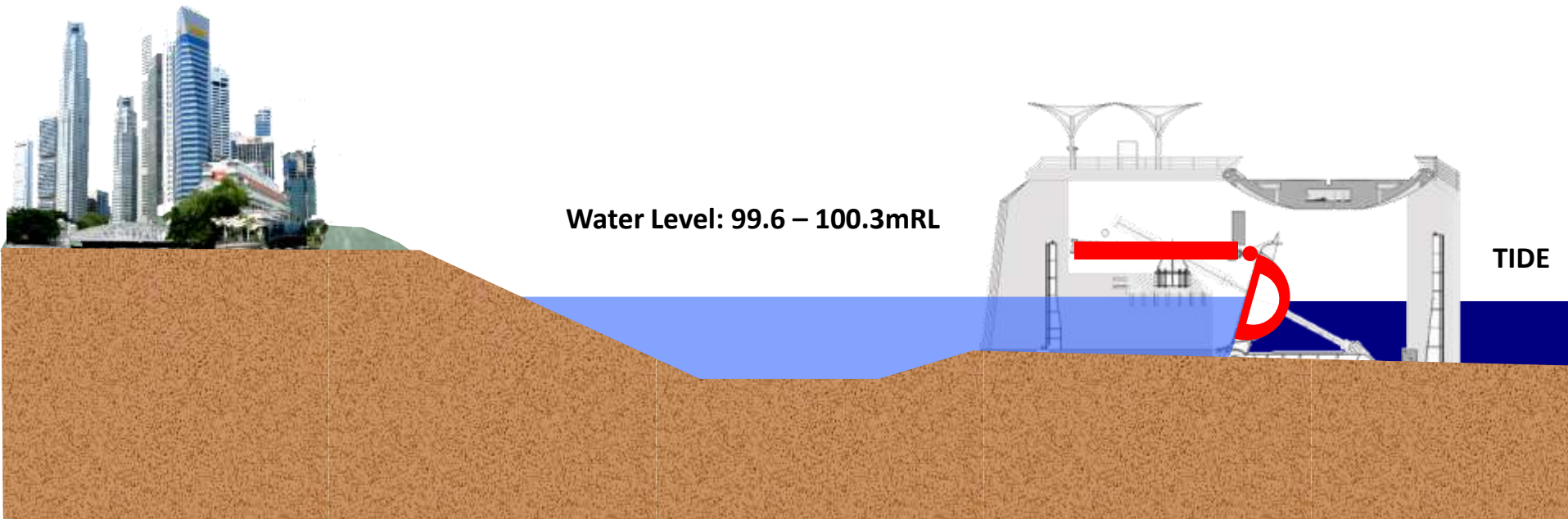


# Overview of Facilities



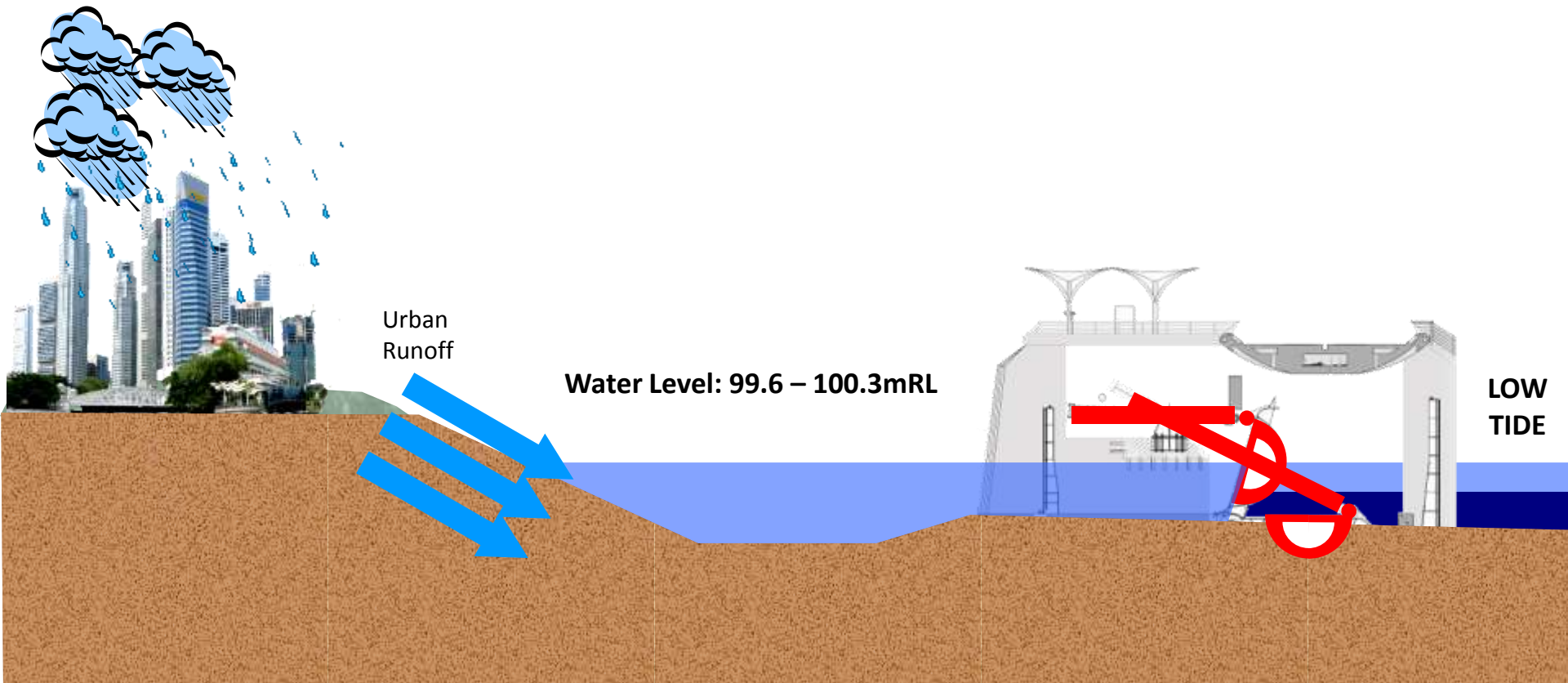
# Marina Barrage - Flood Control

When it is **not raining**, the **crest gates** are **closed**, so a constant water level is achieved throughout the Marina Reservoir and its waterways, regardless of the tide level



