Bioretention Cells: A Way to Improve Storm Water Quality and a Solution for Flood Prevention

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Abstract

Bioretention cells are popular stormwater management practices and low impact development solutions to many of the problems caused by stormwater runoff. Treating stormwater runoff thru biofiltration cells provide a means to reduce runoff volumes and pollutions that would otherwise impair waterbodies. The study has for objectives:

- Evaluate current bioretention cells design standards to determine volume retention using different soil mixtures of sand and compost.
- Control of the infiltration rate in the bioretention cells to minimize the amount of pollutants released into the City's flood control system.

Results will be used to provide recommendation for the improvement of the bioretention cell design parameters in the LASAN Low Impact Development standards.

Background

Implementation of Low Impact Development (LID) techniques, such as bioretention systems, have become a major component in the plans of local municipalities in their response to stormwater regulations. The infiltration rate is the key parameter to maximize volume control and water quality improvement. Infiltration rate is a function of the composition of the bioretention cell media. Based on previous experiments, it is hypothesized that media mix ratios with higher percentages of compost will contribute to slowdown infiltration rates.

Four field-scale biorention cells were constructed at the John T. Lyle Center for Regenerative Studies.

All cells were hydraulically connected to a 550 gallons reservoir and to a pump. Influent flow can be varied by using a combination of gravity and/or pumping.

Figure 1. Site location at the Lyle Center for Regenerative Studies

Figure 2. Render of bioretention cells (left), Constructed cells with gravel and topsoil (right)

Methods & Materials

The biofiltration design criteria followed the specification of the February 2014 County of Los Angeles Department of Public Works Low Impact Development Standards Manual (DPW_LID).

The 3ft x 3ft x 4ft cells have been built using ¼ in thick acrylic. These cells act as a layered scaled down (1:50) bioretention system. From bottom to top, each cell contains a 6 in layer of ¾" washed gravel , a 3 in layer of Pea gravel layer, and an 18 in layer of various compost-sand combination mixes as shown in Table 1. The stormwater quality design volume (SWQDv) was back calculated following the DWP_LID and the tributary area determined using the City of LA Hydrocalc tool. To simulate a storm event, the cell will receive a total volume of 4 ft^3 at different flow rates, with a standard of 48 hours between each simulation.

