

# Integrating Water Management Facilities into The Built Environment – A Smart Green Resilient Approach

Kenneth KWOK<sup>a</sup>, LAU Wing-kam<sup>b</sup>, CHUI Wai-lok<sup>c</sup>, YAU Ka-tai<sup>d</sup>, Katy FUNG<sup>e</sup>, Peter CHAN<sup>f</sup>

<sup>a</sup> Arup, Hong Kong SAR, kenneth.kwok@arup.com

<sup>b</sup> Civil Engineering and Development Department, Government of the HKSAR, Hong Kong SAR, wklaui@cedd.gov.hk

<sup>c</sup> Civil Engineering and Development Department, Government of the HKSAR, Hong Kong SAR, wchui@cedd.gov.hk

<sup>d</sup> Planning Department, Government of the HKSAR, Hong Kong SAR, ktyau@pland.gov.hk

<sup>e</sup> Planning Department, Government of the HKSAR, Hong Kong SAR, kcwfung@pland.gov.hk

<sup>f</sup> Arup, Hong Kong SAR, peter-ly.chan@arup.com

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## ABSTRACT

The Planning and Engineering Study for Housing Sites in Yuen Long South (YLS) has addressed critical issues relating to flood risk, water supply and wastewater treatment by adopting a Smart Green Resilient approach and integrating water management cycle at the heart of the sustainable planning, design and delivery process.

Throughout the planning and design to optimise the development potential of the degraded brownfield land in YLS for accommodating about 85,000 population, “water” has been used as a powerful “integrator” that delivers multiple benefits in supporting the development needs.

Examples of “water” strategies formulated in the YLS development include:

- Smart use of existing combined 3.5km long of concrete-lined drainage channel dissecting various parts of the YLS development for enhancing pedestrian connectivity and traffic safety by partially decking parts of the channels whilst creating scenic open space for enjoyment by local and future residents by revitalising the channels through various hard and soft landscaping treatment.
- Green and sustainable use of treated sewage effluent (TSE) produced by the proposed on-site tertiary sewage treatment works for non-potable water supply including toilet flushing and irrigation. Further polishing of the TSE will be provided in a created reedbed, for environmental enhancement and public enjoyment.
- Resilience built in through introduction of stormwater retention facilities that encompass a 1km long hillside river and provision of a retention lake to attenuate the increase in runoff from YLS in order to mitigate the drainage impacts to the downstream drainage system in the urban area of Yuen Long New Town. Footpaths and cycle tracks will be incorporated into the design of the hillside river and the retention lake to integrate functional facilities.

**Keywords:** *smart, green, resilient*

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## 1. INTRODUCTION

### 1.1. Project background

The Yuen Long South (YLS) area has suffered from proliferated spread of open storage yards, warehouses and industrial workshops, resulting in degradation of its originally rural environment and setting. With growing pressure on land for housing supply and public aspiration of better use of degraded brownfield land for development, the Planning Department and the Civil Engineering and Development Department of the Government of the Hong Kong Special Administrative Region (HKSAR Government) have jointly commissioned the Planning and Engineering Study for Housing Sites in Yuen Long South (the Study), to examine the future land use, optimise the development potential, and ascertain the feasibility for public and private housing developments in the YLS area.

Taking into account territorial development needs as well as local characters and community aspirations, the Study has developed a vision of creating a sustainable, green and liveable community in YLS through provision of essential infrastructure to cater for the future development needs and improving the existing rural environment. The planning and urban design principles for YLS are outlined below:

- Creating an urban to rural experience

The YLS development will integrate with its settings by designating higher density developments in the north near Yuen Long New Town transitioning to medium and low-density development in the south to blend in with the rural setting and the Tai Lam Country Park. A network of bicycle paths, including a scenic cycle track along the hillside river corridor will be provided and active agricultural land retained, to connect urban neighbourhood and the surrounding rural area.

- View corridors and breezeways

The gradation of development intensity and stepping building heights allow developments to optimise views to the mountainous backdrop of the Tai Lam Country Park, which also help wind deflection and avoid air stagnation.

- Creating open space and green network

Open space of various scale and functions together with the preserved active agricultural land, secondary woodland, natural streams as well as revitalised nullahs will form a comprehensive open space and landscape network to meet leisure and recreational needs while creating identity and character for YLS.