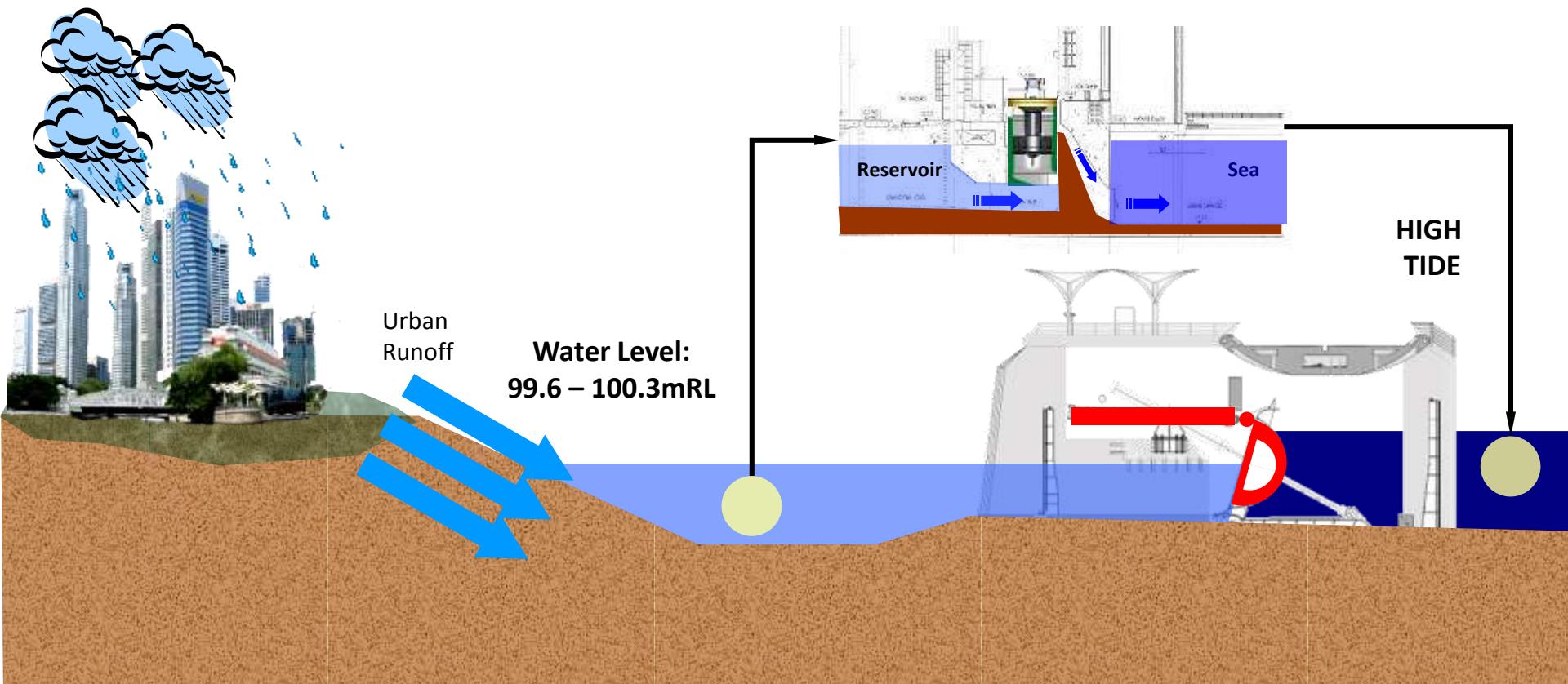
# Marina Barrage - Flood Control

If a **heavy rain coincides** with a **low tide**, the crest gates will be opened to allow the rainwater to flow out to the sea



