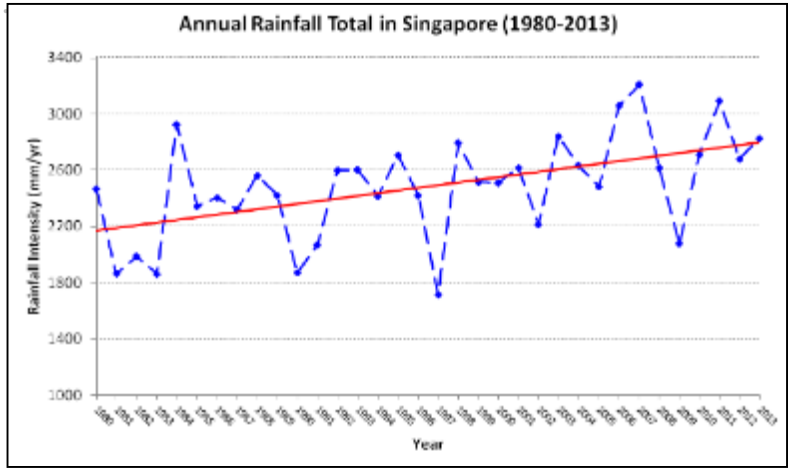
Managing Peak Runoff at Source



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Stormwater Management



CHALLENGES

- Historical rainfall data shows a trend towards higher rainfall intensities
- Climate change projections indicate increase in rainfall intensities
- Increased urbanisation



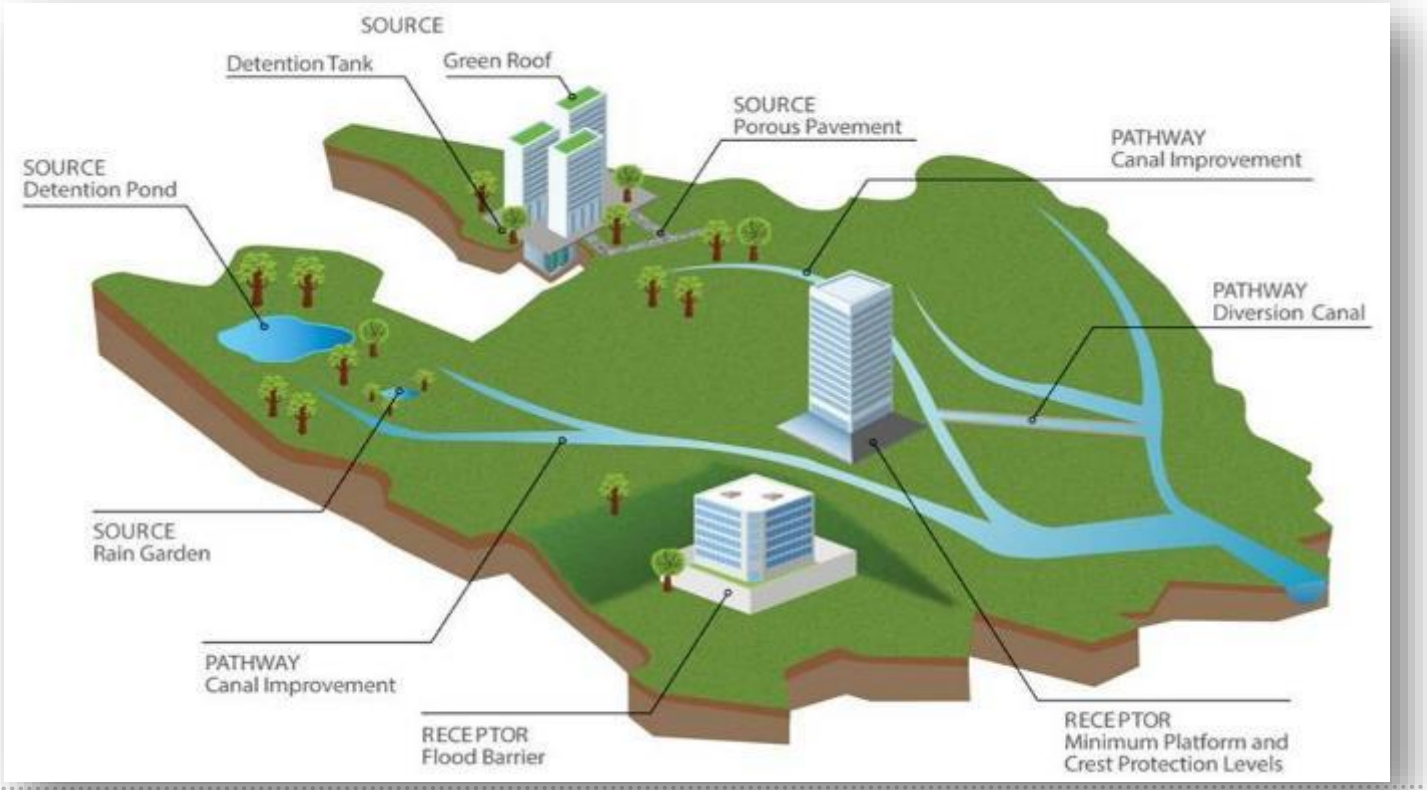
OUTCOME

- Increased peak flows in public drainage system

Holistic Stormwater Management

PUB adopt a holistic, catchment-wide approach to strengthen overall flood resilience

- Addresses not just the pathway over which the rainwater travels (i.e. "**Pathway**" solutions), but also controlling rainwater at where it falls onto the ground, (i.e. "**Source**" solutions) and at the areas where floods may occur (i.e. "**Receptor**" solutions)
- Builds flexibility and adaptability into the entire drainage system



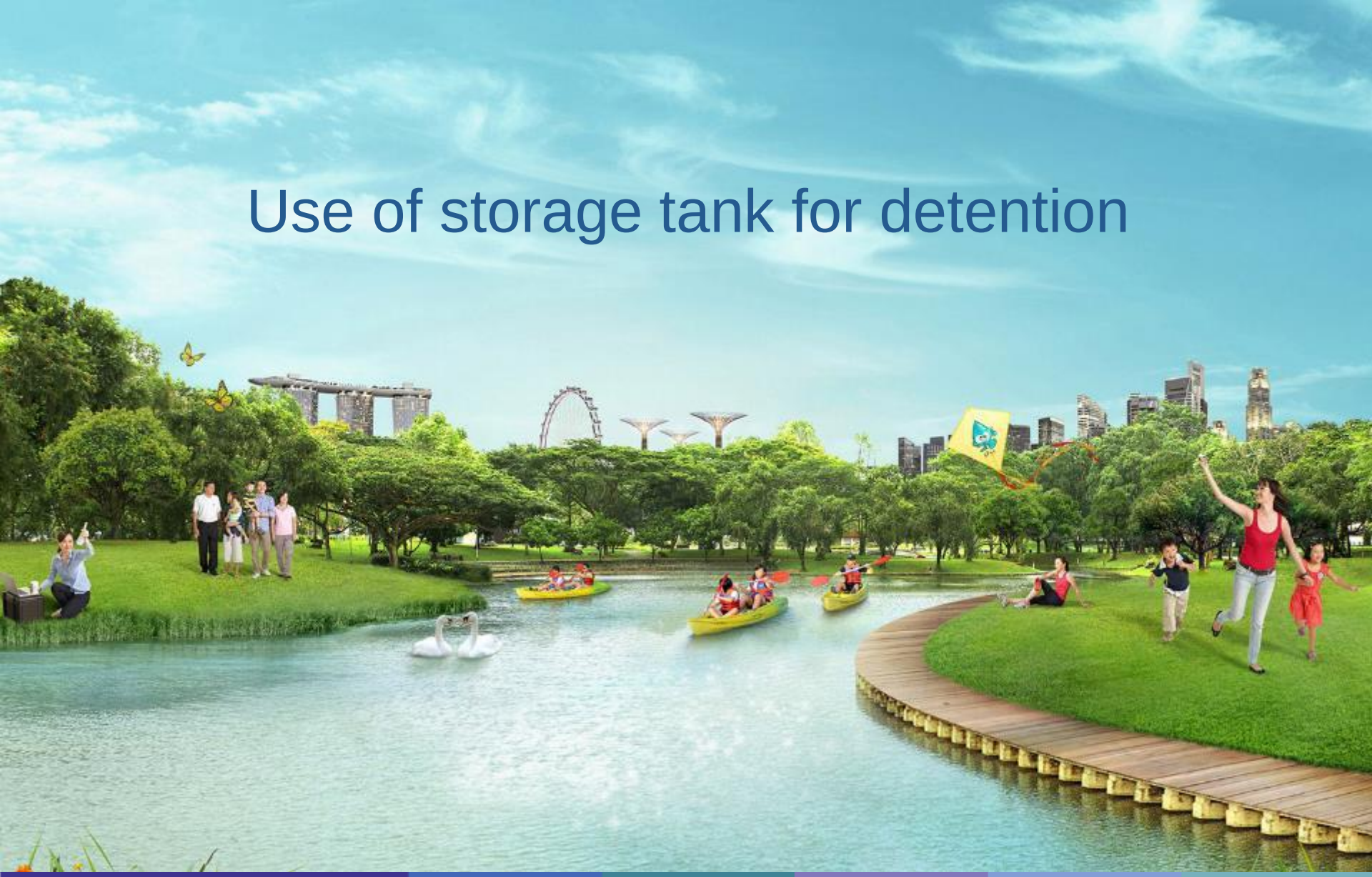
Clause 7.1.5 Maximum Allowable Peak Runoff

Since 2014, it is mandatory that all **new and redeveloped industrial, commercial, institutional and residential developments greater than or equal to 0.2 hectares** in size have to control peak runoff discharged from the development sites.