- Providing major focal points and key activity spine

A key activity node with public transport interchange will be provided at each residential community providing commercial, community, recreational and public transport facilities with comprehensive pedestrian and cycling network connection. Walkable communities with good provision of public transport will be created in YLS.

- Revitalisation of Nullahs

The existing nullahs in YLS are valued as key assets. They will be revitalised to reach their full potential as an attractive public realm, and functions as part of the sustainable drainage system for YLS to cope with climate change. The revitalised nullahs will provide a natural feel in the urban context and act as key north-south connectivity corridors. In line with the advocate of integrated blue-green infrastructure system and aspiration to improve aesthetics and ecological value of the land, a green and eco-hydraulics approach will be applied to improve aesthetic whilst maintain and compensate for the hydraulic performance of the channel.

In order to promote public ownership of the outcome and build community consensus for the YLS development, the Study has gone through a comprehensive and well-designed community engagement programme to present and seek views from the public on its plans and proposals.

## 1.2. Study area

The YLS area is located in proximity to Yuen Long, Tuen Mun and Tin Shui Wai New Towns, and the proposed new development area in Hung Shui Kiu. It is also surrounded by and integrated with various valuable landscape and ecologically important features, including woodland, Tai Lam Country Park, streams discharging to the existing nullahs, an abandoned egretty at Tai Tong and an active egretty at Pak Sha Tsuen.

The area is generally rural in character but occupied by a mixture of brownfield uses, including open storage yards, warehouses, workshops, industrial operations, with villages and residential settlements, agricultural land and unused land scattered in between.

The YLS development on completion can be broadly defined into five planning areas, consisting of three distinct residential communities, a Green Zone and an Employment Belt as illustrated in Figure 1.

The Study Area encompasses a combined 3.5km long of concrete-lined drainage channel dissecting various parts of the YLS development. Opportunity to transform these grey concrete nullahs into potentially attractive blue-green infrastructure system to improve its aesthetic and the environment is a key part of the Study objectives.



Figure 1: Proposed Yuen Long south development

### 1.3. Key challenges on water management

This Study will formulate stormwater drainage; sewerage conveyance, treatment and disposal; and water supply strategies and infrastructure proposals to support the housing development in YLS. The integrated water management planning and design needs to overcome the following key challenges:

- Conflicting traffic and flood protection requirements

There are existing drainage channels that run through the Study Area. Whilst they serve the important function of providing land drainage and flood protection for the immediate and upstream catchments, their alignment dissect the local community and affect the traffic circulation. Their concrete-lined surfaces are not appealing to the public as illustrated by the photos in Figure 2. There have been strong requests from some public to deck the drainage channels to provide space for improving the existing road network.



Figure 2: Photos of existing Yuen Long Nullah

- Potential adverse drainage impacts

The 183 ha of development area will increase paved surface and runoff discharge to the downstream existing drainage system in Yuen Long and Tin Shui Wai town centre, which has limited conveyance capacity to handle additional flows. The impact will be exacerbated with climate change with higher rainfalls and sea levels are anticipated in the future. The associated drainage impact needs to be mitigated to avoid increase in flood risk to the existing Yuen Long town centre.

- Inadequate existing sewerage infrastructure

The proposed development will generate some additional 23,000m<sup>3</sup> per day of sewage flows. Although some of the existing sewerage conveyance, treatment and disposal infrastructure are being upgraded currently to support the rapid development of the existing sewage catchment, their expanded capacities are still inadequate to serve the increase in sewage flows. Further extensive upgrading works or new on-site sewage treatment facilities will be required.

- Requirement of Sewage Effluent Discharge to Receiving Water Body

The treated sewage effluent (TSE) from the proposed development will discharge to Deep Bay, which is a “stressed” water body in terms of water quality. To protect the water quality in Deep Bay, there is a stringent requirement that there should be no “net increase” in pollution loading due to the proposed development, meaning that the TSE still cannot be discharged to the downstream Deep Bay. Either effluent reuse or export scheme will be needed for the development.

## 2. SMART GREEN RESILIENT APPROACH TO WATER MANAGEMENT

### 2.1 General approach

The 2015 Policy Address proposed to adopt the concept of revitalising water bodies in the planning of drainage networks for new development areas of Hong Kong to build a better environment for the public (HKSAR Government, 2015). It aims to integrate environmental and ecological considerations in the design of drainage infrastructure to create a better living place. The HKSAR Government is also promoting the application of “blue-green infrastructure” to improve the sustainability and resilience of Hong Kong’s drainage system to meet the contemporary public aspiration in respect of the natural environment and protection of the local culture and rural lifestyle (Drainage Services Department, 2015).