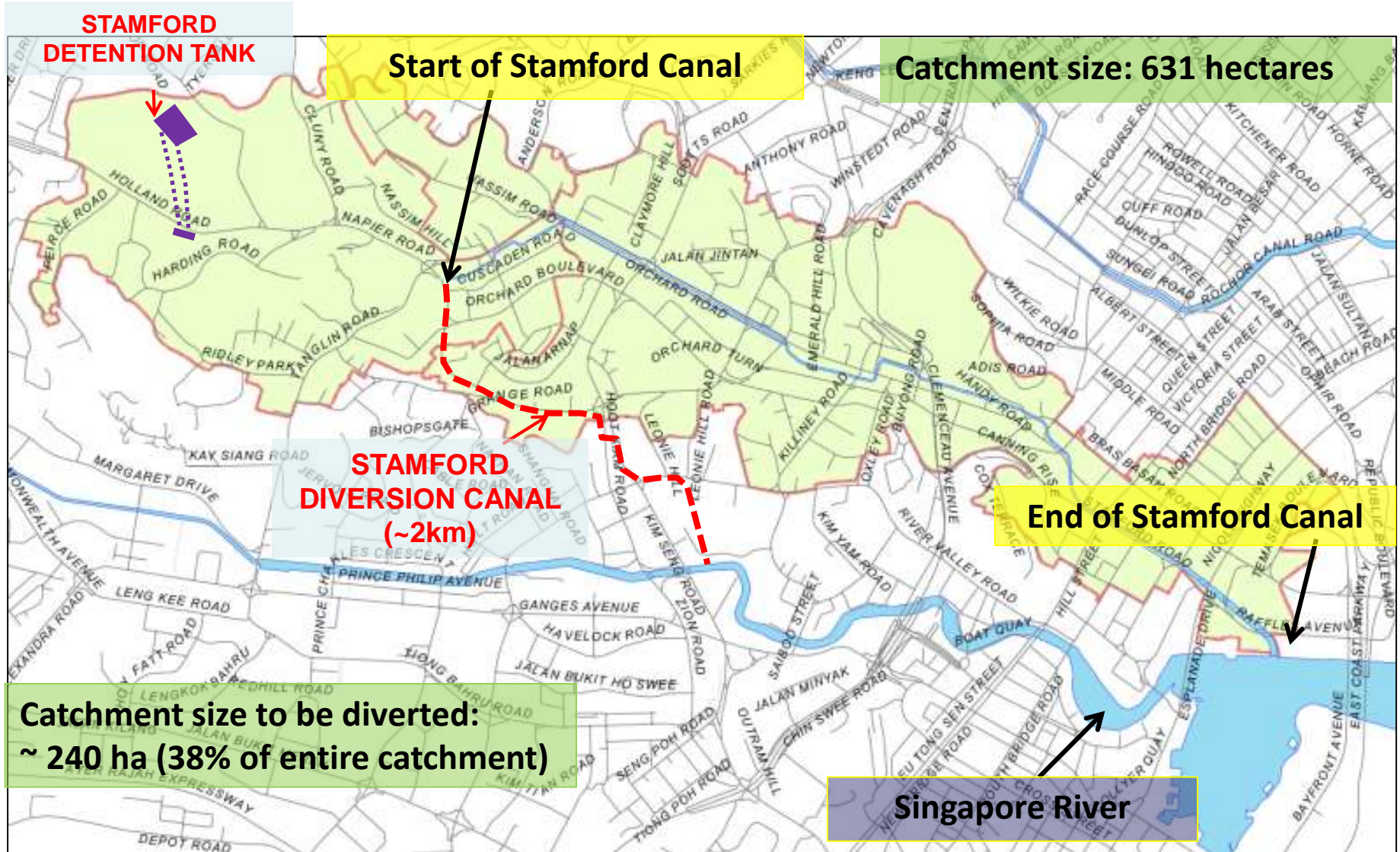
# Marina Barrage - Flood Control

If a **heavy rain coincides** with a **high tide**, the crest gates will be closed to keep the tide out. Pumps will be activated to pump the excess water out into the sea