The **maximum allowable peak runoff** to be discharged to the public drains will be **calculated based on a runoff coefficient of 0.55**, and for design storms with a return period of 10 years and for various storm durations of up to 4 hours (inclusive).

Peak runoff reduction can be achieved through **the implementation of ABC Waters design features and structural detention and retention features.**

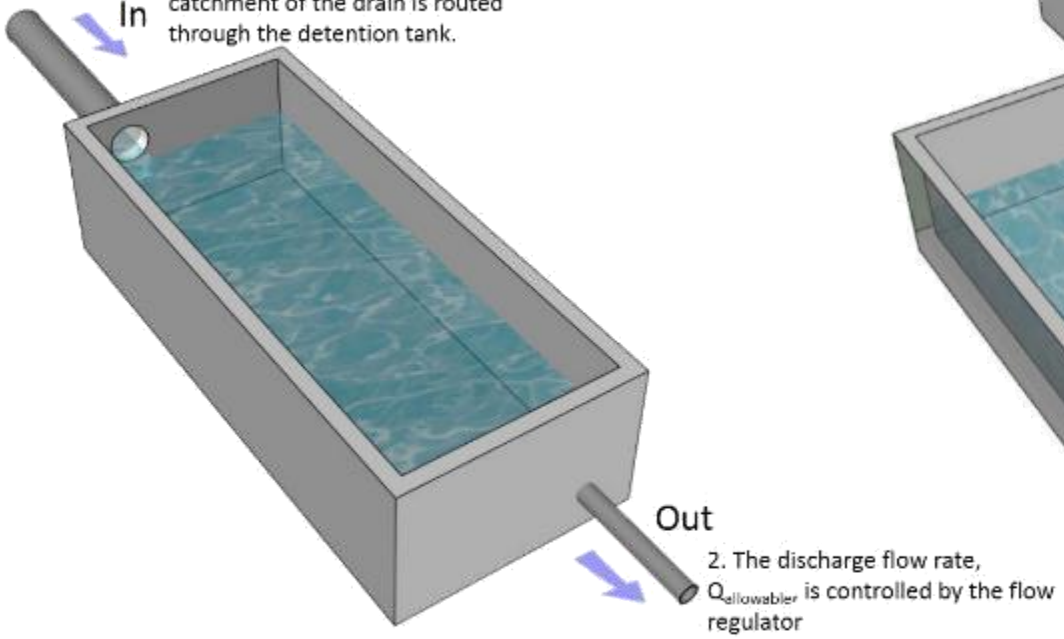
Use of storage tank for detention



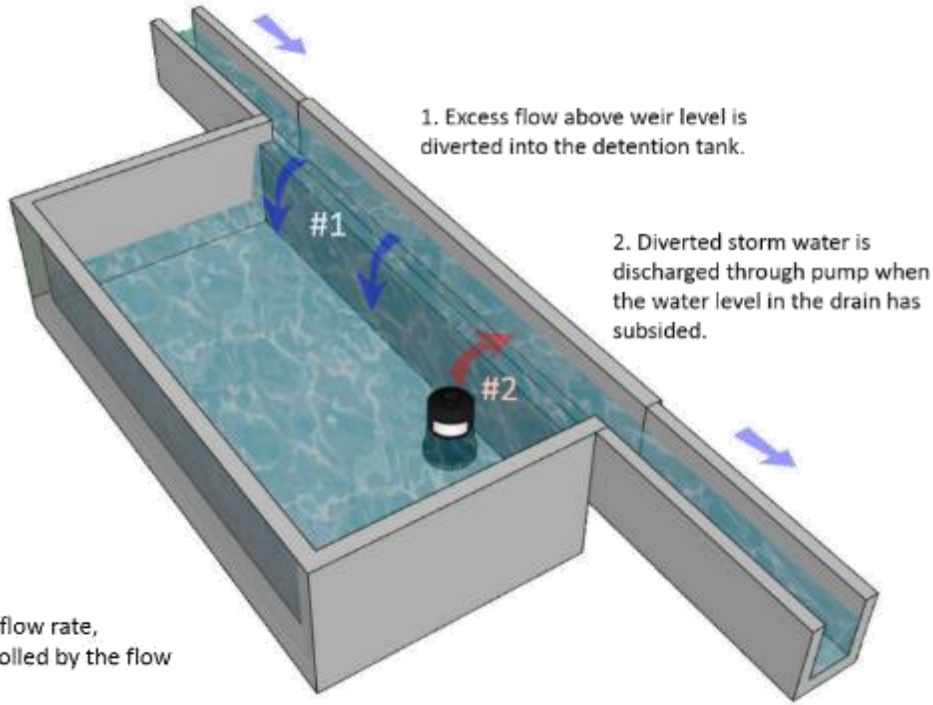
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Types of Detention Systems

