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Technical Memorandum

Project Title: Region 2 NPDES Phase II Permit Support

Project No.: 10005.001

Bioretention Performance Modeling

Subject: Evaluating Hydromodification Performance of Bioretention

Date: June 25, 2014

To: Dan Cloak

From: Tony Dubin

This technical memorandum describes the modeling analysis that was performed to determine whether bioretention facilities sized using the criteria included in Region 2 NPDES Phase II permit would achieve the permit's hydromodification requirement[1]. This memo describes the modeling method, results and implications.

Model Setup and Approach

Stormwater runoff and bioretention performance were simulated using HSPF, which is a physically-based, continuous hydrology model distributed by the USEPA. HSPF was used to simulate (1) pre-project runoff from a representative 1-acre of scrub/range vegetation land, (2) post-project runoff from a 1-acre impervious surface and (3) outflows from a bioretention facility that receives its input from the 1-acre impervious area. The HSPF model parameters and bioretention modeling approach were adapted from the Contra Costa HMP.

Time series input data for the model include hourly rainfall from the Kentfield gauge (from January 1995 to March 2014) and evapotranspiration data from the California Irrigation Management Information System (CIMIS) gauges at Novato (January 1995 to January 2002) and Point San Pedro (December 2002 to March 2014). Evapotranspiration values for the 11 month period between the two gauge records were estimated for each calendar day by computing the average of the evapotranspiration values measured on that same day in other years. Table 1 summarizes the model setup and bioretention facility configuration.

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[1] The hydromodification requirement is described in Section E.12.e(f) of the State Water Resources Control Board Water Quality Order No. 2013-0001-DWQ NPDES General Permit No. CAS000004 – Waste Discharge Requirements (WDRs) for Storm Water Discharges from Small Municipal Separate Storm Water Systems (MS4s).

Table 1. HSPF Model Setup and Bioretention Configuration	
Model Setup Item	**Model Value**
Scenarios simulated	• Pre-project condition (scrub/range vegetation) • Post-project condition (100% paved area) • Post-project, mitigated (flow routed through bioretention)
Rainfall data	• Kentfield gauge, hourly accumulations (Jan. 1995 to Mar. 2014)
Evapotranspiration data	• CIMIS daily data from Novato (1995-2002) and Point San Pedro (2002-2014)
Soil type	• NRCS Hydrologic Soil Group D (clay). HSPF parameters based on Contra Costa HMP analysis.
Bioretention dimensions	• Plan area = 4 percent of impervious tributary area • Surface reservoir depth = 6 inches (elevation of catch basin inlet) • Freeboard = 2 inches (from catch basin inlet to top of bioretention) • Bioretention soil depth = 18 inches • Gravel depth = 12 inches
Bioretention underdrain	• 4-inch diameter pipe with its crown elevation set equal to top of gravel layer
Bioretention infiltration	• Infiltration rate from gravel layer to native soils = 0.25 in/hr

Model Simulations and Results

Long term simulations were run for the three scenarios listed above. Hourly flows for each scenario were exported from the model and then separated into distinct storm events[2]. Each storm event was evaluated to determine a) the peak flow rate and b) the recurrence interval for each significant storm event (the top 100 events over the 19 year simulation period).

The simulated bioretention performance was examined in detail for two large storm events to better understand the function of each part of a bioretention facility. Figure 1 and Figure 2 show the simulated inflows, outflows and water depths within a bioretention facility for a large storm event in early December 2004 that produced 6.5 inches of rain over a three day period.

The bioretention was dry at the start of the event and the soils accommodated the first wave of stormwater runoff, providing treatment and percolating water into the gravel layer. Later in the event, as both the gravel layer and the bioretention soil/surface storage layers became saturated, stormwater was discharged from both the underdrain and the catch basin inlet located at the top of the surface storage layer. The downward sloping portion of the blue line in Figure 2 illustrates infiltration from the gravel layer to the surrounding soils. For smaller events, all incoming stormwater would infiltrate to surrounding soils or be discharged via the underdrain.

[2] The time series of modeled flow rates were divided into distinct events using the partial duration series method, which is preferable for frequency analyses of relatively common storm/hydrologic events (<5 to 10 years).