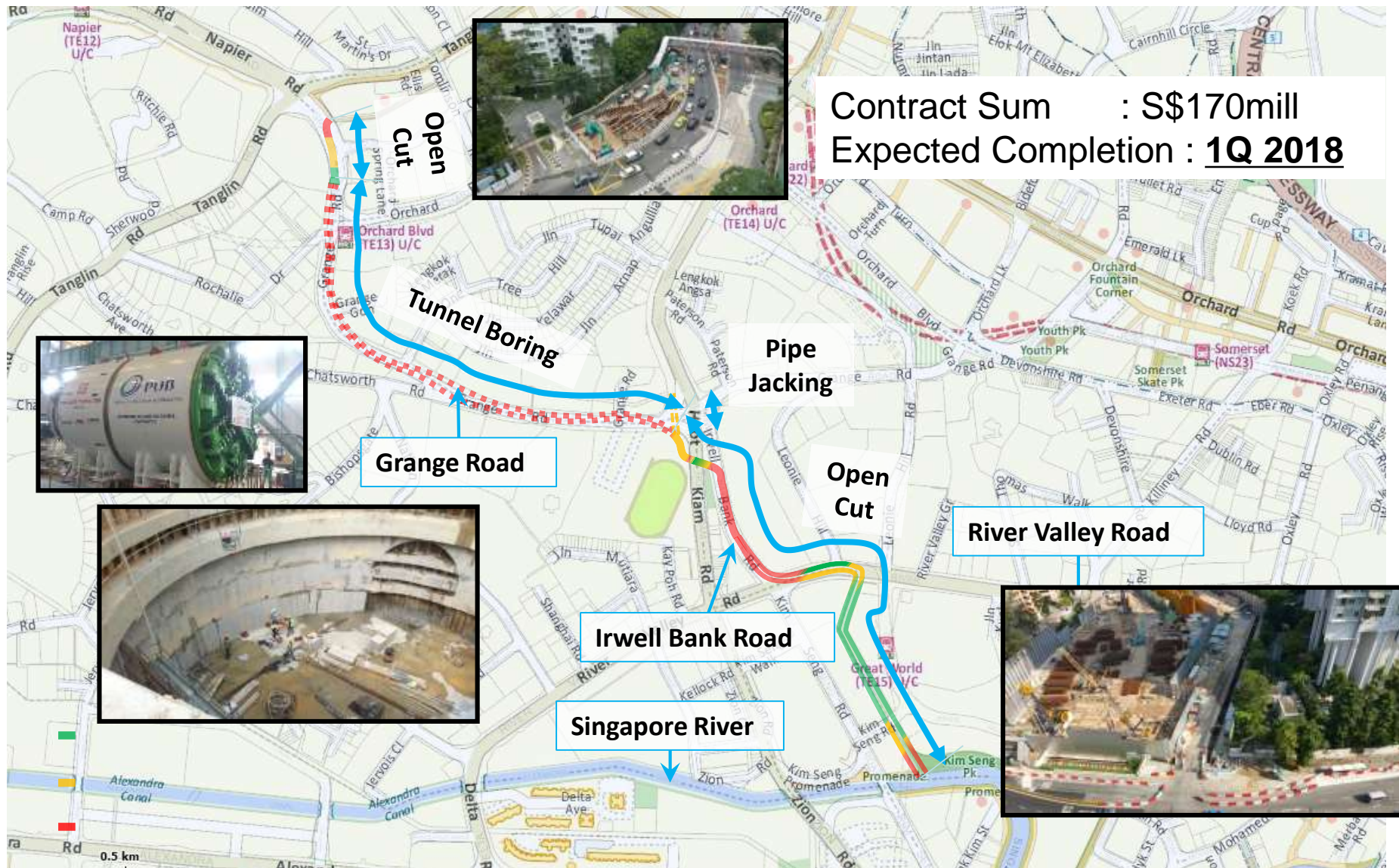
# INFRASTRUCTURAL SOLUTIONS TO RESOLVE FLOODING IN THE STAMFORD CATCHMENT

# Overview of Stamford Catchment





# Stamford Diversion Canal

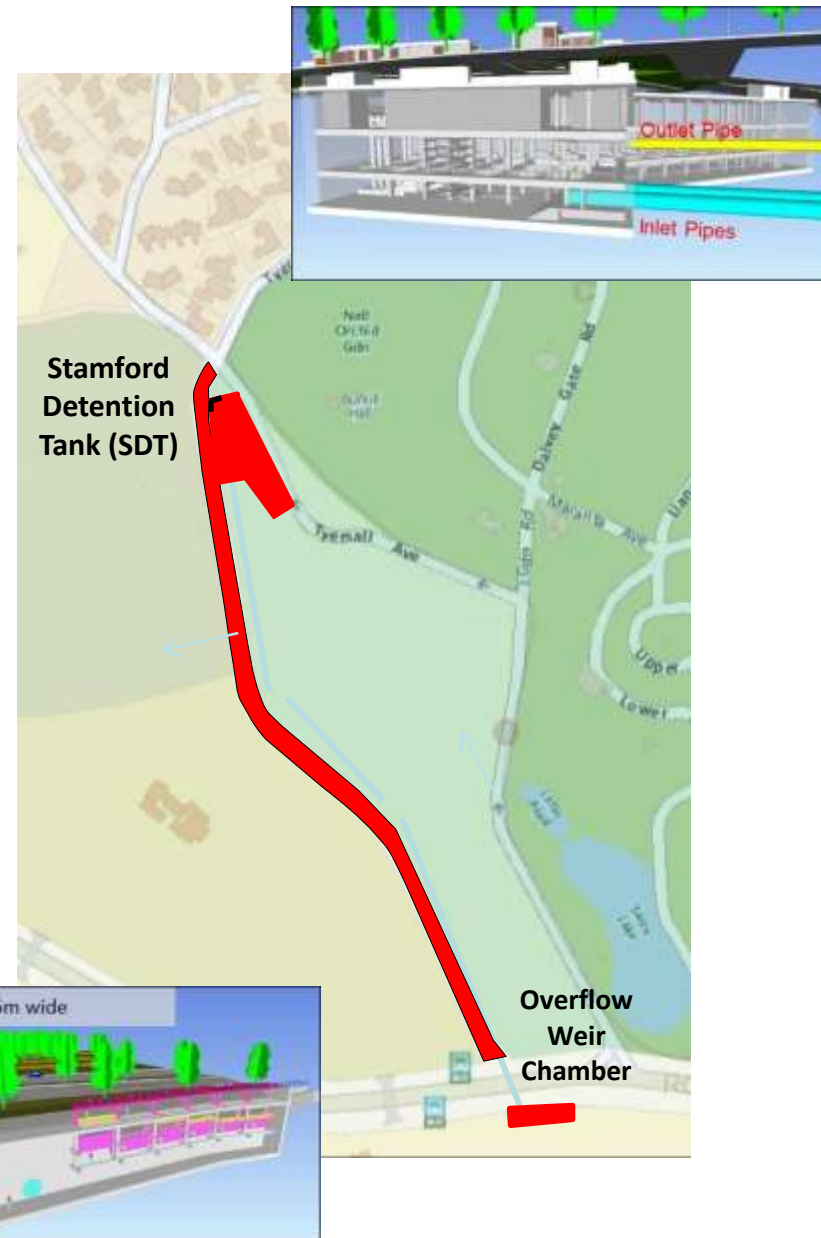


# Stamford Detention Tank

Tank captures excess storm water from the existing drains along Holland Road. The water will then be pumped back to the drains, to be discharged into the Marina Reservoir via the new diversion canal.