Online



Offline

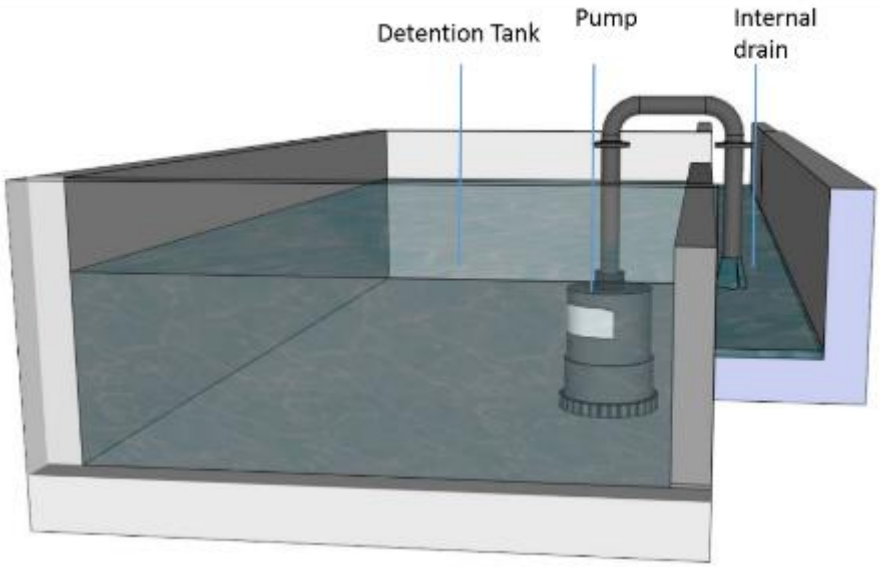


Types of Detention Systems

Discharge Methods

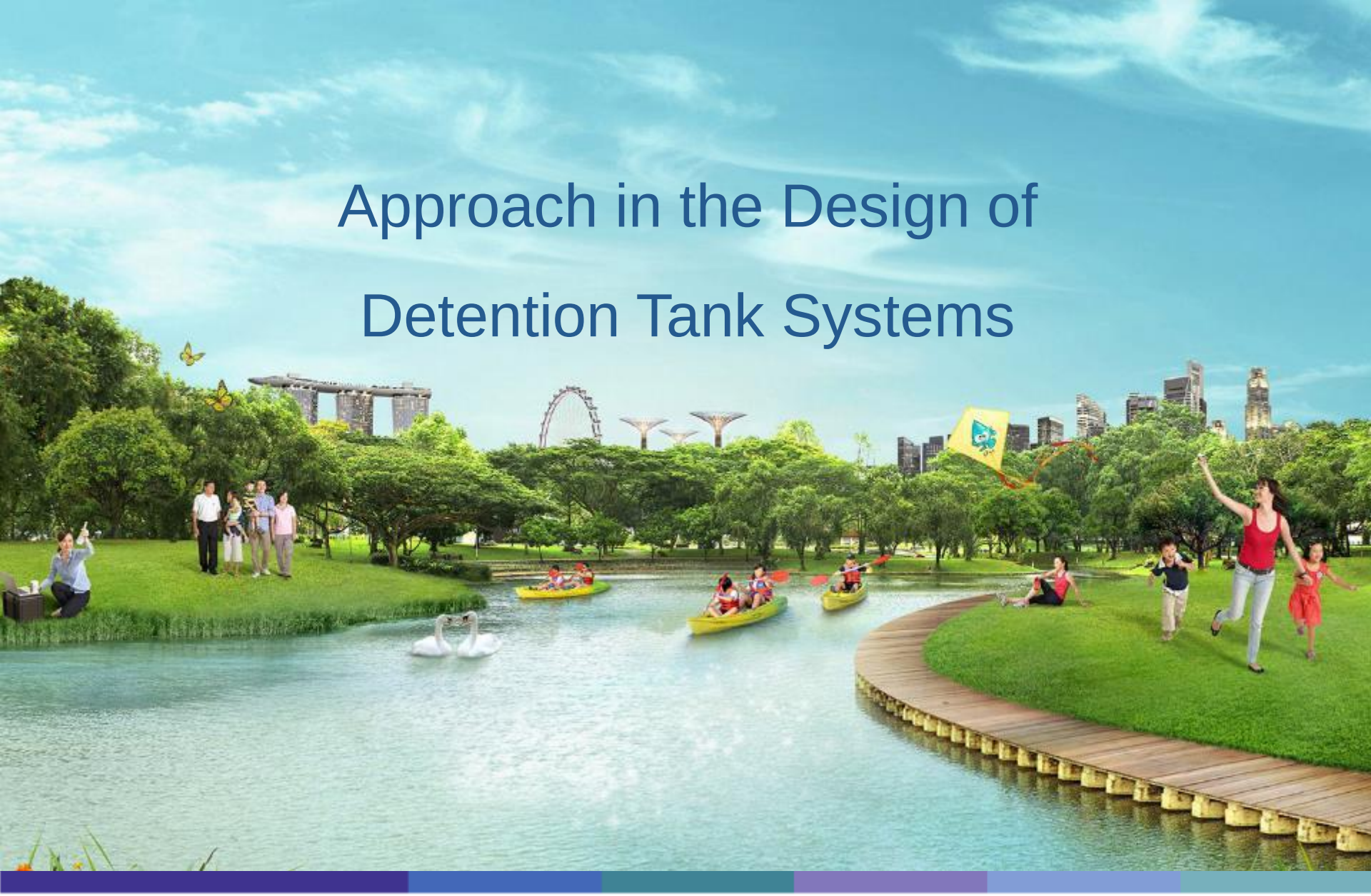


Gravity Discharge



Pumped Discharge

Approach in the Design of Detention Tank Systems



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Step 1: Compare Post-development discharge vs Maximum Allowable

Development site discharging to one public drain

Post-development peak discharge

$Q_{post} = CiA/360$

C: Weighted C
i: $8913/(t_c+36)$
A: Entire site area

Maximum Allowable peak discharge

$Q_{allowable} = CiA/360$

C: 0.55
i: $8913/(t_c+36)$
A: Entire site area

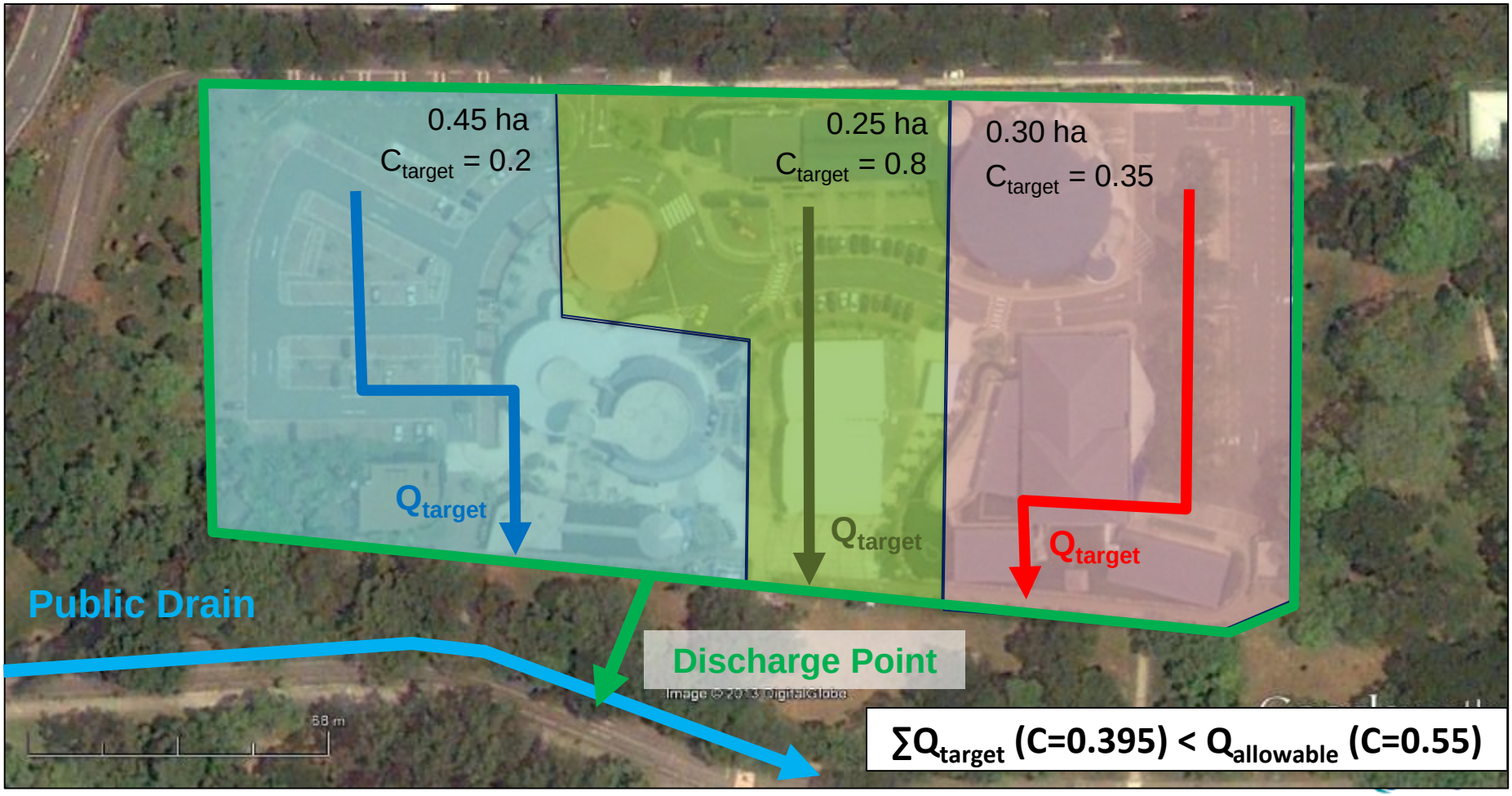


Step 2: Determine Catchment Area for the Detention Tank System

Development site discharging to one public drain

$$Q_{target} + Q_{target} + Q_{target} \leq Q_{allowable}$$

(for sites with more than 1 sub-catchment discharging into the same public drain)



Step 1: Compare Post-development discharge vs Maximum Allowable

Development site discharging to two or more different public drains

Post-development peak discharge

$Q_{post} = CiA/360$

C: Weighted C
i: $8913/(t_c+36)$
A: Entire site area

Maximum Allowable peak discharge

$Q_{allowable} = CiA/360$

C: 0.55
i: $8913/(t_c+36)$
A: Entire site area



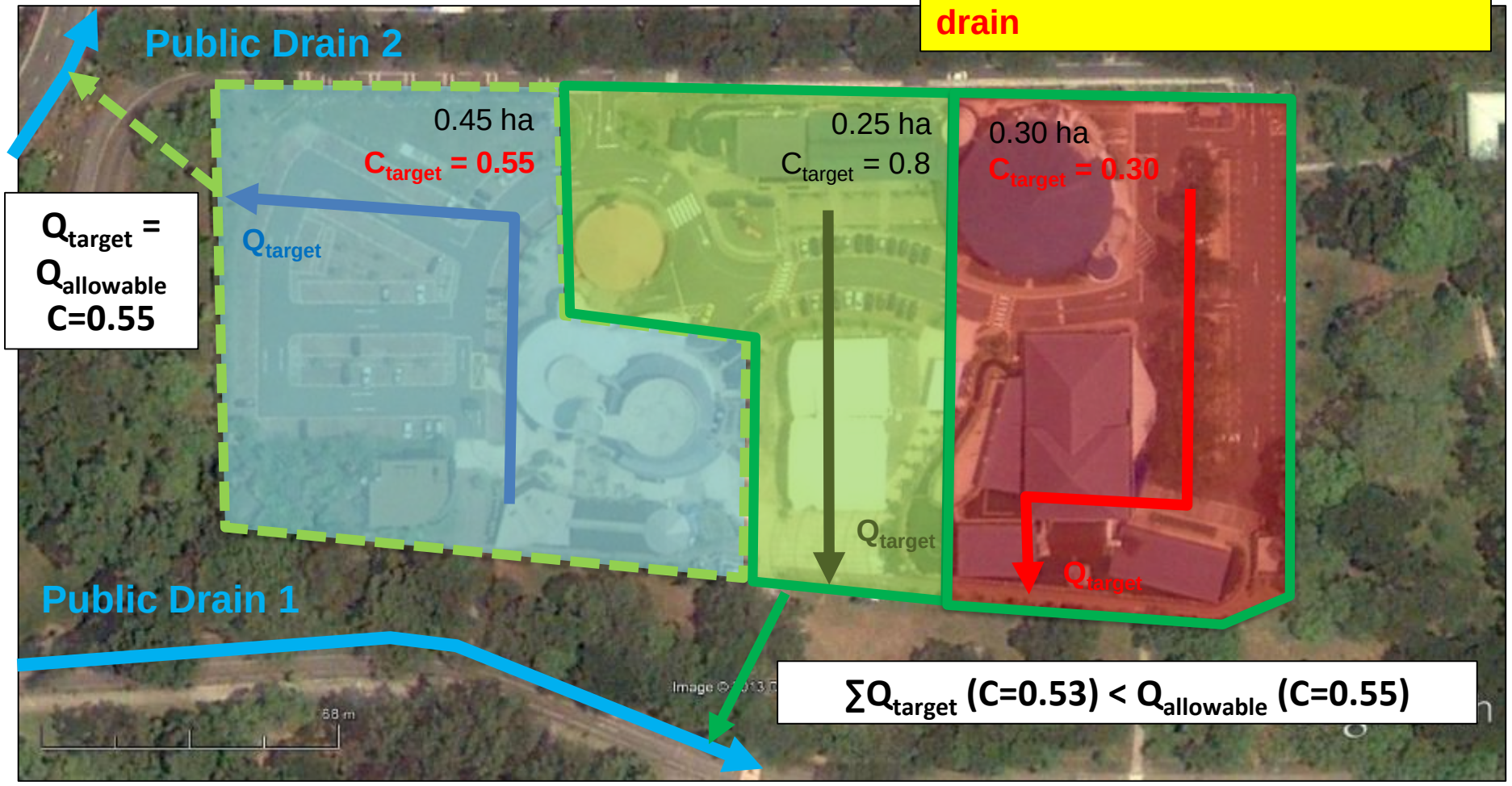
Step 2: Determine Catchment Area for the Detention Tank System