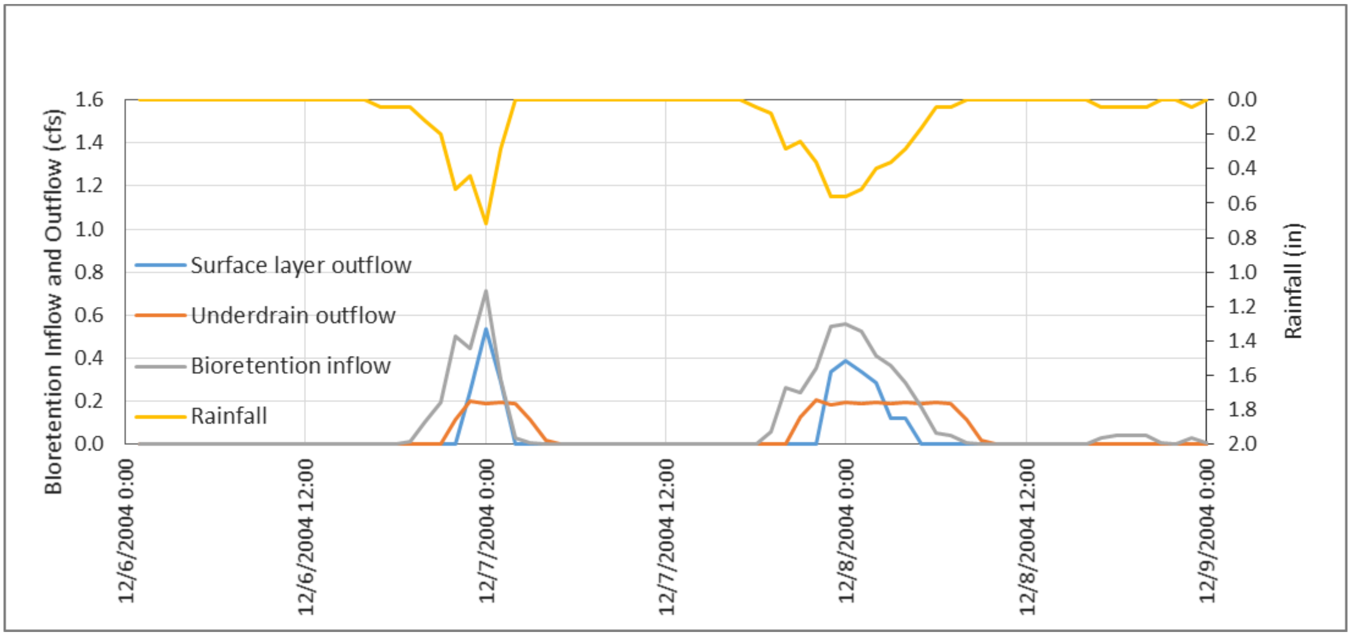

Figure 1. Bioretention inflows and outflows for large December 2004 event

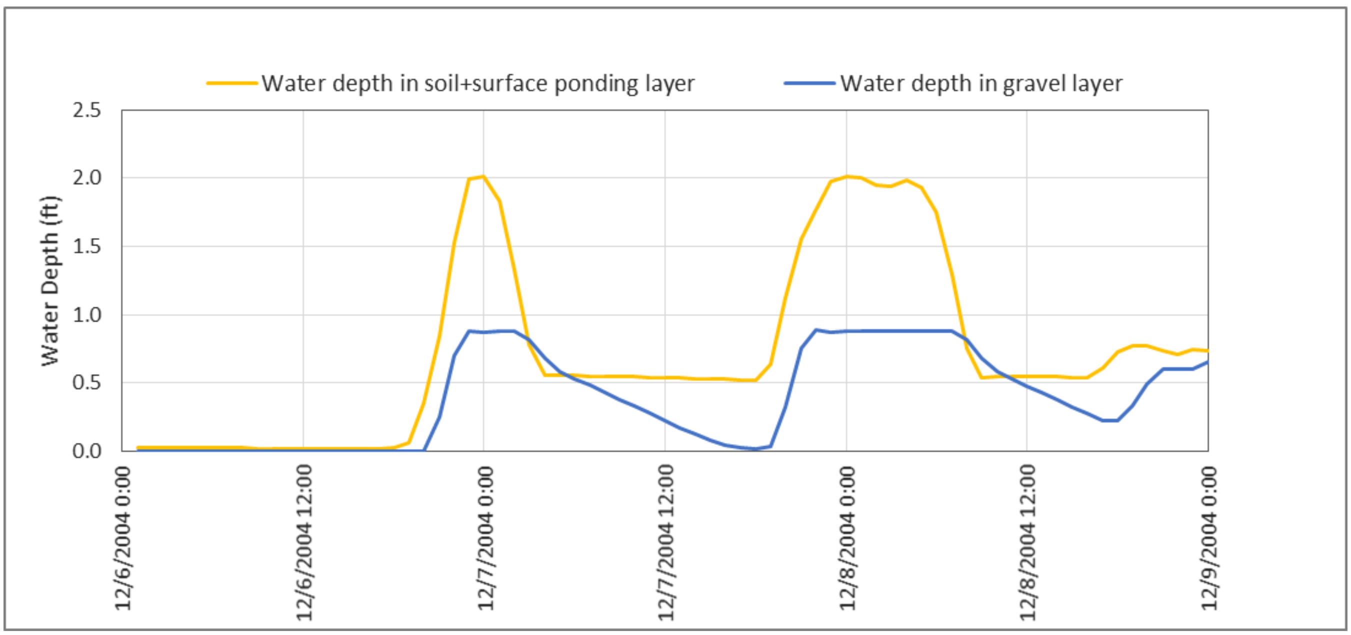

Figure 2. Water depths within the gravel and soil/surface storage layers for large December 2004 event