Contract Sum : S\$70mill

Expected Completion : **1Q 2017**

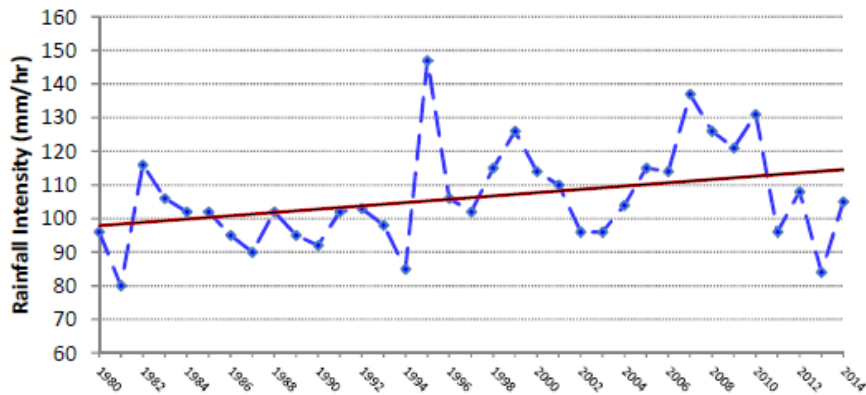


# PREPARING FOR WEATHER UNCERTAINTIES AND CLIMATE CHANGE

# Need for a Holistic Approach

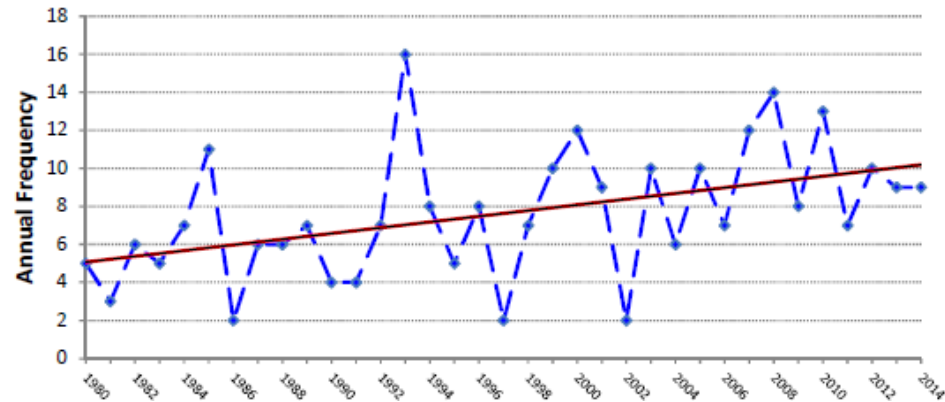
- Constraints of the Conventional Approach
  - Not economical to build drains to cater for most extreme events
  - Limited land available to widen and deepen drains
- Rainfall intensity records over the past 34 years (1980 to 2014) also show **strong evidence of a trend towards higher rainfall intensities and frequency of intense rains.**

Annual Maximum 60-min Rainfall Total in Singapore  
(1980 - 2014)



*Annual hourly maximum rainfall shows an upward trend of 4.9mm per decade.*

Annual Number of Days with Hourly Maximum Rainfall  
Intensity  $\geq 70$ mm in Singapore (1980-2014)