Development site discharging to two or more different public drains

Public Drain 1: $Q_{target} + Q_{target} \leq Q_{allowable}$

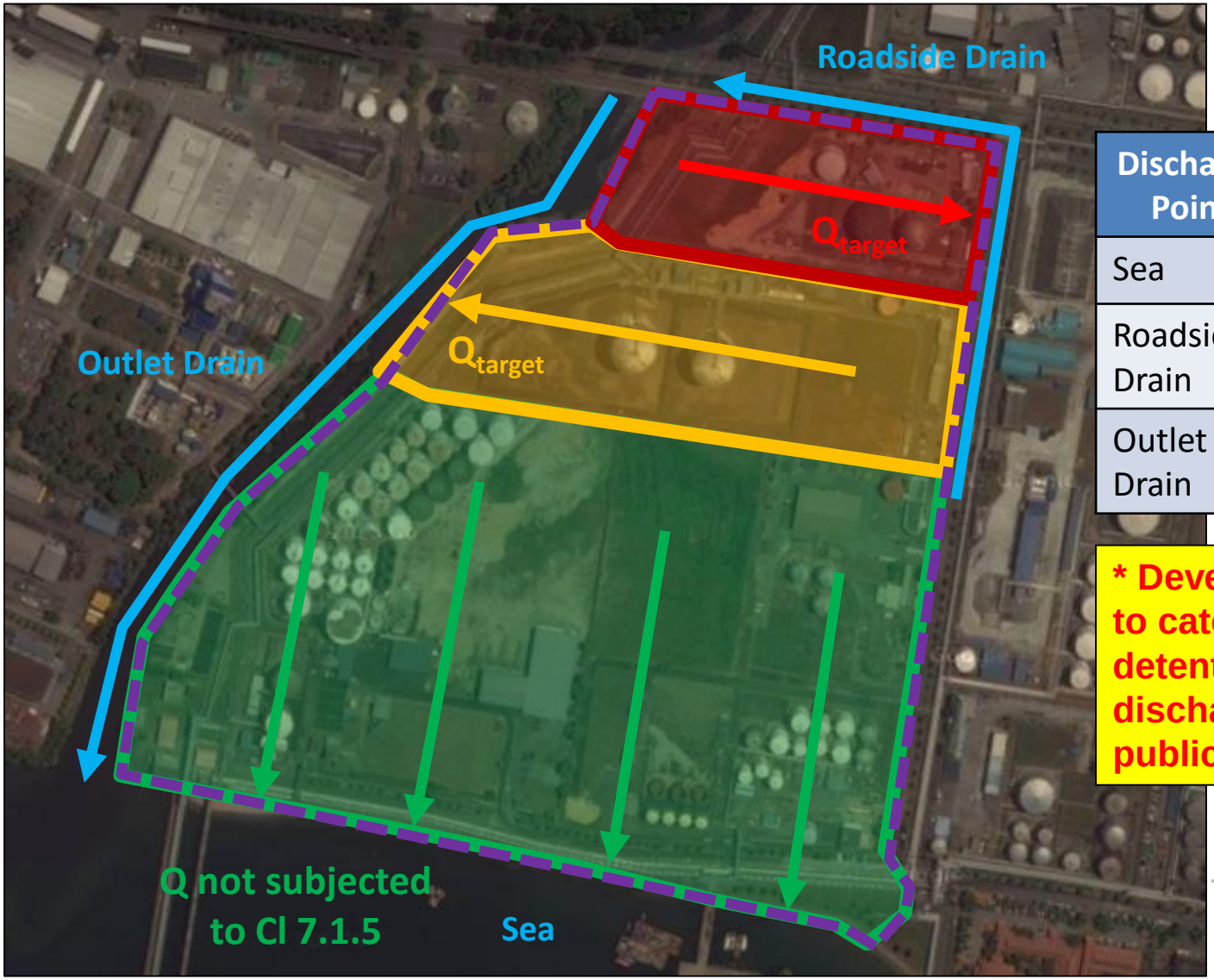
Public Drain 2: $Q_{target} \leq Q_{allowable}$

*** Development will need to cater for separate detention systems for discharge into each public drain**



Step 2: Determine Catchment Area for the Detention Tank System

Development site discharging to **sea and public drain(s)**



Discharge Point	Clause 7.1.5
Sea	Not applicable
Roadside Drain	$Q_{target} \leq Q_{allowable}$
Outlet Drain	$Q_{target} \leq Q_{allowable}$

