Drainage Services Department Practice Note No. 2/2022

Guidelines on Application of Floodable Area and Drainage Facility Co-Use in Drainage Management

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1. INTRODUCTION

The environmental challenges spawned by rapid urban development are now compounded by the global climate change, which causes sea level rise, and more extreme rainfall as well as increases the threat of storm surges. Hong Kong has to make new attempts to tackle these challenges for flood prevention.

To combat climate change, Drainage Services Department (DSD) promotes the "blue-green drainage infrastructure" to improve the city's flood adaptive capacity in Hong Kong. It advocates detention/storage of surface water where it falls as far as practicable instead of the only conventional approach of conveying it offsite. In addition to flood prevention, blue-green drainage infrastructure can help to develop and take forward the concept of "Rivers in the City", as stated in the 2019 Policy Address, through river revitalisation projects and introduction of water bodies rejuvenation facilities. To encourage the project proponent to actively consider the incorporation of Blue-Green Elements and apply the principle of "single site, multiple uses" in drainage impact assessment (DIA) and project design for enhancing the adaptive capacity of the drainage system and other associated beneficial uses, this Practice Note (PN) is prepared to echo with the DevB Technical Circular (Works) No. 9/2020 – Blue-Green Drainage Infrastructure to promote the use of Blue-Green Elements in drainage-related works projects.

In addition, land constraints paired with a commitment to secure liveability within new developments have prompted a shift away from the traditional defensive approach to a more innovative and adaptive approach in dealing with stormwater. This paradigm shift is founded upon the realisation of the need for Hong Kong and its population to 'live with water, not against it'. The application of "Land Co-use" concept also have multiple benefits that not only to increase biodiversity and safeguard the habitat of existing flora and fauna, but also to provide recreational space while at the same time performing flood risk management function.

This PN presents planning and design considerations for the application of "Land Co-use" concept for drainage management to serve purposes of:

(i) Detention or storage of surface runoff for flood prevention; and
(ii) Other multi-functional uses

2. DEFINITION OF FLOODABLE AREA AND DRAINAGE FACILITY CO-USE

2.1 Types of Land Co-use Concept

Three types of Land Co-use concept for drainage management are described in the following. Examples of their applications will be discussed in Section 5:

Type 1 – Floodable Area (Non-drainage asset) (Figure 1)

A multi-functional area (such as recreational ground in normal day) can serve as drainage facilities for temporary storage of floodwater in extreme rainfall event (such as Black Rainstorm Signal) without causing major impact to the area. Examples include basketball courts, hard-paved soccer pitches, parks, and sports fields.

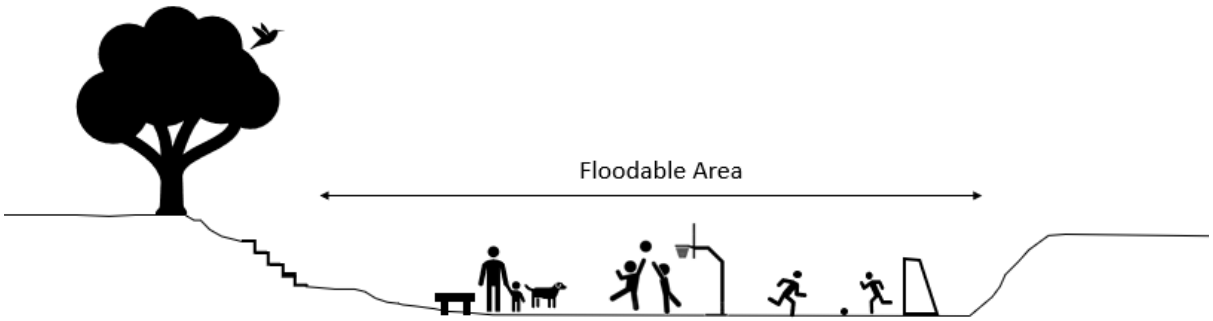

FIGURE 1 FLOODABLE AREA

Type 2 – Flood Lake/Wetland or Detention Pond (Exposed Drainage Asset)

(i) Flood Lake/Wetland (Figure 2)

A surface water body provides the functions of retention, attenuation and/or treatment of surface runoff. The aquatic vegetation along their shoreline, shallow zone, or artificial floating island provide benefits of stormwater purification, biodiversity and amenity for public enjoyment.

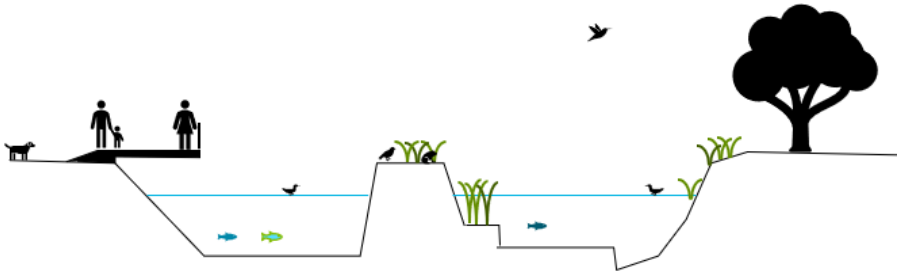

FIGURE 2 FLOOD LAKE/WETLAND

(ii) Detention Pond (Figure 3)

Its primary function is to serve as a drainage facility, which is the main difference from Type 1 - Floodable Area. It stores stormwater frequently and may collect surface runoff in low rainfall events. In dry days, these facilities provide green open spaces for other uses (e.g. recreational or leisure activities).

