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Treating runoff in the construction and operational phases of a greenfield development using floating wetland treatment systems

Traiter les eaux de ruissellement dans les phases de construction et d'exploitation d'un aménagement à l'aide de marais flottants

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RÉSUMÉ

Les systèmes flottants de traitement des zones humides (FWTS) sont une technologie innovante pour le traitement des eaux pluviales, qui est actuellement à l'essai en Australie. Les FWTS apportent un soutien aux espèces de plantes sélectionnées pour éliminer les polluants provenant des eaux pluviales déversées dans un plan d'eau. Les racines des plantes fournissent de grandes surfaces pour la croissance du biofilm, qui sert à piéger les particules en suspension et à permettre l'absorption des nutriments biologiques. Les FWTS peuvent être installés au début de la phase de construction et peuvent donc commencer à traiter les eaux de ruissellement de construction presque immédiatement. Les FWTS ont le potentiel de fournir une gamme complète de traitements des eaux pluviales (par exemple, les sédiments et l'élimination des nutriments) à partir de la phase de construction. Un système FWTS de 2 100m2 a été installé dans un nouveau site de développement sur la Sunshine Coast, dans la région du Queensland. Une étude de quatre ans est en cours pour cibler les trois objectifs suivants : (1) caractériser la qualité des eaux de ruissellement à partir d'un développement Greenfield dans la phase de construction et la phase opérationnelle; (2) vérifier les performances d'élimination de la pollution des eaux pluviales d'un système FWTS pendant la phase de construction et d'exploitation d'un développement Greenfield; et (3) caractériser la capacité du FWTS à gérer la santé du plan d'eau urbain. Ce document présente la méthodologie appliquée à la recherche.

ABSTRACT

Floating wetland treatment systems (FWTS) are an innovative stormwater treatment technology currently being trialled on a larger scale in Australia. FWTS provide support for selected plant species to remove pollutants from stormwater discharged into a water body. The plant roots provide large surface areas for biofilm growth, which serves to trap suspended particles and enable the biological uptake of nutrients by the plants. As FWTS can be installed at the start of the construction phase, they can start treating construction runoff almost immediately. FWTS therefore have the potential to provide the full range of stormwater treatment (e.g. sediment and nutrient removal) from the construction phase onwards. A 2,100m^2 FWTS has been installed within a greenfield development site on the Sunshine Coast, Queensland. A four-year research study is currently underway which will target the following three objectives; (1) characterise the water quality of runoff from a greenfield development in the construction and operational phases; (2) verify the stormwater pollution removal performance of a FWTS during the construction and operational phases of a greenfield development; and (3) characterise the ability of FWTS to manage urban lake health. This extended abstract presents the proposed research methodology and anticipated outcomes of the study.

KEYWORDS

Construction runoff, floating wetlands, greenfield development, stormwater treatment, urban runoff

1 BACKGROUND

Floating Wetland Treatment Systems (FWTS) have been used in aquatic enhancement projects for over 20 years internationally to treat effluent and to provide and/or improve water habitats (Burgess and Hirons, 1992; Kerr-Upal et al., 2000; Headley and Tanner, 2008; Sukias et al., 2011). The purpose of several early FWTS projects was to provide habitat for aquatic waterfowl (Kerr-Upal et al., 2000), while other projects focused on the removal of total suspended solids (TSS) pollutants from mine tailings (Burgess and Hirons, 1992; Smith and Kalin, 2000; Walker et al., 2015a). These are designed to simulate naturally occuring floating wetlands with the aim of maximising root exposure to the water column, therefore providing a significant surface area for biofilm growth.

Manufactured FWTS are supported by a floating medium, typically comprised of woven plastic, matting, or fibreglass, where plant roots grow directly into the water column, similar to a hydroponic system. As the plant roots grow through the floating medium and into the water below, they provide an extensive surface area for biofilm to grow on the root hairs (Figure 1). Biofilm coverage is an essential requirement for the sequestration of nutrients from stormwater (Borne et al., 2013; Winston et al., 2013), as it helps remove nutrients (particularly nitrogen) from the water through nitrification/denitrification processes, and is ultimately taken up by the macrophytes. Phosphorus can be retained through binding processes that occur within the biofilm (e.g. adsorption) and uptake of orthophosphates is achieved by vascular macrophyte species.

Figure 1 - Floating Wetland Schematic

Research in the United States (Stewart et al., 2008) and New Zealand (Sukias et al., 2011) has found that FWTS can provide an effective, low cost and low maintenance means of treating domestic and agricultural wastewater. Sukias et al. (2011) found that FWTS were capable of reducing TSS by up to 81%, total nitrogen (TN) by up to 34%, and total phosphorus (TP) by up to 19%. However, the number of studies on the performance of FWTS in treating urban stormwater runoff is limited.

2 PURPOSE

To quantify the ability of FWTS to remove sediment and nutrients from runoff, a total 2100m^2 FWTS is being installed within a new greenfield development, Parklakes 2, on the Sunshine Coast, in Southeast Queensland, Australia. This will be the largest installation of FWTS into a greenfield development in the world and is subject to a four-year research project. This research project will address the following objectives:

(1) characterise the water quality of runoff from a greenfield development in the construction and operational phases;

(2) verify the stormwater pollution removal performance of a FWTS during the construction and operational phases of a greenfield development; and

(3) characterise the ability of FWTS to manage urban lake health. This paper will present the research methodology.