*** Development will need to cater for separate detention systems for discharge into each public drain**

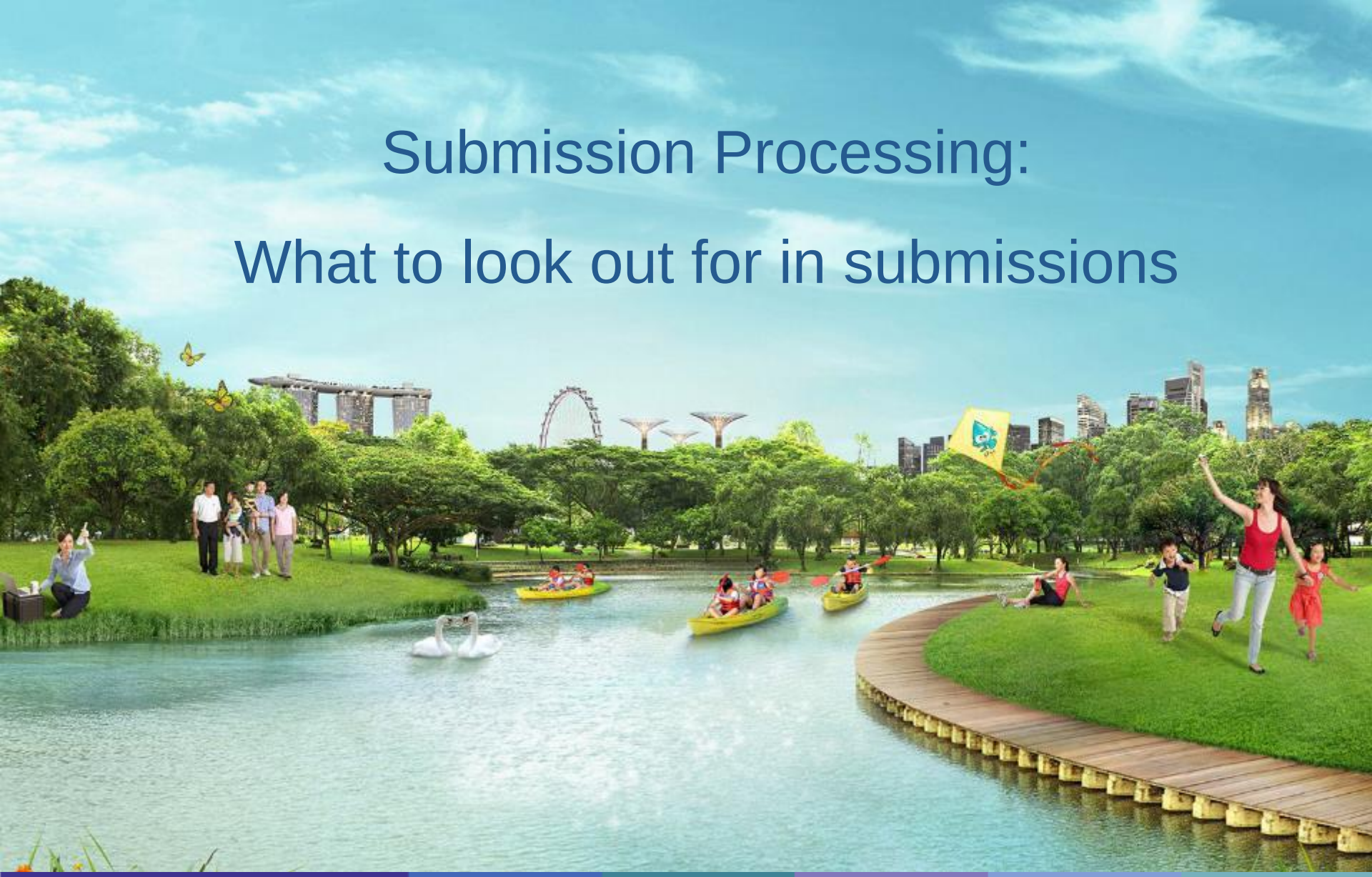
PUB

Step 3: Select the Type of Detention System to adopt

Type of System	**Online**			**Offline**
Time of Discharge	**During Storm**		**After Storm**	**After Storm**
Discharge Mechanism	**Gravity**	**Pumped**	**Gravity/Pumped**	**Gravity/Pumped**
Benefits	• No M&E components	• Suitable for most sites	• Runoff from the remainder of the site may be left uncontrolled	• Requires smaller detention volume
Limitations	• Requires sufficient elevation difference between proposed system inlet and outlet point	• Pumping required for every storm event (associated O&M cost)	• Requires large detention volume	• Pumping required for every storm event (associated O&M cost)

Submission Processing:

What to look out for in submissions



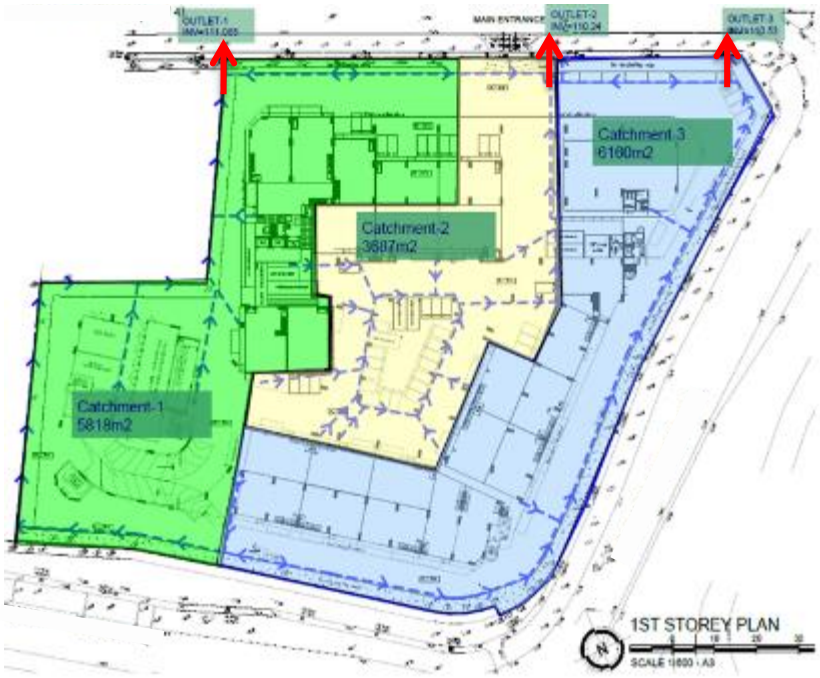
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Proposed Treatment to the discharge from each sub-catchment

i. Clearly defined Sub-catchment plan

ii. Proposed Outlet discharge points to public drain

iii. Site analysis table with clear description on the proposed detention system to employ for each sub-catchment



Description	Symbol	Catchment 1	Catchment 2	Catchment 3
Sub-catchment area	A (ha)	0.3ha	0.25ha	0.1ha
Weighted runoff coefficient	C_{post}	1.0	1.0	1.0
Time of concentration	t_c (min)	5min	5min	5min
Average rainfall intensity for 10yr storm event	i_{10} (mm/hr)	$\frac{8913}{t_c+36} = 217mm/hr$	$\frac{8913}{t_c+36} = 217mm/hr$	$\frac{8913}{t_c+36} = 217mm/hr$
Peak discharge from sub-catchment	Q_{post} (m^3/s)	$\frac{C_{post} i_{10} A}{360} = 0.181m^3/s$	$\frac{C_{post} i_{10} A}{360} = 0.151m^3/s$	$\frac{C_{post} i_{10} A}{360} = 0.060m^3/s$
Maximum allowable peak discharge for entire site	$Q_{allowable}$	$\frac{C_{0.55} i_{10} A}{360} = \frac{0.55 \times 217 \times 1.0}{360} = 0.332m$		
Target runoff coefficient	C_{target}	0.55	0.93	0
Target peak discharge for sub-catchment	Q_{target} (m^3/s)	$\frac{C_{target} i_{10} A}{360} = 0.099m^3/s$	$\frac{C_{target} i_{10} A}{360} = 0.140m^3/s$	$0m^3/s$
Check $\sum Q_{target} \leq Q_{allowable}$	-	$0.099+0.140+0+0+0.093=0.332m^3/s$ (yes, $\sum Q_t$		
Type of detention system to employ	-	Online, during storm, gravity discharge detention system	Online, during storm, pumped discharge detention system	Direct discharge to public drain
Design calculations template	-	Appendix B	Appendix C	Appendix D

Design Calculations

i. For each sub-catchment
   - Weighted runoff coefficient
   - Post-development peak discharge
   - Maximum allowable peak discharge
   - Detention volume

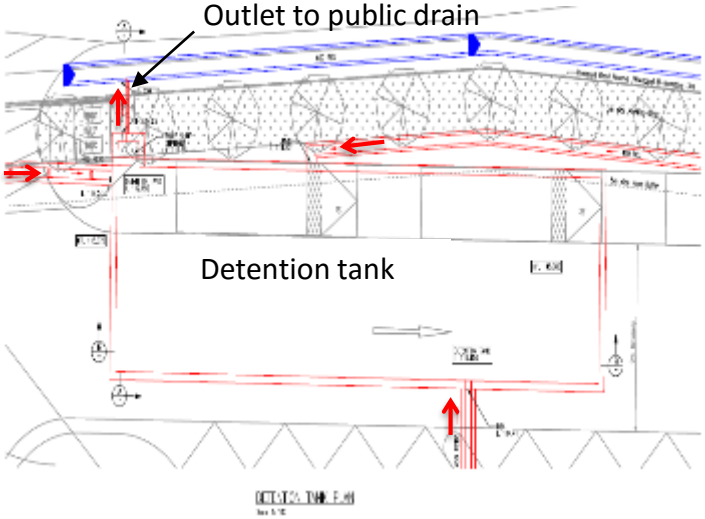
ii. Discharge method of detention tank
   - Gravity: Orifice calculation
   - Pumped: Routing sheets

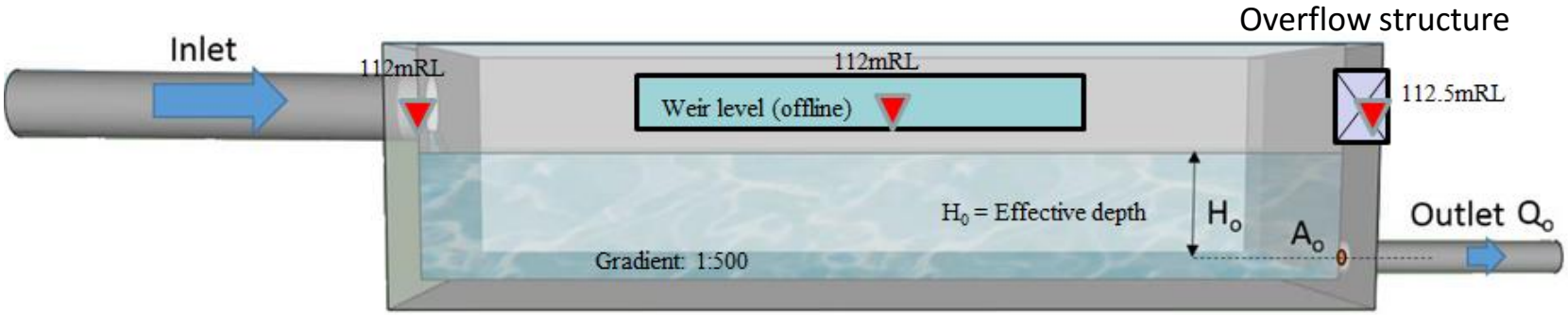
iii. Modelling results (for offline design)



