

Annex A: GIC 3 Challenge Statements

S/N	Challenge Statement	Background
1	Phos4SG – Recovering the “P” from PUB’s used water treatment to improve Singapore’s food security How might PUB recover phosphorus from dewatered sludge, dewatering centrate or sewage sludge incineration ash (SSIA) cost-effectively for safe and sustainable local vegetable production via hydroponics cultivation?	Phosphorus is a critical yet non-renewable resource for modern agriculture. Its current global reserves are expected to be depleted within the next 50 - 100 years. The phosphorus scarcity issue poses a serious threat to food security globally. Under the ‘30 by 30’ goal, Singapore aspires to build up the capability and capacity of our agri-food industry to produce 30% of our nutritional needs sustainably by 2030. With limited land, Singapore has identified hydroponics as one agri-tech that can help speed up the growing cycle of our homegrown food tech without compromising on nutritional value. Several trials to investigate the applicability of phosphorus recovery from waste streams at PUB’s water reclamation plants found that: a) Struvite recovered from dewatering centrate and dewatered sludge is slow releasing in solution, and cannot be readily dissolved in solution for hydroponics applications; and b) Application of dewatering centrate (blended with commercial nutrient solution at different mixing ratios) was not feasible due to bioaccumulation of contaminants in the harvested hydroponics. Growth yield was also found to be impeded. PUB is interested to work with partners on solutions or ideas to overcome the above challenges and cost-effectively recover phosphorus from PUB’s waste streams for safe and sustainable local vegetable production via hydroponics cultivation.
2	Utilising By-Products from Carbon Capture How might we make the most effective use of the calcium carbonates and magnesium hydroxides/carbonates formed through the capture of carbon dioxide (CO₂) in seawater in the	In line with Singapore public sector’s target, PUB aims to achieve net zero emissions around 2045 through a three-pronged strategy – (a) Replace carbon-emitting fuels or energy with renewables, (b) Reduce carbon emissions by improving efficiency and reducing water demand, and (c) Removing carbon from the environment through technologies that can be integrated with PUB’s operations.

	most beneficial and economically viable way?	Under the strategy to remove carbon, PUB is exploring with partners on technologies to capture CO₂ in seawater and locking it in calcium carbonate and magnesium hydroxide/magnesium carbonate precipitates that form as by-products. Besides permanently storing carbon dioxide, these carbonate and hydroxide precipitates could potentially have valuable industrial applications such as base materials for cement and concrete production, cosmetics, paints, and many others. PUB is seeking industry partners who can identify and demonstrate the application of these materials for reuse in industry. The calcium carbonates and magnesium hydroxides/carbonates exist in slurry form with saline water content of between 50-99% which could either be used directly or further treated and repurposed for alternative applications. We are seeking to support solutions that will be able to demonstrate through lab scale or pilot trials, the utilisation of these by-products for industrial applications within Singapore in the most economical and environment-friendly way.
3	Sewer sampling robot How might we collect factory premises' used water samples from various types of sanitary lateral connections for used water quality monitoring and surveillance, without the need for man-entry into the sewers?	The discharge of trade effluent containing prohibited substances or excessive concentrations of regulated substances into sewers may cause health and safety risks to workers maintaining the system and disrupt downstream used water treatment processes in PUB's water reclamation plants. To ensure compliance to trade effluent discharge limits, industries with higher probabilities of discharging such substances are required to install online water quality monitoring instruments in their last inspection chambers. Inspections are conducted frequently at these premises. Special operations are also conducted at premises suspected of illegal discharge activities, where PUB staff would monitor for abnormal trade effluent discharge from the manholes outside these premises. For premises whose sanitary drainage connect to the sewer via a top saddle connection (where effluent is flowing vertically down), a robotic crawler would be deployed for sample collection at the connection point. However, it is unable to collect samples in other types of

		sanitary sewer connections due to its design limitation. PUB is seeking a robust solution that can collect samples from all types of sanitary sewer connections, which we could deploy for special operations.
4	Smart Drain Inspector How might we deploy a cost-effective solution to autonomously inspect our drainage network to identify drain defects and map out the drain alignment/dimension?	Public drains are inspected regularly for defects and subsequent rectification to ensure that the drainage network is structurally safe and functional. Currently, manual inspections are conducted for most open and closed drains which is labour intensive. In addition, closed drains with confined space pose atmospheric and physical hazards. Man-entry into closed drains is potentially hazardous and requires precautions, which reduces inspection efficiency and increases costs. Recently, autonomous drones that can navigate in GPS-denied and unilluminated closed drains have been deployed in drains that are more than 2m wide. They are unable to inspect smaller drains (i.e., less than 2m wide), which form a significant portion of the drainage inventory, due to the bigger drone size required to house a battery of sufficient capacity. In addition, for drains wider than 2m, it is difficult to manoeuvre the drone around underground services/animals (due to its relatively big size) and measures need to be taken to prevent the drone from coming into contact with water. Besides visual information, the solution is also required to detect drain defects and anomalies automatically using AI-based video analytics and to map out drain alignment. Mapping is required to update as-built drawings or provide new data for the older drains where as-built data is not available. PUB is seeking an autonomous solution that can sustainably increase our inspections of drains for defect identification, and digitally map drain alignment as well as dimensions.