The Study has fully adopted these intentions into the heart of its planning and design principles. In addressing critical issues relating to flood risk, water supply and wastewater treatment, the Study has used an integrated water management approach by adopting a Smart Green Resilient concept (Lau et. al., 2016) and integrating holistic water cycle management into the sustainable planning, design and delivery process. The proposed strategies will achieve wider benefits beyond their primary functions, as defined in Figure 3.

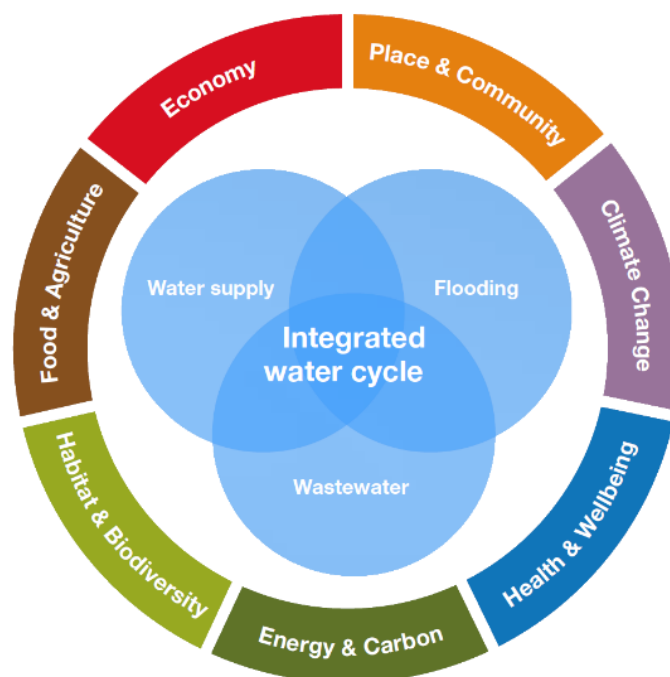


Figure 3: Placing an integrated water cycle at the centre of design to deliver multiple wider benefits (Arup, 2013)

Below are some examples of integrated water management strategies that have been applied to YLS, to deliver multiple benefits to the development based on a smart green resilient approach.

## 2.2 Smart use of existing combined 3.5km long concrete-lined nullah

To address current road safety concerns and meet future traffic needs after YLS development, decking of the existing Yuen Long Nullah will be required to create space along some sections of the Kung Um Road and Kiu Hing Road for road improvement works. Instead of investing in otherwise traditional large underground concrete structure for drainage with tarmac on top for road, we have adopted a partial decking design and proposed to revitalise the existing concrete-lined trapezoidal Yuen Long Nullah to form an aesthetically pleasant viewing corridor with integrated soft and hard landscaping themes. To compensate for the reduction in the hydraulic capacity due to the partial decking and revitalisation of the existing nullah, new box culverts are proposed that will run parallel with the existing nullah to increase its conveyance capacity.

There have been many successful international examples of regeneration of urban drainage channels, e.g. Cheonggyecheon in Seoul. Various hard and soft landscaping treatments and features will be applied to improve aesthetics, e.g. softscaped treatment of the bottom and the sides of the nullah to allow enhancement of biodiversity and visual integration, involving the use of low-maintenance planting at various levels.

To enhance pedestrian connectivity both internally and externally, it is also proposed to create the pedestrian spine along the sides of the revitalised Yuen Long Nullah. The pedestrian corridor with decent landscaping, comprising those planned along the proposed roads and improvements to existing ones, are highly visible and will link up major destinations. In terms of external connectivity, it is intended for the pedestrian network to tie in with the existing footpath in Yuen Long New Town. A cycle track is also proposed along the southern part of Yuen Long Nullah for public enjoyment and more importantly, for connecting the scenic cycle track to the woodland, natural stream as well as the proposed hillside corridor and reedbed, forming part of the recreational network for visitors and residents to enjoy the ambience of the green environment.

The partial decking design would also provide the opportunity to widen and upgrade the existing roads leading to Yuen Long New Town to facilitate traffic flow and improve the existing congested traffic condition.