Detention Tank Layout (site plan, section plan)

i. Effective depth of tank
ii. Invert level of inlet drain(s)
iii. Orifice size of outlet drain
iv. Overflow weir level – for offline detention system
v. Overflow structure level – good engineering practice to allow secondary means of discharge for extreme storm events or in the event that system malfunctions





Details of Discharge Configuration

Gravity discharge

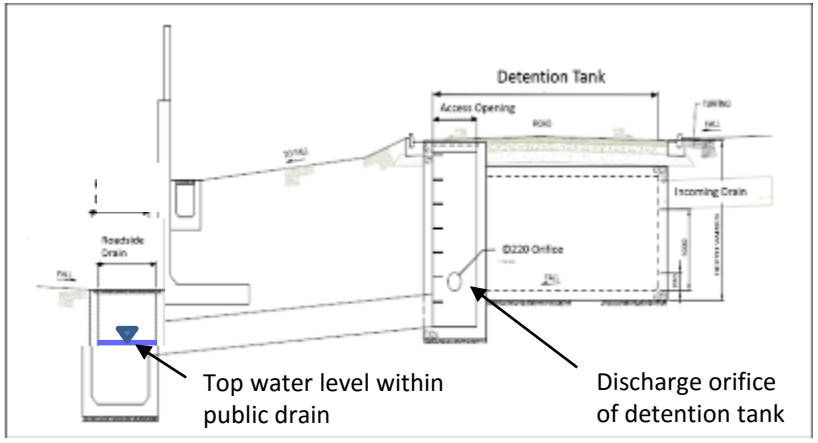
i. Connecting levels to the public drain – orifice to be located above top water level within public drain to prevent back flow

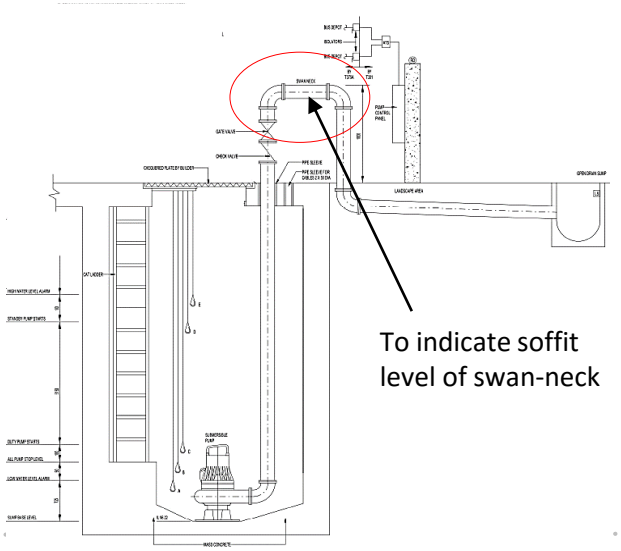
Pumped discharge

i. Provision of swan neck – to meet crest protection requirement in COP

ii. Water level sensors for triggering of pump operations (for after storm discharge system)

iii. Pump operations – numbers and capacity of duty and standby pumps to empty tank within a maximum of 4 hours and their respective operation/cut-off levels





Other Design Considerations

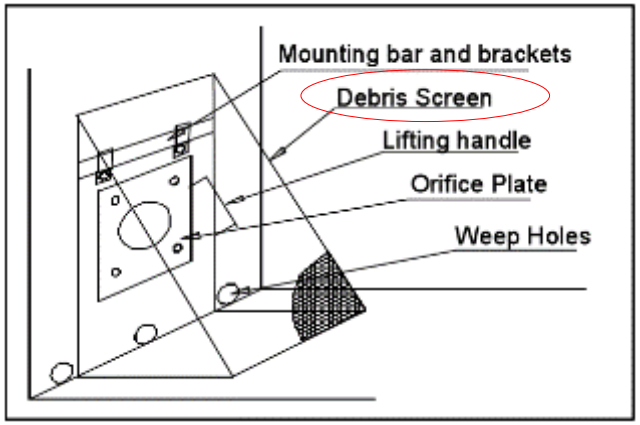
i. Debris screen

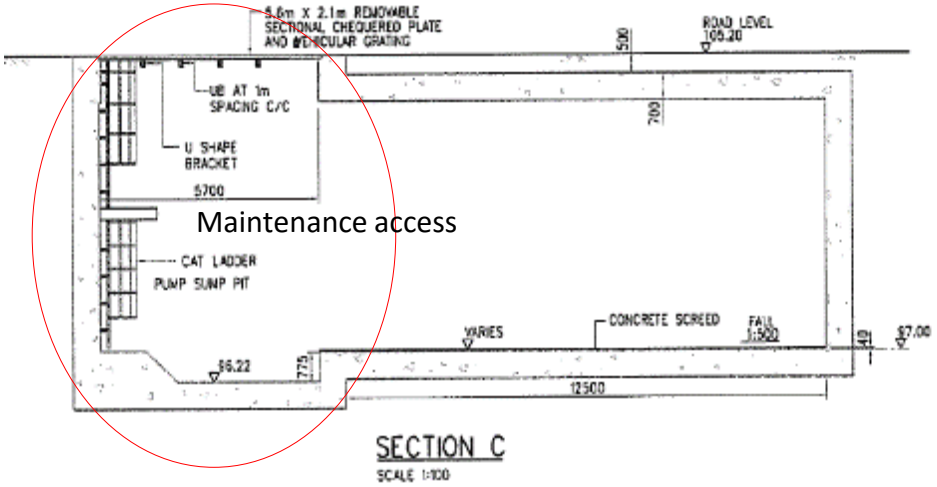
– to prevent blockages at discharge outlet of the tank

– should be easily removable for cleaning and inspection

ii. Maintenance access

– to consider for human and vehicular entry





Operations and Maintenance Considerations

1. Regular inspections and maintenance is important to ensure that the detention tank system is able to perform as required during a storm event.

2. Maintenance and Servicing of M&E equipment of the tank should be carried out at least once per year, preferably before the year-end monsoon season.
   - Developer/Owner/MA shall submit annual declaration to PUB via QP Portal on the inspection of pumped drainage systems

3. Maintenance works should include cleaning the detention tank, cleaning trash screens, servicing/testing the pumps, pump starters, the instrumentation and control systems and the standby generator.

Other Forms of Detention Features to consider

Detention requirement can also be met by having:-

1. Larger drains within the development to serve as detention purposes

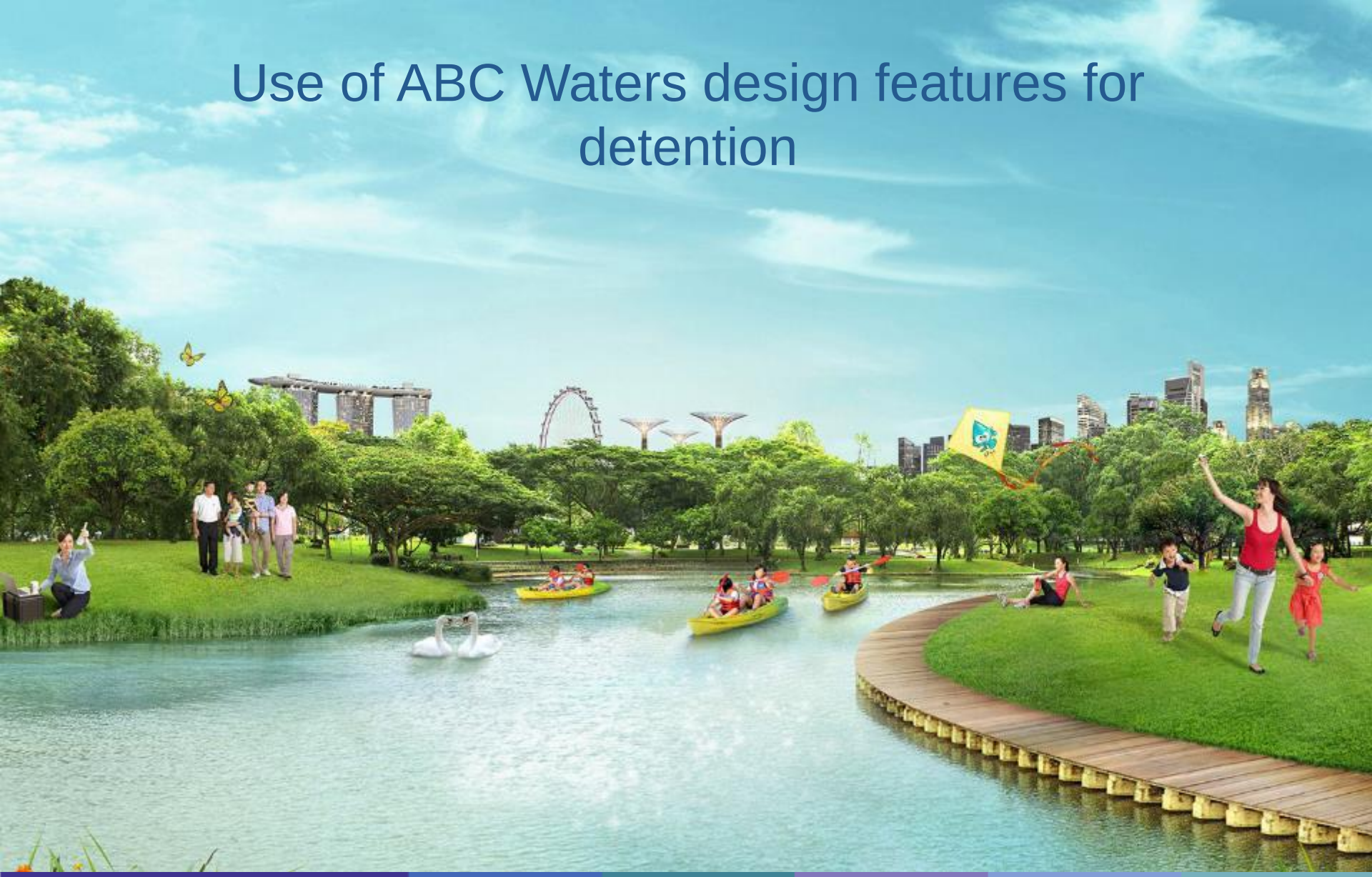
2. More green spaces within development to reduce overall runoff coefficient and tank size