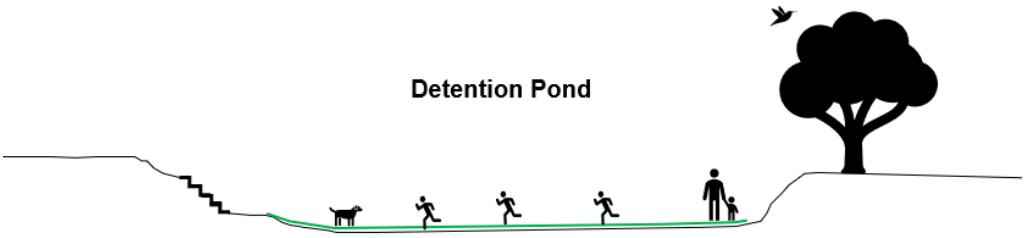

FIGURE 3 DETENTION POND

Type 3 – Flood Storage Tank (Underground Drainage Asset) (Figure 4)

An underground space for temporary storage of surface runoff before controlled discharge or reuse the stormwater for irrigation or other purposes. The space above the stormwater storage tank can be for recreational or other uses, while the space inside could be explored for suitable uses during dry season.

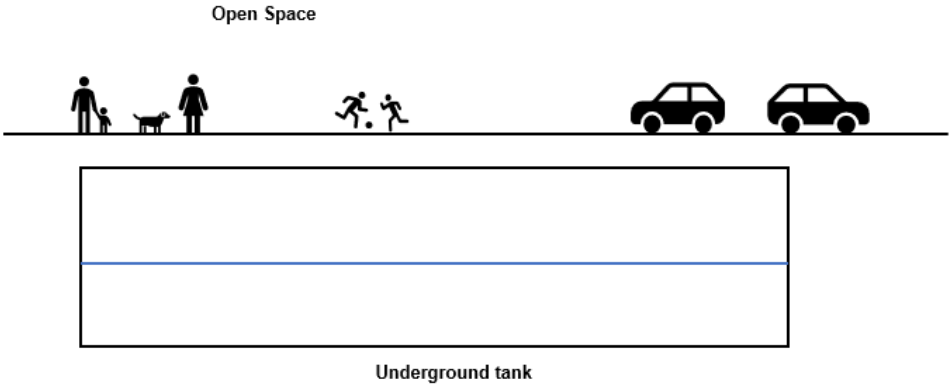

FIGURE 4 FLOOD STORAGE TANK

Type 3 costs higher construction expenditure in comparison with Type 1 and Type 2, because it likely involves complex construction process (e.g. deep excavation and massive concrete structure). The project proponent is advised to optimise the excavation extent and depth and should make good use of excavated material to reduce the construction waste generated.

2.2 Benefits and Challenges Comparison

A brief summary table (Table 1) tabulated the properties defined for the three types of Floodable Area and Drainage Facility Co-use concepts together with their advantages and challenges. Since such concepts are new to Hong Kong, the project proponent is suggested to start the dialog with relevant parties / authorities at early stage of project regarding those essential issues, for instance, O&M issues.

TABLE 1 BENEFITS AND CHALLENGES COMPARISON

Type	Drainage Asset	Storage sharing same space with other uses	Influence to other uses during rainstorm	Flood warning system for evacuation	Construction cost	Operation and Maintenance cost	Other Advantages	Other Challenges
Type 1 – Floodable Area	No. Flooded under extreme rainfall events only	Yes	Not often affected	Yes	Fair	Fair	Make use of extra flood storage on top of its primary use	Impose limitation to its primary use Facilities for other uses need to be invulnerable to flooding
Type 2 – Flood Lake/Wetland	Yes	Yes	More frequently affected	Yes	Fair	High (active management and maintenance of co-use land)	• Provide waterscape • Promote water friendly activities (need to maintain water quality) • Enhance aquatic life	Facilities for other uses need to be invulnerable to frequent flooding
Type 2 – Detention Pond							More additional lands for other uses	
Type 3 – Flood Storage Tank	Yes	No	Rarely affected	No	High (deep excavation with large-scale underground structure	High	More flexible for other uses, which rarely affected by rainstorm	More energy consumption due to pumping from deeper level Seepage may damage E&M equipment

3. DESIGN AND PLANNING STRATEGIES

3.1 Hydrology and Hydraulics

The design of storage capacity requires both hydrological and hydraulic information in order to develop a storage-outflow relationship. Project proponent can refer to the existing drainage assessments and studies, such as the Drainage Master Plans or Drainage Impact Assessment process, to obtain basic information like catchment characteristics, design rainfall profile, existing drainage network near the proposed site, surface runoff from upstream catchments, and peak flow from a selected design storm, etc. Reference should be made to the current version of DSD Stormwater Drainage Manual.

When determining the size, dimension and shape of the storage space, project proponent should consider land availability, aesthetics, retention time, possible flood extent and consequence of overtopping, etc. Type 1 normally have a size and shape depending on its primary use, for example, recreational and sports. (Figure 5)