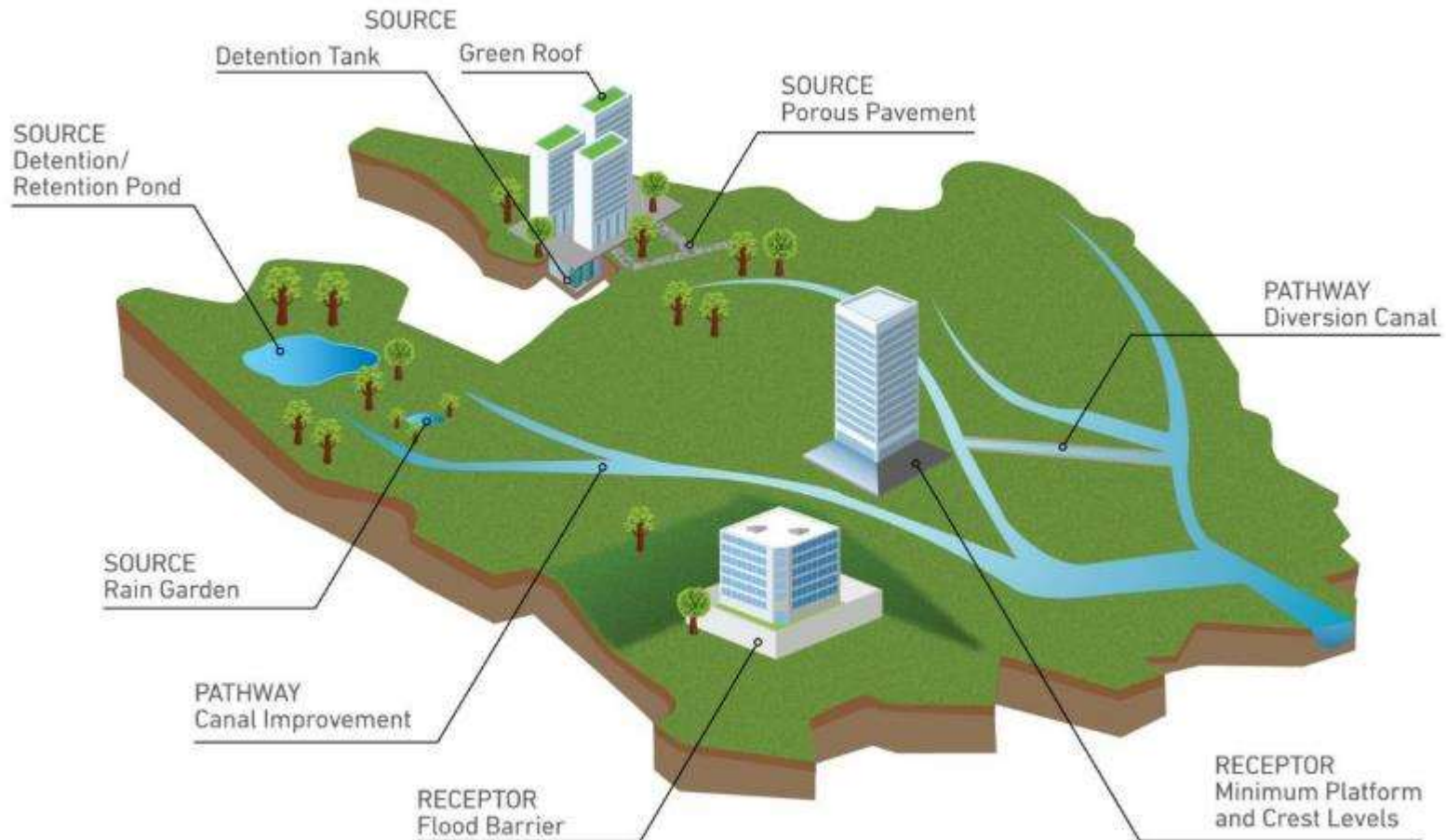


*Annual frequency of occurrence of maximum hourly rainfall exceeding 70mm shows an upward trend of 1.5days per decade.*

- Climate Change projections expect increases in rainfall intensity of between 20% to 25% by 2100

