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Analysis and Evaluation of Stormwater Quality and Quantity Performance for Three Permeable Pavement Systems in Fort Collins, Colorado

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Abstract. Urbanization and the subsequent increase of effective impervious area (EIA) result in an increase in storm runoff volumes, peak flow rates and pollutant concentrations. Stormwater management has recently shifted towards a focus on site level low impact development (LID) techniques that aim to reduce the total stormwater runoff volumes in addition to attenuating peak flows and removing pollutants at or near the source of runoff. Permeable pavement systems (PPS) are a subset of LID stormwater BMPs of particular interest in dense urban areas because they can be installed in parking areas and low traffic roadways where the availability of land space for more traditional BMPs is not available. However, few studies have documented the performance of PPS in terms of reducing runoff volume, peak flow and pollutant loads in semiarid environments such as Colorado. Such information is necessary to improve the selection of BMP/LIDs for stormwater management.

This study evaluated effluent runoff volumes and water quality of three PPS in Fort Collins, Colorado. The sites were monitored between 2009 and 2011 to evaluate pollutant reduction, runoff volume reduction performance and surface infiltration rates. The Mountain and Walnut permeable inter-locking concrete paver (PICP) sites, referred to collectively as Mitchell Block, were each designed with differing "no-infiltration" sub-base designs to compare performance between a system with a sand filter layer (Walnut) and one with only gravel layers (Mountain). The third site, referred to as CTL, is a porous concrete (PC) parking lot that allows full infiltration, and was only monitored for water quality and surface infiltration rates. Mountain, Walnut and CTL all had lower effluent median event mean concentrations (EMCs) than those found at two Fort Collins stormwater outfalls for; total suspended solids (TSS), total recoverable zinc (TR Zn), total phosphorous (TP), total nitrogen (TN), total organic nitrogen (TON), total Kjeldahl nitrogen (TKN) and ammonia (NH_3). EMCs for TR copper (Cu), nitrate (NO_3) and total dissolved solids (TDS) at all three sites were elevated compared to the outfall sites.

Recorded effluent volumes and estimated influent volumes to the PPS at the Mitchell Block sites were used to calculate runoff volume reduction on an event-based and long-term basis. Both sites provided runoff reduction for over 70% of the monitored events, with Mountain and Walnut reducing 45% and 35% of the total runoff volume monitored at each site, respectively. These results confirm that "no-infiltration" PPS designs are capable of reducing large volumes of storm runoff. Field capacity (water retention capacity) of the two sites was investigated with regard to runoff reduction. Runoff volume reduction at Mountain exceeded the field capacity for the two longest storms monitored. This suggests that runoff volume reduction potential can exceed field capacity given long intermittent rainfall events. An investigation of hydrologic storm parameters indicated a discernible trend between runoff volume reduction and antecedent dry time, showing increasing runoff volume reduction with increasing antecedent dry time.