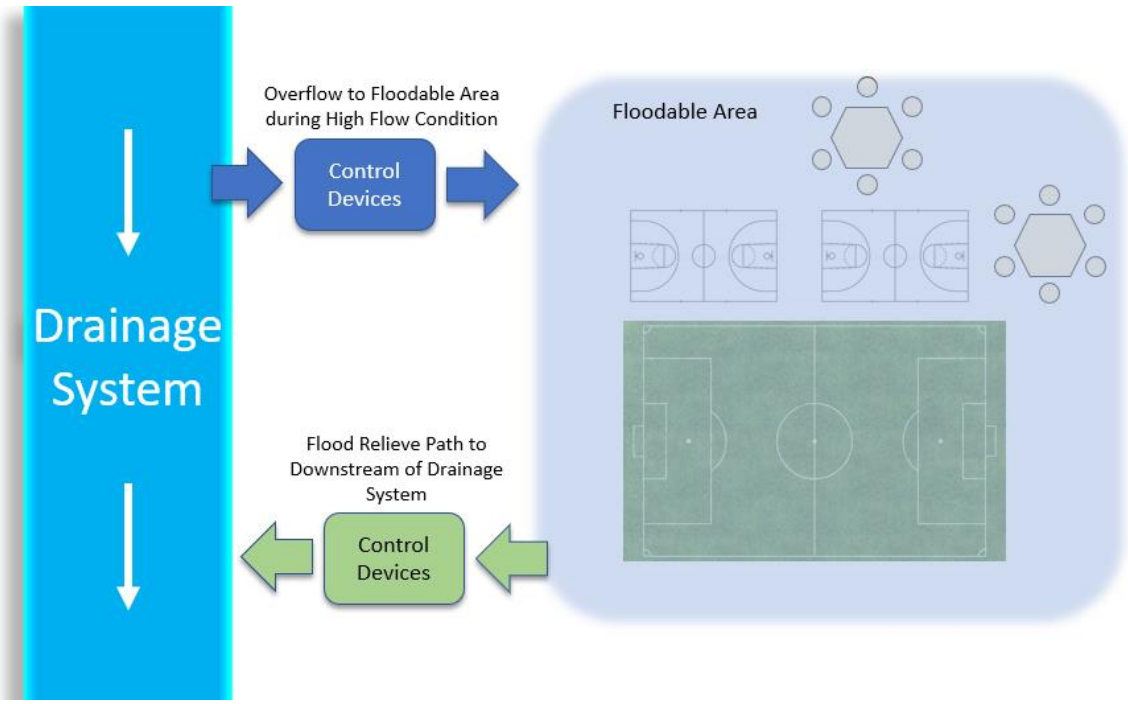

FIGURE 5 SCHEMATIC DIAGRAM OF TYPE 1

Type 2 are highly site specific and they are generally more flexibility when it comes to size and shape. Since most of the Type 2 areas are open-surface water bodies, mild side slopes leading to and within the water bodies are recommended for safety reason. If space permits, water basins with gently curving and irregular shapes are more favourable because they create a natural look, while rectangular steep-sided basins, though maximise the storage volume, may detract from appearance of the landscaping. (Figure 6 and Figure 7)

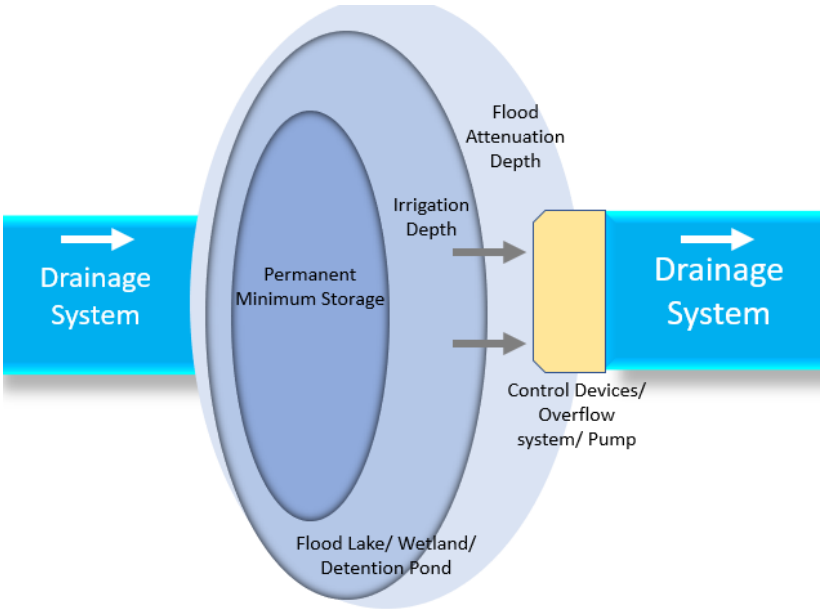

FIGURE 6 SCHEMATIC DIAGRAM OF TYPE 2 (FLOOD LAKE/ WETLAND) (PLAN)

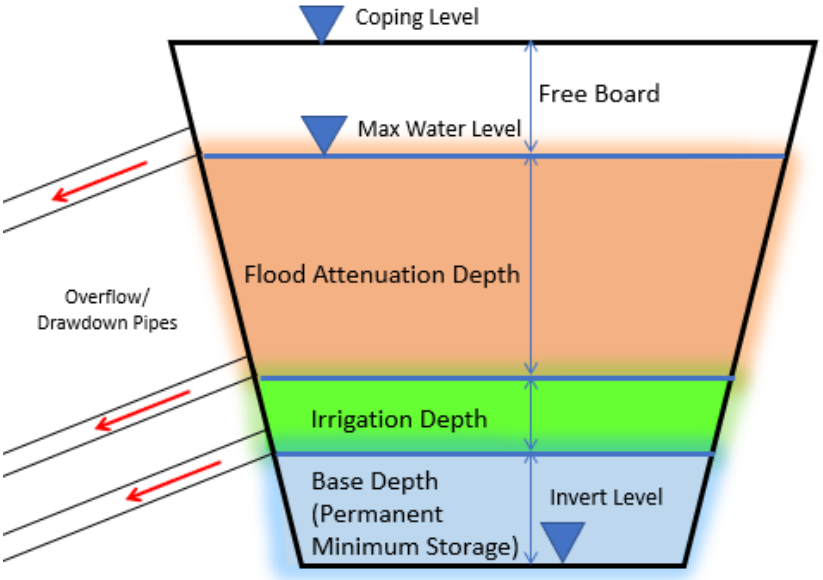

FIGURE 7 SCHEMATIC DIAGRAM OF TYPE 2 (FLOOD LAKE/ WETLAND) (SECTION)