3. ABC Waters design features





Use of ABC Waters design features for detention



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Outline

1. What are ABC Waters design features?
2. Application in a case example – Waterway Ridges

1. What are ABC Waters design features?

ABC Waters design features

What are they?

- Green treatment features using plants and soil media to clean the water through sedimentation, filtration and nutrient uptake
- Help to improve runoff quality, provide some detention of runoff, enhance biodiversity and site aesthetics

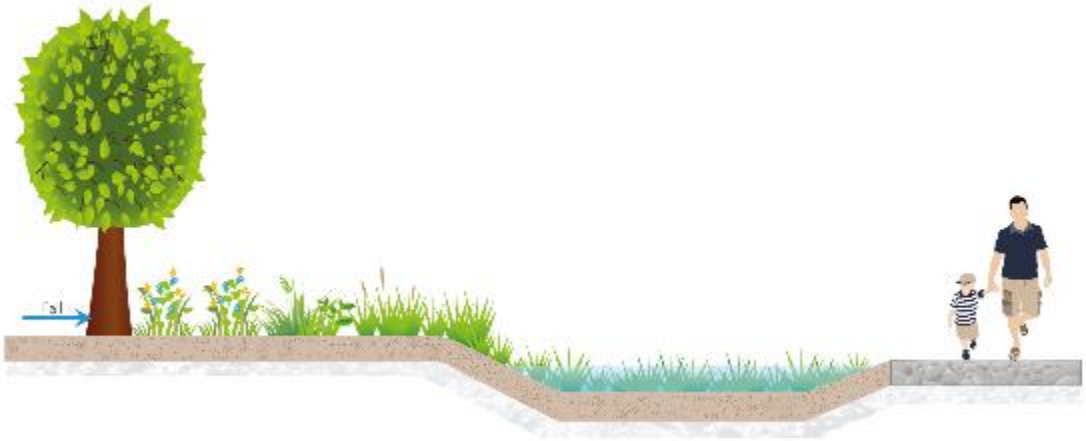
Types

- Vegetated swale
- Bioretention swale
- Bioretention basin (Rain garden)
- Sedimentation basin
- Constructed wetland
- Cleansing biotope



Vegetated Swales

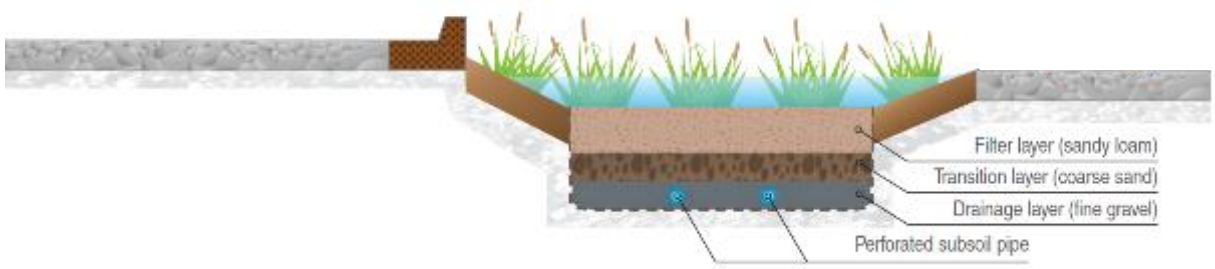
- Natural drainage channels with mild slope
- Provide effective pretreatment for downstream ABC Waters design features by trapping coarse particles





Bioretention Swales

- Vegetated swales with bioretention systems located within the base
- Designed with gentle gradient and temporary ponding to facilitate infiltration
- Runoff is filtered through planted surface vegetation and a prescribed filter media

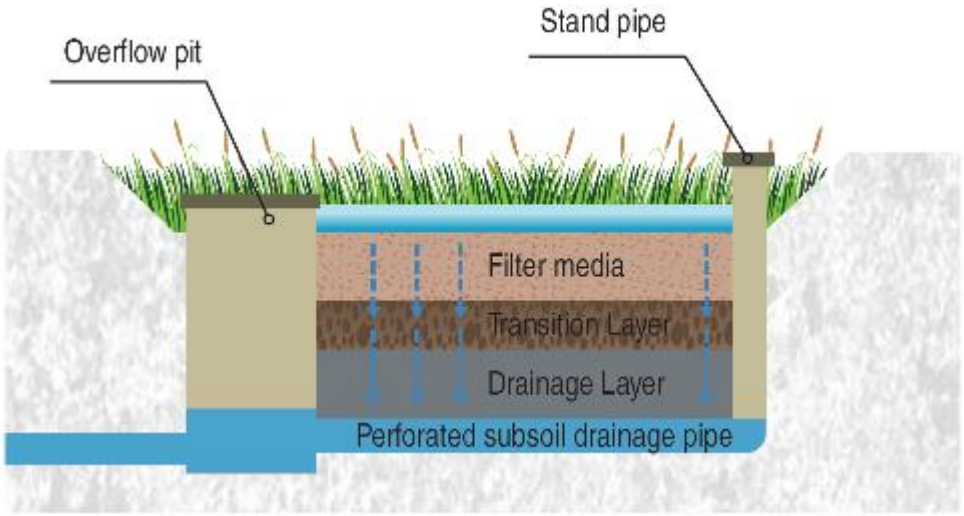




Faber Hills Estate

Bioretention Basins (Rain Gardens)

- Bioretention basins are vegetated land depressions designed to detain and treat stormwater runoff
- Runoff is filtered through planted surface vegetation and a prescribed filter media
- Sedimentation forebay constructed upstream of the bioretention basin as a pre-treatment measure to remove coarse particles

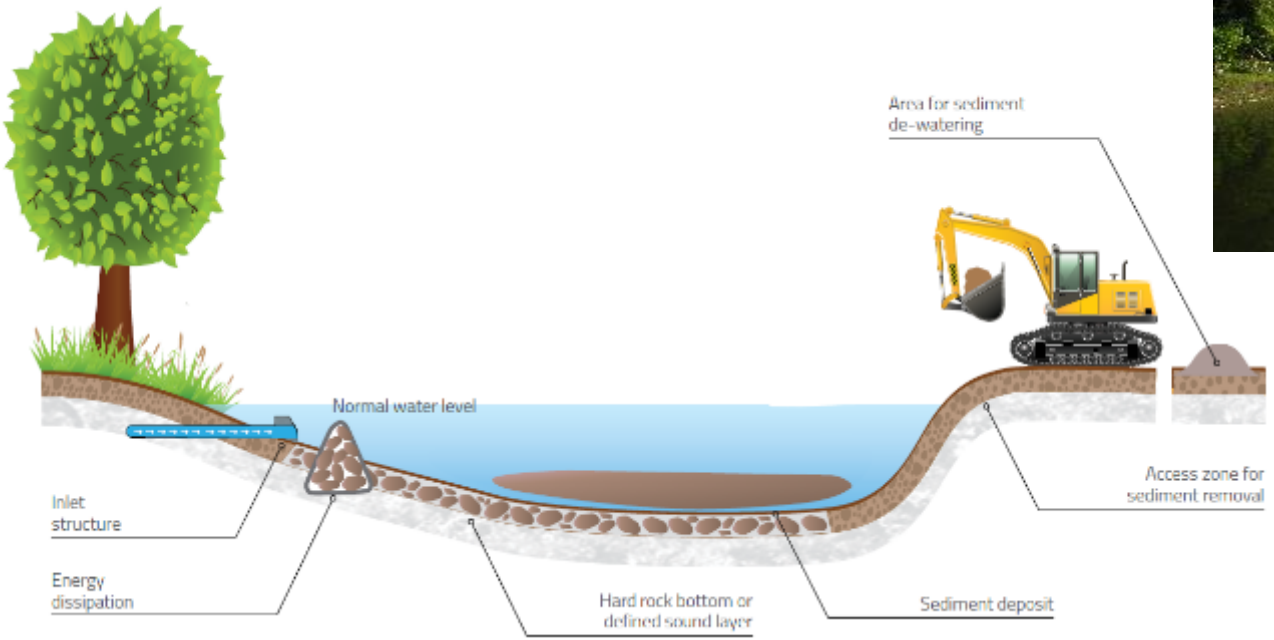




Balam Estate

Sedimentation Basin

- Sedimentation basins are ponds that provide temporary retention
- Reduces stormwater flow velocity to promote settling of particles by gravity
- Designed to capture 70-90% of coarse to medium-sized sediment
- Typically deployed as pre-treatment units