Key Activity Nodes which serve the residents by providing living necessities, retail and leisure opportunities will be located along side the revitalised Yuen Long Nullah. The integration of multi-functional facilities through smart and adaptive design creates a synergetic and sustainable environment for the benefit of the community, and serves as a focal point of the YLS development.



Figure 4: Photomontage of the revitalised Yuen Long Nullah

## 2.3 Green and Sustainable Use of TSE from on-site Tertiary Sewage Treatment Works for Non-potable Water Supply

The existing sewerage infrastructure and its expansion has no spare capacity to convey, treat and dispose the sewage flow generated from YLS development. It is proposed to provide a designated new sewerage system to serve YLS development together with the adjacent village developments. The new sewerage system will comprise sewers, sewage pumping stations, rising mains and a sewage treatment works (STW).

The new STW will be designed to provide tertiary sewage treatment to produce high quality TSE that is suitable for reuse as non-potable water supply. As an alternative water supply source, the TSE is being considered to be reused locally for toilet flushing, landscape irrigation and make-up for water features within YLS development. A new TSE supply system, including TSE pumping station, service reservoir, transmission and distribution network will be provided for YLS development. This is an important green and sustainable measure to make use of “wastewater” as a valuable source of water supply and will help to preserve fresh water for potable consumption only.

The provision of tertiary sewage treatment and recycling of the TSE as non-potable water supply will also support the compliance of the stringent requirement of no “net increase” in pollutant loading for Deep Bay. The YLS development is expected to consume some of the total TSE generated from the STW. To ensure no TSE is discharged to the Deep Bay, opportunities will be explored to export the remaining or surplus TSE to other new development areas or existing urban areas in the vicinity for similar non-potable uses.

To further enhance the quality of the TSE, it is proposed to develop the 3.8 hectare site adjoining the STW into a reedbed wetland to further enhance the quality of the TSE for reuse. The TSE will discharge first to the reedbed wetland, where the residual pollutants will be further uptake by the plants therefore reducing the TSE residual pollution loading. The design of the reedbed wetland will also incorporate facilities for the public such as, walkway, cycle tracks and sitting out areas for public enjoyment.

## 2.4 Building Resilience with Storm Water Retention Facilities including Hillside River and Retention Lake

The existing Yuen Long Nullah and Tin Shui Wai Main Drainage Channel systems downstream of YLS has no spare capacity to accommodate the additional flow discharges from YLS development. Flood retention facilities are proposed for attenuation of the increase in peak runoff, such that there will be no increase in the 50 year peak flow discharge after YLS development to the downstream existing drainage systems in Yuen Long and Tin Shui Wai. Stormwater runoff will discharge into the retention facilities for temporary storage. The retention facilities will be provided with control outlets that limit discharges to pre-development level.

The proposed retention facilities will encompass of a 1km long hillside river and a 0.6 hectare of retention lake. The hillside river is located in between the mountain backdrop and the new developments of YLS development. The hillside river forms a protective barrier for the future developments downstream, collecting stormwater runoff from the slopes while providing an attractive leisure environment. Nearby, a created reedbed is proposed for further water polishing of the TSE, whilst providing an attractive wetland area, allows an enhanced ecological footprint and in combination with the adjacent recreational grounds a large scale natural area in biodiversity.

To build better resilience for climate change impacts, the design of the hillside river and retention lake has also considered impacts of increased rainfall intensities, which will generate additional surface runoff from YLS development and the existing drainage catchment. Areas have therefore been reserved adjacent to the retention lake. In the future, the retention lake can be further enlarged to provide additional storage volume.



Figure 5: Photomontage of the riverside channel and retention lake

### 3. CONCLUSION

The planning of YLS development aims to create a sustainable, green and liveable community for accommodating about 85,000 population. It will provide infrastructure to cater for the future development whilst improving the existing rural environment. The blue-green infrastructure system comprising the enlivened and new watercourses/ the preserved natural streams, the Green Zone and hillside landscape enrich the character of YLS development and promote urban, rural and nature integration attracting both residents and visitors.

The concept of revitalising water bodies in the planning of drainage network has been fully considered and applied in the development area by the smart use of the existing concrete-lined channel. Coupling with the provision of cycle track and pedestrian walkway network, it promotes walkability and sustainability which are essential for new development for the future generation. With the stringent requirements on no net increase in pollution loading for Deep Bay, a great challenge has to be overcome and the beneficial use of the treated sewage effluence would be explored for various non-potable uses.

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