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Subject: **Design of Integrated Management Practices**
Vertical Position of Underdrains in Bioretention Facilities
Review and Interim Guidance

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Summary

The elevation of bioretention facility underdrains and exit points should be near the top of the gravel drainage layer except where:

- Infiltration is not allowable and is prevented with an impermeable liner or other impermeable construction, or
- Based on direct knowledge of site conditions, it is expected that the gravel drainage layer will not drain completely within approximately one week of a rain event due to very impermeable soils, bedrock, high groundwater, or similar conditions.

In these latter cases, the elevation of the underdrain pipe and exit point should be at the bottom of the drainage layer. (In flow-through planters, infiltration to native soils is prevented, and underdrain pipes and exit points should always be located at the bottom of the drainage layer.)

Background and Discussion

Design for Flow Control (Hydrograph Modification Management)

Bioretention facilities designed for runoff flow control as well as treatment are equipped with an orifice at the exit point of the underdrain pipe.

Flow-through planters designed for flow control are similarly equipped. Note flow-through planters may be used for flow control only on sites where native soils are Hydrologic Soil Group “C” or “D” and facilities are located on upper-story plazas, adjacent to building foundations, where mobilization of pollutants in soil or groundwater is a concern, and where potential geotechnical hazards are associated with infiltration.

Maximum discharge flow rates and orifice diameters are calculated according to equations provided in the *Stormwater C.3 Guidebook* or by using the IMP Sizing Calculator. The orifice diameter is designed to limit flow to the specified maximum discharge flow when the head of the orifice is one foot.

In the development of these equations, 30+ years of hourly rainfall data were used to continuously simulate inflow to a facility. Soil saturation and the filling and drainage of the underdrain layer were calculated for each hour of the simulation and the head above the orifice was used to calculate the discharge rate during that hour. This hourly discharge data was compiled and compared to hourly discharge data simulated from rainfall on an undeveloped site, and the design iterated until it could be shown that the facility controlled peak flows and durations for the given range of flows.

As part of the modeling, the effect of underdrain exit point elevation was also considered. With a higher exit point, more storage is initially available, and discharges are reduced. However, with closely spaced runoff events, the gravel layer does not drain completely. As a result, uncontrolled discharge through the overflow at the top of the surface storage layer becomes more frequent. A lower exit point ensures storage is available for subsequent events and uncontrolled discharges through the surface overflow are less frequent. Therefore the combined effects of raising or lowering the height of the exit point tend to offset each other, making the flow-control performance of the facility relatively insensitive to this design parameter.

Design to Maximize Infiltration Volume

Municipal Regional Permit Provision C.3.c. requires stormwater treatment facilities for Regulated Projects be designed to provide treatment of the specified volume or flow by infiltration, evapotranspiration, or harvesting and reuse. “Biotreatment” may be used if infiltration, evapotranspiration, and harvesting and reuse are infeasible. BASMAA is developing Infeasibility criteria and will propose those criteria to the Board by May 1, 2011.

Bioretention facilities are designed to facilitate infiltration and evapotranspiration to the extent feasible given conditions at the facility location.

Setting the underdrain and exit point near the top of the gravel layer will tend to maximize the amount of runoff that is captured and made to infiltrate into native soils rather than being discharged through the underdrain. Note that a design which captures a specified runoff volume beneath the underdrain exit height must infiltrate that volume within the corresponding period (typically 48 hours) to successfully meet the objective of infiltrating 80% of average annual runoff.

In balance, in both treatment and treatment-and-flow-control bioretention facilities, it makes sense to locate underdrains near the top of the gravel layer as long as native soils provide sufficient drainage so that the facility does not hold stagnant water for long periods of time. Many Contra Costa “Group D” soils will drain sufficiently fast, particularly if they are not compacted and if there are slopes or retaining walls nearby. However, designers should use their own judgment based on site-specific investigation. Observing soil moisture and surface conditions in the days following a wet period may be sufficient information for making this decision and—as drainage on disturbed urban sites is often anisotropic—such observations may be more directly applicable than *in situ* or laboratory testing of soil characteristics.