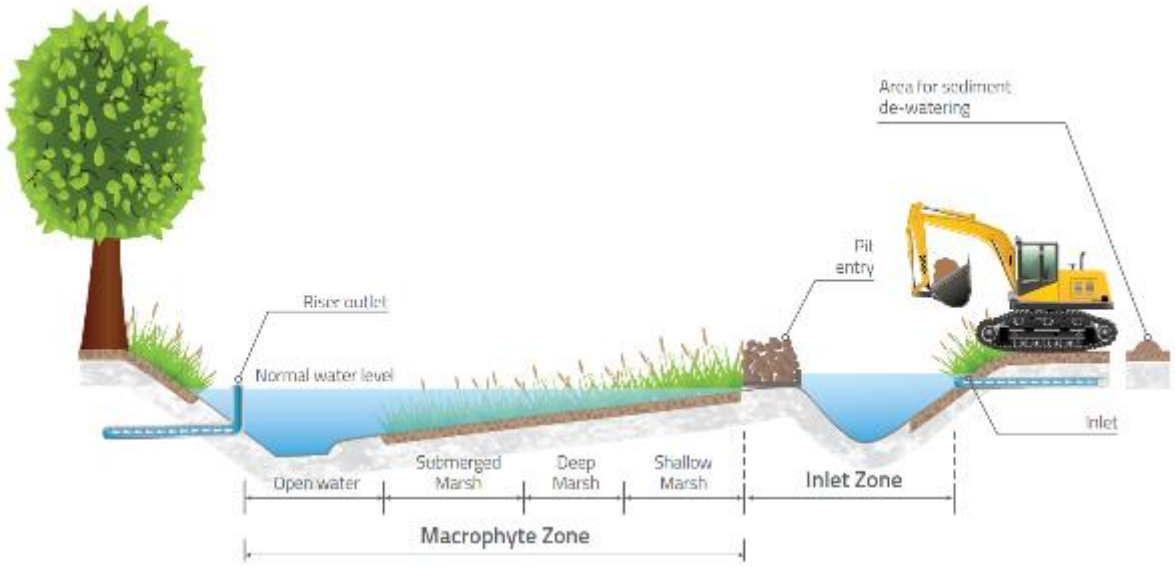




Sedimentation basin
@ Jurong Eco Garden

Constructed Wetlands

- Shallow and extensively vegetated water bodies that consist of an inlet zone, a macrophyte zone and a high flow bypass channel
- Designed to remove suspended particles and dissolved contaminants





Alexandra Canal

2. Application in a case example
- Waterway Ridges (Punggol East C39)

Waterway Ridges (Punggol East C39)





Objectives:

- Water Quality - designed to meet performance target for ABC Waters design features (treat 3 month ARI storms and achieve 80% removal of TSS removal; 45% removal of TN & TP)
- Hydrology - provide detention for stormwater runoff
- Social - bringing people closer to water

Waterway Ridges (Punggol East C39)

ABC Waters Design Features



Lush Rain Garden integrated seamlessly with Landscape



Lawn-type rain garden that doubles up as a play area

- Include 21 rain gardens (3 lawn-type), 4 vegetated swales and 2 gravel swales
- Designed to allow the precinct to achieve C=0.55 for the 10-year design storm → via 400 -750mm thick gravel storage layers beneath features and controlled flow via orifice outlets



Vegetated swale to remove TSS



Vegetated Swales that also enhance the landscape

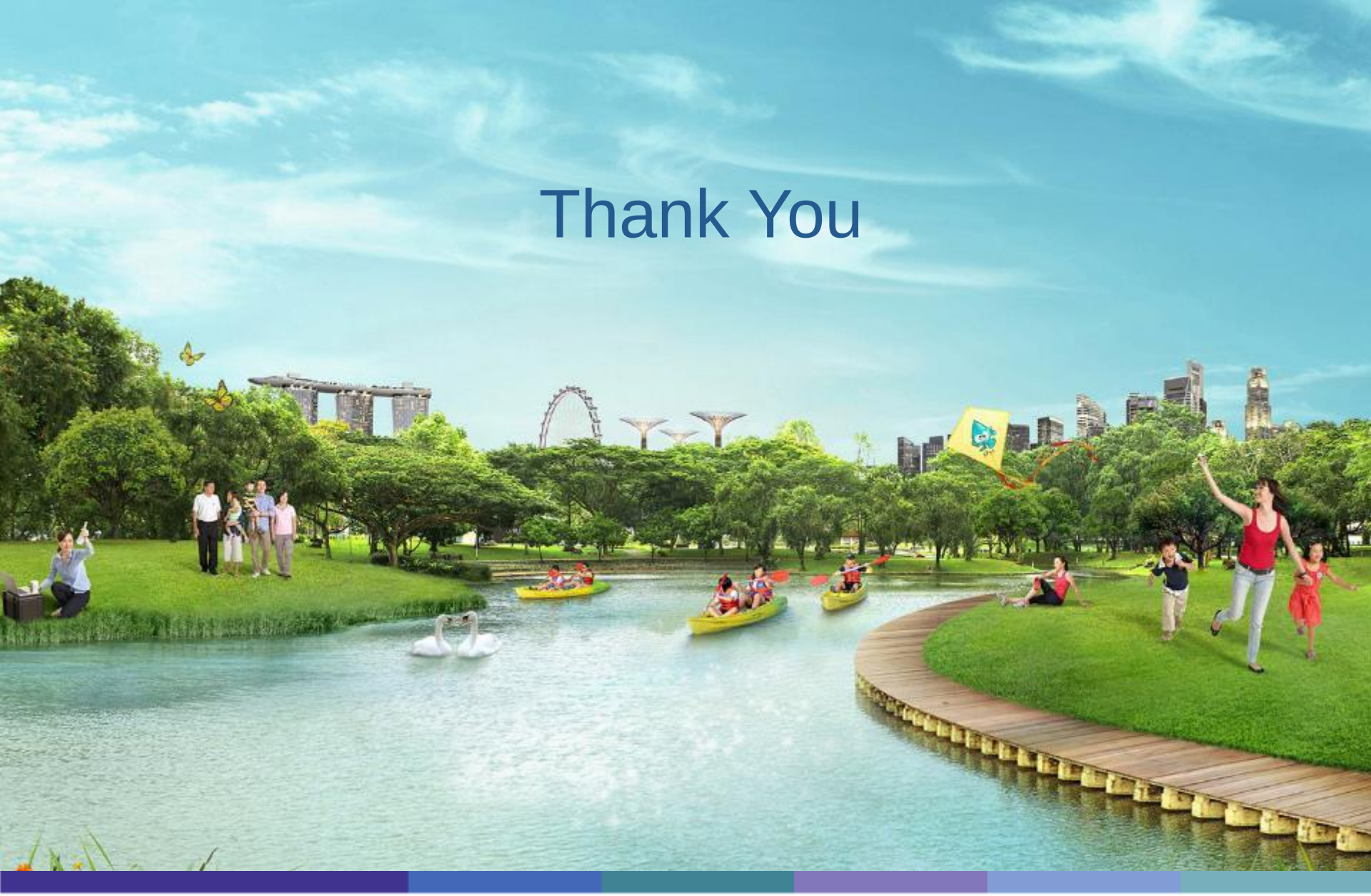
Modified bioretention basins for enhanced detention

- Runoff would flow into the basin during a rain event and be allowed to pond up to 200mm on the surface. Concurrently, the runoff percolates through the filter media and eventually reaches the gravel layer and subsoil perforated pipes
- Excess runoff >200mm surface detention depth will overflow into the overflow manhole and be directed into the gravel layer for detention and storage via subsoil perforated pipes
- Meanwhile, flow leaving the feature and entering the discharge pipe will be regulated through the orifice outlet, the opening size of which was predetermined through calculations based on C=0.55 for the 10-year design storm
- If the underground gravel layer is full, water level in the manhole will rise to the overflow standpipe opening and be discharged via the discharge pipe that connects to roadside drains within the precinct

Modified vegetated swales for enhanced detention

- Equip vegetated swales with gravel layers for storage purposes
- During rain event, runoff flows along the swale channel and eventually into the downstream overflow manhole
- Runoff flows via the subsoil pipe into the gravel storage layers
- Meanwhile, flow leaving the feature follows the same path as that in bioretention basin:
  - Flow entering the discharge pipe will be regulated through the orifice outlet
  - If the underground gravel layer is full, water level in the manhole will rise to the overflow standpipe opening and be discharged via the discharge pipe that connects to drains within the precinct

Thank You



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