For Type 3, a project proponent can consider cylindrical shape or round structure instead of conventional box-shaped to reduce corners that may trap debris and accumulate stagnant water. The project proponent can also explore innovative tank configuration that not necessarily make it a confined space (Figure 8). For instance, the tank can be partially open instead of fully covered by the superstructure on top of it. The tank can also consist multiple compartments, separated by vertical baffles or horizontal decks. The multi-compartment configuration allows the tank to be filled up in stages, leaving some of the tank dry in events that are less than the

design storm. This could potentially save maintenance cost and leave more flexibility and safety margin if public access is allowed into the tank for attending activities/events. Barrier free access should also be considered by the project proponent if public access is allowed into the tank for attending activities/events. Headroom, ventilation systems, lighting facilities, etc. should be considered for underground storage tank where public access is allowed. Deep excavation should be minimised or avoided from construction and maintenance cost/difficulties point of view unless the site is limited by available footprint.

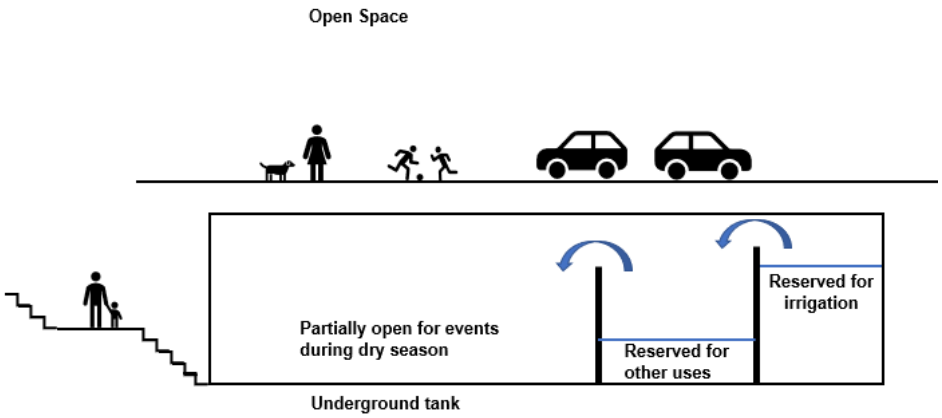

FIGURE 8 ILLUSTRATION OF TYPE 3 (FLOOD STORAGE TANK)

Depending on the type, major hydraulic structures include but not limited to inlets, outlets and overflow structures. Inlet structure should be designed to control the inflow velocities for erosion control and slope protection. Examples include riprap, gabions, or flow-diffusion devices. Inlets should not be placed too near the outlets to avoid short-circuit flow path. The inflow and outflow pipes should not directly across or in close proximity to one another, because in these settings, a person who is knocked over by the sudden inflow of floodwater might be easily pushed into or pinned again the outlet structures.

Outlet structures come in various forms and sizes, but all serve the same purpose - control the nature of the release patterns in terms of the timing and quantity. To release water in a controlled manner, project proponent can consider adding orifice, valves, penstock or smart gates to the outlet structures. In general, discharging the collected water by gravity is preferred because it is a more economical and less energy-intensive option as compared to pumping, unless draining by gravity is not feasible commonly seen in the case for Type 3. If pumping is required, pump house, intake and discharge pumps, control panels, electrical controls should be secured to prevent public access.

An overflow system must be provided in case the capacity of the floodable area is exceeded due to a blockage of outlet pipe or a storm larger than the storage design storm. One of the most commonly used arrangement is an overflow weir for open-surface water retaining structures (e.g. Type 1 and Type 2) and access chamber/manhole or an overflow pipe that connects to a safe discharge point downstream for underground storage (e.g. Type 3).

3.2 Vegetation

Vegetation is beneficial to erosion control and site stability. In addition, it enhances the aesthetic value and creates natural landscapes in the urban context. Vegetation particularly for native species could also have ecological value to enhance biodiversity. Project proponent is encouraged to incorporate mixed types of vegetation into the design wherever possible.

To curb the urban heat island effect, different types of land cover surfaces have been studied with regards to the efficiency of surface temperature reduction. The following non-exhaustive table summarizes the efficiency of different land cover types reduce the surface temperature comparing with bare concrete surface. The project proponent should have due consideration of selection of suitable land cover types to improve the human comfort.

TABLE 2 TYPES OF SURFACE REGARDING URBAN HEAT ISLAND EFFECT

Land Cover Surface Type	Bare Concrete	Semi-Grass*	Full-Grass**	Under Tree	Water
Surface Temperature Reduction	-	Moderately Effective	Moderately to highly Effective	Highly Effective	Highly Effective

*Semi-grass refers to land cover with 50% of grass cover and 50% of soil/concrete cover
**Full-grass refers to land cover with 100% of grass cover with long grass leaves

Bare concrete surface is not recommended due to its ability to absorb solar heat and leading to high surface temperature. The project proponent should avoid bare concrete surface within the project area unless otherwise justified. Land cover effect on human thermal comfort should be considered by project proponent to have a sustainable development. For example, tree with a wide canopy for shading is highly recommended for it can effectively reduce surface temperature and improve human thermal comfort. Combination of blue-green design is highly recommended, in particular for hard-paved floodable area such as basketball courts, soccer pitches and sports fields.