3 APPROACH

In order to achieve the above objectives, field and laboratory monitoring will take place. The field monitoring will be event-based, with samples collected at the inlets and outlets of two floating wetland areas (Figure 2). Lab verification testing will take place to verify the results of the field study in controlled circumstances, using real and artificial stormwater. Pollutant removal performance will be investigated in both the construction and operational (e.g. build form) phases of the development. Low-intensity storm events will be replicated using a recirculation pump that has been installed in the development. As part of the event replication, analysis will be conducted on the ability of the FWTS to remove algal cells and reduce cholophyll-a concentrations. The purpose of this assessment is to determine if FWTS are an adequate management strategy for algal growth in constructed water bodies.

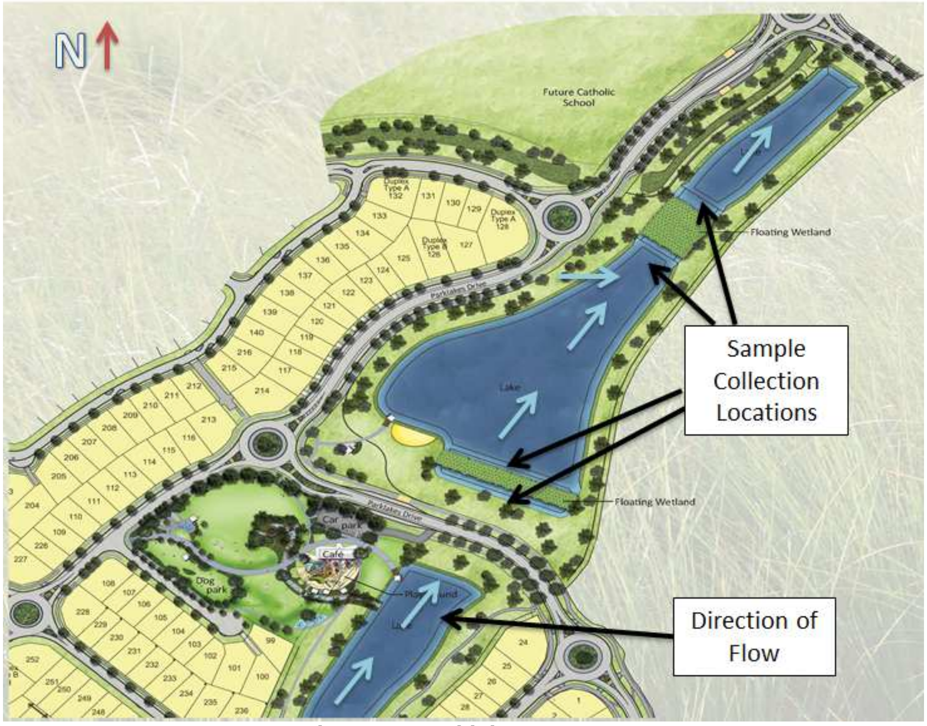

Figure 2 - Parklakes 2 FWTS

4 ANTICIPATED OUTCOMES

Many WSUD stormwater treatment systems, such as bioretention basins and constructed wetlands, function best when ‘offline’, with extended detention depths minimised and events greater than four Exceedances per Year (EY) bypassing such systems (Water by Design, 2012a, 2012b). This often requires detention/retention basins to be separate from treatment systems. In contrast, FWTS have the potential to substantially reduce the footprint required for stormwater treatment compared with other systems for two main reasons. Firstly, the hydroponic nature of root development allows for a great surface area for biofilm growth and inherently more contact between biofilm coated roots and polluted stormwater. It is anticipated that the results of this study will clearly show that FWTS have the potential to provide significantly greater rates of stormwater pollution removal per unit area compared with constructed wetlands, as biofilm growth is limited to plant stalks in constructed wetlands (Walker et al., 2014a; Walker et al., 2014b).

Secondly, FWTS are not affected by variations in extended detention depths, as the floating matrix rises with the water level during storm events. In contrast, prolonged extended detention in constructed wetlands and bioretention basins can lead to plant mortality. These factors allow detention and treatment systems to be combined on a large scale with minimal impact to treatment efficacy. Subject to appropriate system design, there is virtually no impact on flood storage capacity. It is also theerfore anticipated that the results of this study will demonstarte how FWTS can substantially reduce the stormwater treatment footprint on residential development, thereby providing greater areas of passive / active open space or increasing lot yields per hectare.

In addition to the above, given that the FWTS are not impacted by extended detention and can be incorporated into detention systems, these systems are able to be installed during the construction phase of a development, rather than at its completion. In Australia, WSUD systems are not typically established (e.g. planted) until 80% of the dwellings within the contributing catchment are completed, as the impacts from sediment laden runoff can significantly reduce the lifespan of traditional systems (e.g. constructed wetlands and bioretention basins). In contrast, FWTS are not impacted by construction runoff and may in fact benefit from it, as fine particles within construction runoff are often bound by nutrients, due to the greater surface area and greater binding capacity provided by fine sediment particles. The results of this study are expected to demonstrate the benefits of implementing FWTS at the start of the construction phase.

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