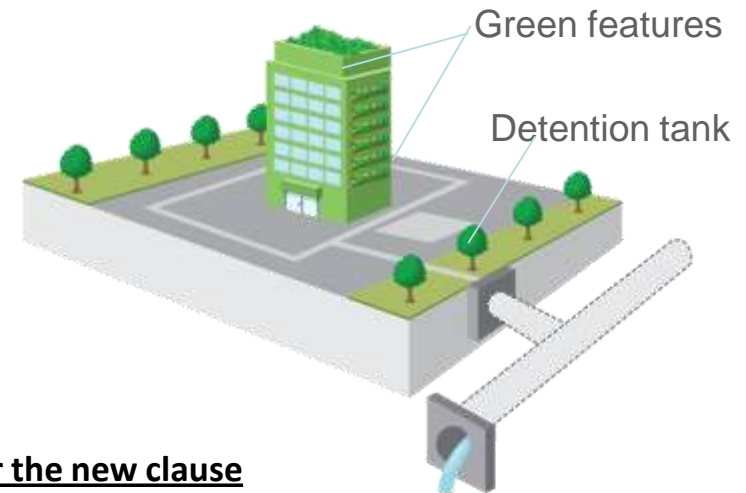
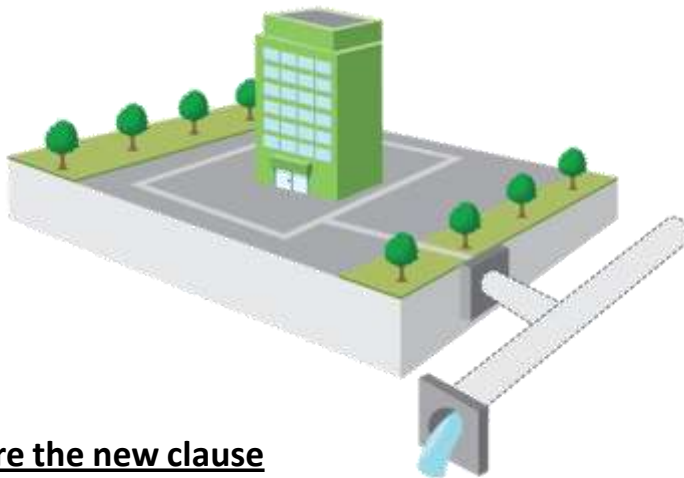
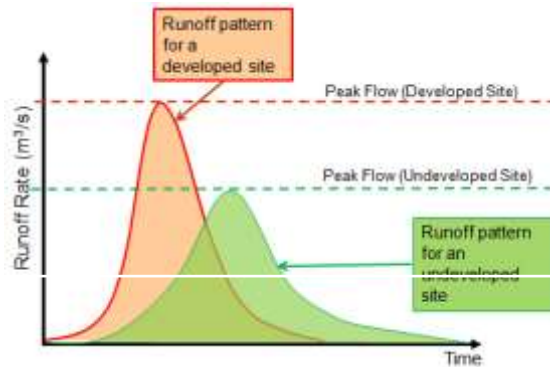
# Source-Pathway-Receptor Approach

A holistic, catchment-wide approach is needed to strengthen overall flood resilience where measures are implemented at all parts of the drainage system to **build in flexibility and adaptability** to cope with higher intensity storms.



# Managing Peak Runoff at Source

- Since Jan 2014, PUB introduced a new requirements for developments to slow down and capture of urban runoff within developments via ABC Water design features, detention tanks/ ponds, etc



## Before the new clause

About 80% - 90% of rainwater that falls on the site is translated into surface runoff and discharged immediately during a storm

## After the new clause

Detention tank and green features will slow down and reduce peak flows discharged to the public drainage system by 25% to 35%.

# ACTIVE, BEAUTIFUL, CLEAN WATERS (ABC WATERS) PROGRAMME

# ABC Waters Programme

Long-term strategic initiative to enhance our water and bring Singaporeans closer to water so that they can appreciate and cherish this precious resource

## ACTIVE:

- Providing new community and recreational spaces

## BEAUTIFUL:

- Improving the aesthetics of the urban environment

## CLEAN:

- Improving water quality through:
  - (a) natural cleansing features and
  - (b) public education by building closer people-water relationships





# Transformation of the Kallang River at Bishan Park



# Clean - Improving water quality using ABC Waters design features



**Vegetated Swale and Rain Garden @ Kallang River (Potong Pasir)**



**Constructed Wetland @ Lorong Halus Wetland**



**Cleansing Biotope @ Bishan - AMK Park**



**Sedimentation basin @ Sg Ulu Pandan**

Thank you