There are three primary types of vegetation that can be considered: turf/grasses, aquatic plants, and trees/forested areas. Turf and grasses are the most commonly seen vegetation for reasons of aesthetics, ease of maintenance and relatively low cost. They are a viable option for dry polders, landscaped areas in parks, or ancillary areas of soccer pitches and basketball courts. Native aquatic plants including submerged, floating and emergent plant types can be included in water retaining facilities like flood retention lakes/wetlands. Trees, brushes, shrubs and groundcovers are often planted for aesthetic and slope stabilization. They can also provide shading in hot days. However, care should be taken when determining (1) the planting locations to avoid detrimental effects on the hydraulic capacity and efficiency and (2) the species invulnerable to flooding in particular for Type 2. Vegetation type should be carefully selected with due considerations such as intended use(s) for site, hydrology, proximity to natural habitats, ease of maintenance, etc. For example, short height vegetation is preferred at the access to avoid blocking the view of the visitor and mosquito nuisance. The following technical factors are non-exhaustively listed to be duly considered: normal water depth, tolerance of plants to flooding/drought, accessibility of site for maintenance.

3.3 Biodiversity Enhancement

The project proponent is encouraged to identify opportunities and explore elements for biodiversity enhancement measures. These include planting native plants that provide fruits and nectar for birds and insects, natural substrates and emergent plants for water features, nest boxes and artificial shelters for wildlife, floating platform for birds in open water, as well as poles near water edges for perching. With due consideration, the project proponent should adopt measures to maintain the balance between the drainage function and sustainability of ecology in a long-term perspective. For instance, the habitat of the target species should be so properly arranged that it will not be affected by the drainage function of the facility. Ponds in urban parks may become popular spots for release of abandoned pets such as Red-eared Slider which are invasive alien species. The project proponent should also consider measures to discourage the release of invasive alien species by public.

3.4 Rainwater Harvesting [1]

Since water is stored within the flood lake/wetland or flood storage tank under rainstorm events, the project proponent is encouraged to consider adopting rainwater harvesting design to echo with the water saving initiative and to achieve cost-effective design from a long-term perspective. The harvested rainwater can be potentially used for irrigation, toilet flushing, firefighting, etc. Reference could be made to WSD's Technical Specifications on Grey Water Reuse and Rainwater Harvesting or any latest relevant guidelines for the water quality and potential uses of harvested rainwater as well as the design, installation, commissioning, operation and maintenance of rainwater harvesting systems. For irrigation and ecological use, in view that the suitability of harvested rainwater hinges on the water quality, the project proponent should further examine the water quality of particular site and determine the water quality enhancement measures to be adopted before using for irrigation and ecological use.

3.5 Permanent Minimum Storage for Flood Lake/ Wetland

The project proponent should determine the amount of permanent minimum storage in the proposed flood lake / wetland, with due consideration for the ecology, overall aesthetic, landscaping etc. Different target species selected by the project proponent may require different minimum water depth. Maintenance difficulties and sustainability of the proposed biodiversity enhancement measures mentioned in Section 3.3 should be considered when determining permanent minimum storage.

3.6 Water Quality Goals, Enhancement and Monitoring

The ideas of water quality enhancement and monitoring are similar to those of river revitalisation. The relevant discussions are covered in DSD Practice Note No. 3/2021 "Guidelines on Design for Revitalisation of River Channel".

3.7 Leisure Facilities

Leisure facilities such as benches and pavilions are essential to create a comfortable rest space for the public. To encourage exercise, sports equipment can also be installed. The areas should be well lit where night time use is expected to ensure public safety. Project proponent should

[1] Please note the "Technical Specifications on Grey Water Reuse and Rainwater Harvesting" issued by the Water Supplies Department for reference.

provide a safe means of access to and egress (e.g. stairs and ramps) from the floodable areas. All major facilities components (e.g. pumps, outlets) should be easily and safely accessed for regular inspection and maintenance. For Type 1 where activities take place in areas that is floodable, portable / removable installations should be avoided and the materials used should be able to withstand flooding for a certain period and have good corrosion resistant property.

FIGURE 9 URBAN WETLAND IN MELBOURNE

The needs for fence installation around the premises of the Type 2 should be site specific. The DSD has been actively promoting water-friendly culture and exploring the feasibility to open up more drainage facilities to the public. Removing fences may encourage people to access the dry polders or flood lakes and benefit from the open and pleasant environment that they offer. In some cases where barriers are necessary due to safety or security reasons, the project proponent can consider adopting shrubbery instead of fences to soften the barrier, adding an aesthetic feature to the waterscape. Multi-functional railing (e.g. long bench) is another alternative to replace fences (Figure 10).

FIGURE 10 MULTI-FUNCTIONAL RAILING

3.8 Educational Means to Promote Floodable and Land Co-use for Drainage Management

Project proponent is encouraged to provide educational means (e.g. information boards, display panels and education kiosks, etc.) to promote the concept of floodable and land co-use for drainage management. Through various educational means, the public can also learn more about the benefits, challenges and limitations of the new drainage management and various flood resilience measures against the challenges brought by climate change so that public awareness on flood hazards and climate resilience can be raised.

3.9 Programmes and Activities

Under the concept of multi-functions, various programmes and outdoor activities can be hosted when these areas are safe and dry. With a vision to enhance leisure offerings in Hong Kong, the land co-use concept could be a starting point to trigger a renaissance of 'outdoor living'.

The land co-use concept refers to the usage of the co-use land other than its drainage function, which includes sports field, venues for art and cultural events, local aspirations, and other innovative ideas. When designing and implementing for any particular site, these concepts should be evaluated in parallel with its physical scale, its relationship to local community, regional transport network and other urban programs, demographical factors and the character of neighbourhoods.

The project area can be used as a venue for organizing events for education / cultural promotion. Project proponents may approach LCSD in due course for liaison of organizing events. Organizing events within the co-used land should be properly planned beforehand, taking into account the relevant considerations such as crowd control, access control, safety management as discussed separately.