The NPDES Phase II permit covering parts of Marin, Napa, Sonoma and Solano Counties specifies that the peak 2-year outflow from the bioretention facility cannot exceed the pre-project peak 2-year flow for the project site. The bioretention outflows and pre-project flows were compared for the 2-year recurrence and for other storms up to the 10-year recurrence level (Figure 3). The results demonstrate that the bioretention facility dimensions included in the permit will limit peak outflows to levels that are below the pre-project peak flows. *Note: The comparison of storms > 2-years was performed only because I had the automated tools already in place.*

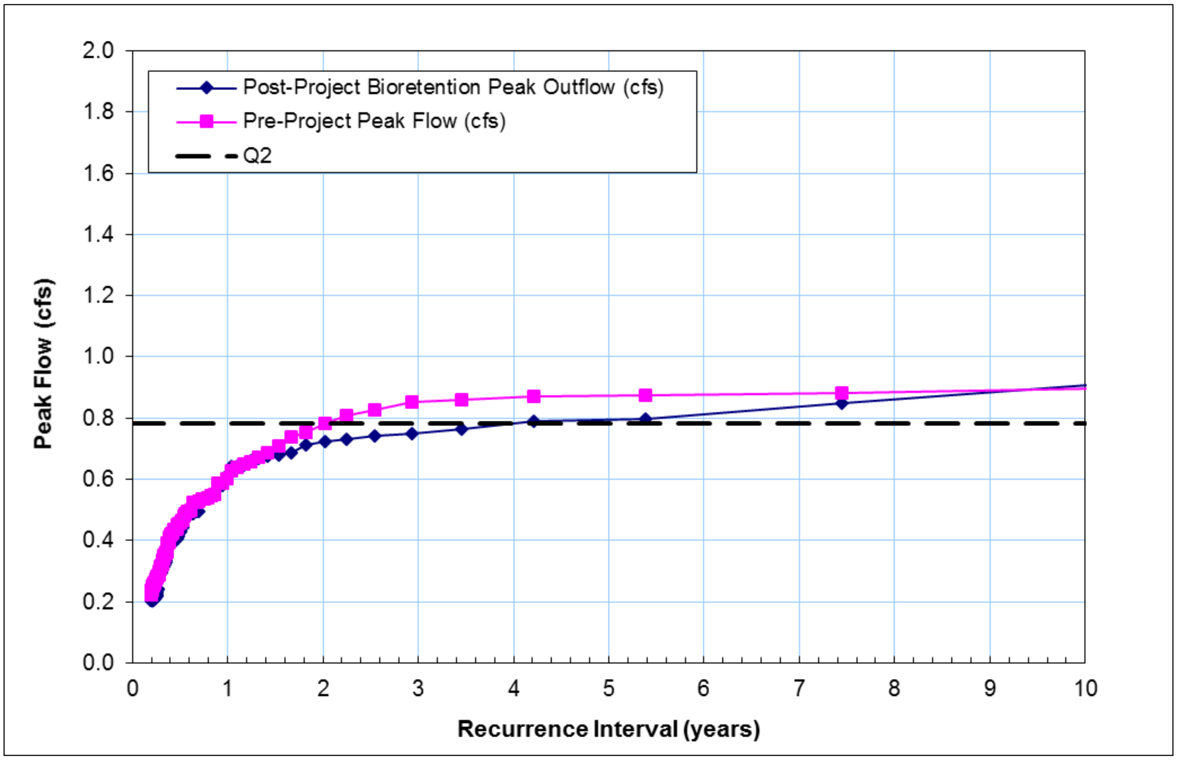

Figure 3. The NPDES permit's bioretention sizing criteria will reduce peak flows below pre-project levels for the 2-year recurrence event required by the permit and for larger storms.

Conclusions

HSPF modeling was used to evaluate whether a bioretention facility sized with the criteria included in the Region 2 NPDES Phase II permit would control 2-year peak flows to pre-project levels. This analysis was performed using rainfall data collected at Kentfield, which is among the wettest areas covered by the permit, and for NRCS Group D (clay) soils, which is the most commonly found soil type within the permit area.

The modeling results show the bioretention's peak 2-year outflow rate would be 7 percent lower than 2-year peak flows for pre-project conditions. The bioretention facility would also control peak flows for storms up to the 10-year recurrence interval.