Optimization of Subsurface Fresh Water Storage in New Land Developments

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ABSTRACT

Coastal cities worldwide are dealing with the effects of rapid urbanization and climate change, yet most cities infrastructure and resources are barely able to cope. In many cases, further expansion of a city into the mainland is no longer possible for geographical and financial reasons, so developers turn to the sea. Land reclamation projects are currently underway in several cities such as Jakarta in Indonesia, Singapore and Lagos in Nigeria. While these new land developments may face the same resource problems as on the mainland, they also present new possibilities.

The case study area for this research is one of a number of new islands, which are planned in the Jakarta Bay as part of the Jakarta Coastal Development Strategy. The island is named Pluit 1 and is designated for residential and commercial use. Like on the mainland, providing fresh water for the island will not be easy or straightforward but this research may provide developers with an innovative water management strategy that will help solve that problem.

The storage of fresh water in the subsurface for later recovery (aquifer storage and recovery) provides a storage method which makes use of the purification properties of the subsurface, the geological characteristics of the aquifer and the density difference between fresh and saline water. We propose a further optimization of ASR systems by applying the possibilities presented by new land developments, allowing us to include dredging materials and techniques in the optimization of fresh water infiltration, storage and extraction.

A conceptual hydrological model is used to simulate infiltration and groundwater recharge in the island's urban environment. Then, using the calculated recharge as an input, several theories on how to best store fresh water in and extract it from the subsurface are tested using the groundwater modelling environment mfLab. Modelled scenarios include the simulation of sustainable urban drainage systems (SUDS) to increase infiltration rates, the use of different hydraulic fill materials to optimize the subsurface storage capacity and the implementation of impermeable barriers along the island borders to minimize losses.

The scenarios are tested and described, using the new island development in the bay of Jakarta, Indonesia as a case study but the ultimate goal is to develop a set of design criteria for subsurface fresh water storage in land developments worldwide.