FIGURE 11 INTERACTIVE EXHIBITION "AFTER THE DELUGE" AT TAI HANG TUNG STORMWATER STORAGE TANK

3.10 Health and Safety Concerns

3.10.1Flood Forecast and Warning System

Type 1 and Type 2 co-use land allow public access in dry days, however, they can be flooded during rainstorms instantaneously. A flood forecasting and warning system may be required to allow people to have sufficient time to take necessary actions. Underground Storage Tank of Type 3 may also allow public access when it is used to host events for art/cultural promotion under proper management.

The project proponent can make reference to DSD Practice Note No. 3/2021 "Guidelines on Design for Revitalisation of River Channel" to select the appropriate type of flood warning system (i.e. Type I – Weather Forecast & Hydrological/Hydraulic Model, Type II System-Weather Forecast & Real-time Observation and Type III System – Real-time Observation Only), provide necessary equipment as well as to deploy sufficient resource for operation.

For consideration of areas to be flooded during rainstorms, project proponent may require to determine the maximum water depth in the area site-specifically with due consideration of evacuation lead time, flow velocity, risk of drowning, etc.

3.10.2 Other Health and Safety Concerns

Besides drowning, other health safety hazards should also be considered. For instance, steep or vertical side slopes without suitable safety barriers could be a potential fall hazard to both the public and the maintenance workers. Hydraulic structures should also be designed and maintained in a manner that makes them safe for the public to be around. For example, outlets should be covered and protected with trash/safety racks, and steel bars on grate should be free of sharp edges. Moreover, project proponent should also consider water sanitation and hygiene. Silting, overgrown aquatic weed, shallow and stagnant pools of water can result in mosquitoes and odour issues. For project with ancillary plants required (e.g. pump for underground storage tank), project proponent is reminded to consider possible noise, visual and environmental impact.

Ingress and egress should be carefully planned and designed, based on the site areas, shape and relevant requirements and constraints. For underground storage tank with potential public access, ventilation facilities and precautionary measures should be taken to avoid potential safety hazards.

4. MANAGEMENT AND MAINTENANCE ISSUES

4.1 General

This Section identifies the maintenance and management requirements and potentially operation issues for a floodable area, along with possible solutions. The requirements will vary with the type and complexity of the floodable area. Table 3 shows the consideration for design, maintenance and management issues for each of the three types of Co-use lands.

Although management and maintenance needs may vary from site to site, they generally include 1) identifying and repairing areas with damages (e.g. bank erosion, pump malfunction) especially after major storm events 2) removing sediment and debris before rainy season, 3) maintaining vegetation, and 4) managing leisure and sport facilities, if any.

One of the most importance maintenance needs is to ensure the outlet structures do not get blocked and clogged so that floodable area can be drained effectively. In fact, all hydraulic structures should be adequately maintained and monitored to ensure their proper functioning. For example, when outlet structures are fully or partially blocked with debris, the risk of water overtopping and failure increases. A malfunction outlet structure can also lead to prolonged pooling of shallow and stagnant water, which is a breeding ground for insects and rodents. Specifically, for mosquitos breeding that normally occurs in a shallow standing water surface, the proposed floodable areas shall be well drained and cleaned to minimise mosquito nuisance.

Flood forecasting and warning system may be required for the project to ensure public safety. The system comprises hardware (e.g. water level gauges, CCTV monitors, flood warning facilities, life-saving equipment, operations centre, management office) and software (e.g. forecasting model, patrol team). For hardware, regular inspection, testing and replacement are required to ensure normal functioning; while for software, maintenance and update for forecasting model and man power inputs are needed.

The project proponent should have due consideration regarding the venue management during operational phase, such as the security, management office, patrolling schedules. Management of the facilities consideration should also be taken into account, e.g. the ponds could be potentially a popular spot for release of abandoned pets such as Red-eared Slider which are invasive species. Regular patrol may help to prevent such improper manner.

Since the concept of land co-use may involve unconventional maintenance and operation issues to be agreed/resolved by relevant departments, the project proponent is advised to commence the planning of the Blue-Green Elements at early stage and allow sufficient time to settle the maintenance and operations issues with relevant departments on a case-by-case basis.

The project proponent should also consult and seek agreement with O&M parties regarding the need and area requirement of management office and storage areas at design stage of the project in a collaborative manner. The design, recurrent cost, O&M manual of the blue-green drainage infrastructure should be agreed by the O&M parties during the design stage of the project. The project proponent may consider erecting proper signage with site layout plans showing the contact points of the management parties for the Blue-Green Elements to encourage reporting of defects or blockages by the visitors when necessary.

TABLE 3 KEY CONSIDERATION FOR DESIGN AND MAINTENANCE

Key Issue		Solution to Key Issue and Operation Consideration
Type 1 Floodable Area		
Safety and Risk Management	• People safety concern • Emergency procedures related to human activities, e.g. injury, drowning • Evacuate people in time before the flooding occurs • Overbanks flows damaging facilities	• Develop a warning system, evacuation route, standard emergency procedure • Employ experienced officer to monitor and operate the warning and evacuation system • Limit the flow velocity from the inlet structure to prevent rapid rising water level • Install flood-tolerant facilities and seek comment such as ArchSD, EMSD and HyD. • Deploy patrol team • Provide safety measures (e.g. first-aid stations, life buoys) and CCTV monitoring system • Provide access in accordance with "Design Manual: Barrier Free Access"
Flood Control	• Overgrown weed, litters and sediments reduce flood conveyance • Maintain the design flood conveyance of all hydraulic structures	• Plant species adaptive to flooding conditions with low maintenance requirements in riparian zone to control weed growth • Remove overgrown weed, litters and sedimentations regularly • Inspect hydraulic structures and remove blockages regularly and after rainstorm • Ensure no obstructions along the flow path
Leisure and Amenity	• Additional leisure and recreational spaces and facilities needed • Keep the facilities clean and neat	• Arrange leisure spaces (e.g. cycling tracks, footpaths, lawn areas, benches) • Maintain the landscape and cleanness of the area • Inspect and maintain the facilities for good functioning, landscapes (e.g. trim grass, remove litter)

Key Issue		Solution to Key Issue and Operation Consideration
Type 2 Detention Pond		
Safety and Risk Management	• People safety concern • Emergency procedures related to human activities, e.g. injury, drowning • Evacuate people in time before the flooding occurs • Flood overflows damaging facilities	• Develop a warning system, evacuation route, standard emergency procedure • Deploy experienced officer to operate the warning and evacuation system • Limit the flow velocity from the inlet structure to prevent rapid rising water level • Install flood-tolerant facilities • Deploy patrol team • Provide safety measures (e.g. first-aid stations, life buoys) and CCTV monitoring system • Provide access in accordance with "Design Manual: Barrier Free Access"
Flood Control	• Water overtopping • Ensure the storage capacity meet the design criteria • Install emergency spillway / overflow structure	• Remove sediment accumulation in the polders if required • Regularly inspect inlet, outlet and overflows for blockages, and clear if required • Regularly Inspect the sediment accumulation and polder's flood capacity • Provide vehicular access and parking area for maintenance vehicles
Water Quality	• Polluted surface runoff accumulated	• DWFIs can be provided to divert low flows to sewerage system • Provide a forebay to settle out dirt and other items • Control the nutrients source (e.g. wastewater, agricultural runoff) • Regularly inspect and maintain the forebay
Leisure and Amenity	• Requirement of leisure and recreational space • Keep the facilities clean and neat	• Arrange leisure spaces (e.g. cycling tracks, footpaths, lawn areas, benches) • Maintain the landscape and cleanness of the area • Inspect and maintain the facilities for good functioning, landscapes (e.g. trim grass, remove litter)

Key Issue		Solution to Key Issue and Operation Consideration
Type 2 Flood Lake/ Wetland		
Safety and Risk Management	• People safety concern • Emergency procedures e.g. injury, drowning • Evacuate people in time before the flooding occurs • Flood overflow damaging facilities • Public access to high-risk areas (e.g. deep-water zone, steep slope)	• Develop a flood forecast and warning system, evacuation route, emergency procedure • Maintain the wetland's maximum permanent water depth e.g. 1.2m, unless all safety considerations allow a larger depth • Maintain the wetland's temporary storage e.g. 0.5m above the permanent level for small to medium-sized wetland • Maintain gentle bench slopes • Provide maintenance access routes • Provide CCTV monitoring system
Retaining Ecological value	• Opportunities to enhance biodiversity and ecology	• Identify species with ecological value to preserve, explore compatible species • Plant native species where suitable • Recommend elements to support biodiversity, e.g. bird box, bat box, dragonfly pond
Flood Control	• Rainfall events exceeding the wetland's design capacity • Divert exceedance flow to the downstream drainage system	• Install overflow pipe or weir/spillway structure above the design water level • For small wetlands, a simple grass channel is suitable for exceedance route • Regularly inspect and remove blockages • For large wetland, a freeboard of 300mm is needed for the design rainfall event • Overflow/spillway structure should be properly located to avoid putting risk to downstream people and property

Key Issue		Solution to Key Issue and Operation Consideration
Water Quality	• Sediment and associated pollutants being eroded and flushed out during storms • Stagnation and low dissolved oxygen conditions for large wetland (> 1.5m in depth) in summer • Retain the permanent wetland • Keep sufficient dissolved oxygen • Prevent high temperature during summer times	• Provide a forebay to settle out dirt and other items • Control the nutrients source (e.g. wastewater, agricultural runoff) • Provide recirculation, e.g. base flow, fountain, aerator • Provide aeration to save aquatic creatures if eutrophication is severe • Regularly inspect and maintain the forebay and the aeration • Regularly maintain the plants to ensure proper growth. • Install water quality monitoring equipment and bypass system
Leisure and Amenity	• High fencing isolates the wetland system and reduces amenity benefits • Insufficient leisure facilities for local residents and visitors • Public are not familiar with and lack responsibility towards the new common space	• Use toddler-proof fencing combined with the planting and landscaping • Pedestrian access to shallow areas without increasing safety risks • Provide leisure facilities (e.g. picnic tables, seating benches) and walking trails • Erect information boards • Inspect the hard/plant fencing to ensure they are stable and not losing • Inspect the leisure facilities and trails to ensure their normal functioning • Visitor amount should be controlled to not disturb specific species if required

Key Issue		Solution to Key Issue and Operation Consideration
Type 3 Flood Storage Tank		
Safety and Risk Management	• Safety concern of getting too close to major hydraulic structures such as inlets, outlets and pumps • Public get trapped inside the tank • Poor ventilation in the tank	• Set up warning signage, and CCTV monitoring system at high risk spots • Inlet/outlet pipes, culverts and pumps should not be accessible • Fence off headwalls of large pipes • Install sufficient access and egress with clear signage • Provide ventilation openings • Deploy patrol personnel • Critically consider the ventilation system as the tank may be classified as a "confined space"
Flood Control	• Overflow of the storage tank • Maintain the retention facility's flood capacity	• Inspect and remove blockages of inlets/outlets and drainage pipes • Inspect and maintain the pump station (if provided) • Inspect regularly and after rainstorms for blockages, and remove them if required • Inspect for satisfactory operation of pumps, both automatic and manual operation. • Inspect function of telemetry devices and telemetry alarm system • The maintenance frequency may vary according to the frequency of rainstorms • Provide emergency power generator for back-up electricity during power failure
Leisure and Amenity	• Insufficient leisure facilities and educational information • Make visitors and residents understand the integrated values of stormwater retention facilities	• Set up information boards and leisure equipment • Inspect and maintain the information boards and leisure equipment to keep them in good shape

5. EXAMPLES OF APPLICATION OF 'FLOODABLE AREA' AND 'DRAINAGE FACILITY CO-USE' CONCEPTS

5.1 Benthemplein Water Square in Rotterdam (Type 1 – Floodable Area)

Benthemplein Water Plaza is one of the water squares in Rotterdam and was constructed and completed in 2013. It occupies an irregular space for recreation facilities (e.g. basketball court/ football field). It will be filled out with runoffs from the immediate surroundings to form a decentralised water retaining system and mitigate localised flooding.

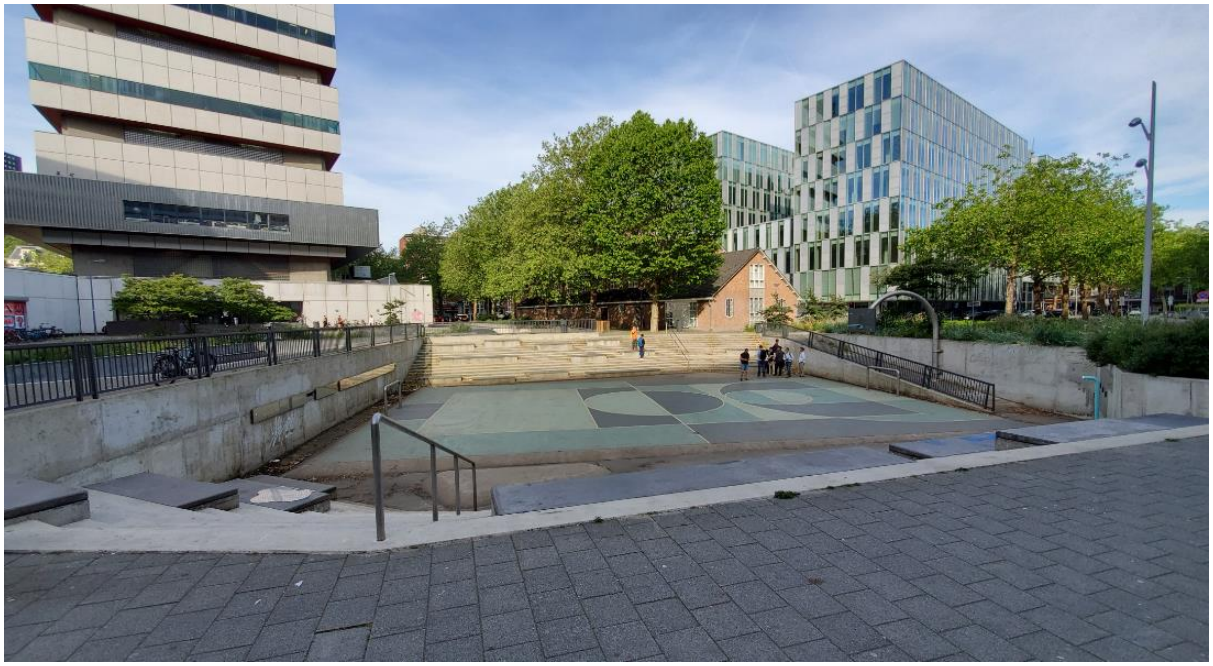

FIGURE 12 THE BENTHEMPLEIN WATER PLAZA IN DRY CONDITION

5.2 Tsang Tai Uk Polder (Type 2 – Detention Pond)

Tsang Tai Uk Polder Scheme is one of the polder schemes and maintained by the DSD for flood storage to protect low-lying villages. This polder is dry during non-rainy days and currently, is the only polder with zoning as 'Open Space' and allowance of public access. Flood warning signs are displayed on site to warn public not to enter the polder during flooding.

FIGURE 13 EXISTING CONDITION OF TSANG TAI UK POLDER

5.3 Anderson Road Quarry Flood Lake Park (Type 2 – Flood Lake/ Wetland)

Flood Lake Park in Anderson Road Quarry (ARQ) Development Area is an application of Type 2 – Flood retention lake in Hong Kong. The Attenuation Lake is within the Quarry Park with the stormwater recycle ability. The lake is used to attenuate the stormwater from the rock slopes and the park area at the northern side of the development. During normal condition, the lake will be a water feature within the development and will provide open space as well as allow general public to experience water-friendly activities.

The Flood Lake is designed to optimize water storage: it will be concrete-lined with vertical retaining walls along the east, south and west banks. Some riparian planting is proposed in these areas. The northern bank will have a shallow gradient to provide connectivity with the adjoining floodable lawn. This design provides more opportunities for emergent and aquatic planting which support numerous aquatic insects, amphibians, fish and birds.

With the idea of water re-use adopted, the water within the lake is used for different purposes. A certain depth of water in the lake is reserved for irrigation of green area in the park, while another portion supports the water-friendly activities.

FIGURE 14 ARQ FLOOD LAKE PARK

5.4 Happy Valley Underground Stormwater Storage Scheme (Type 3 – Flood Storage Tank)

The Happy Valley Underground Stormwater Storage Scheme (HVUSSS) with a capacity of 60,000 m^3 aims to provide flood attenuation in the Happy Valley catchment by temporarily storing excessive floodwater and discharges the flow to the downstream stormwater drainage system after storm event.

The storage tank, located right beneath the Happy Valley Recreation Ground, well demonstrates the concept of space co-use. In addition, the harvested rainwater can be used for flushing, washing and irrigation at the recreation ground facilities.

FIGURE 15 HAPPY VALLEY UNDERGROUND STORMWATER STORAGE SCHEME

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