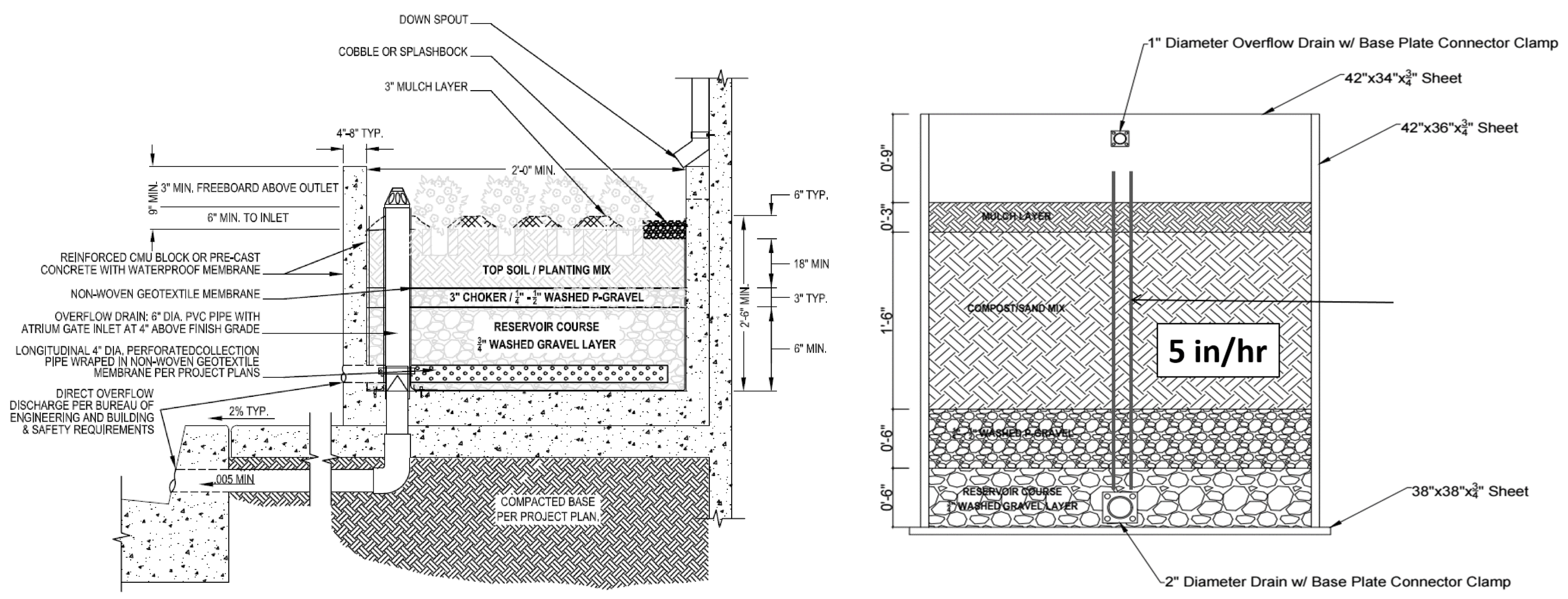


Figure 3. Bioretention cell cross section details, City of LA standards (left), field scale cell (CPP systems) (right)

On-Site Retention Calculations

Using the DWP_LID standards each bioretention cell, with surface dimensions of 3'x3', can treat a maximum of 4 ft^3 of storm water. The cell area simulates the characteristics of a 40 ft^2 of tributary area, 100% impervious at the 85th percentile.

California State Polytechnic University, Pomona and the City of LA Research on Bioretention

Bioretention $SWQD_v$ Calculations

Used nomenclature for calculation

- **$SWQD_v$** - Storm Quality Design Volume (ft^3)
- **V_B** - Biofiltration Design Volume (ft^3)
- **d** - Ponding depth (ft)
- **SF** - Safety factor
- **V_R** - Retained Volume (ft^3)
- **W** - Width (ft)
- **L** - Length (ft)
- **f_{design}** - Design infiltration rate (in/hr)
- **A** - Bioretention cell's area (ft^2)
- **LID** - Low Impact Development
- **t_p** - Time for surface ponding to occur (hr)

Steps:

1: Look for city's standards related to Bioretention or LID to be used as guidelines.

2: Calculate your bioretention cell's area using the following formula:

$$A = \frac{V_B}{d}$$

3: Calulate the $SWQD_v$: $V_B = 1.5 * (SWQD_V - V_R)$ where V_R is zero because we assume that no water will be retained inside the cell. That means that the amount of water that enters is the same that exit to the reservoir.

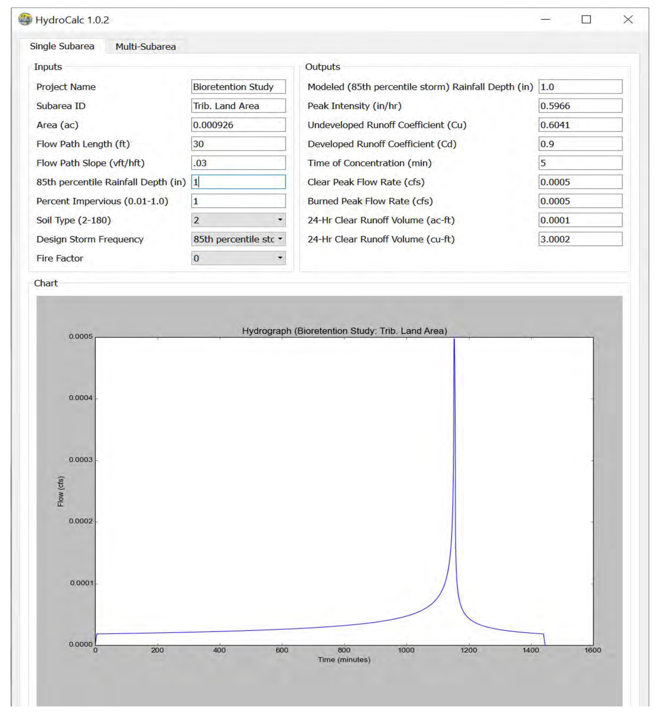
4: Find the time surface ponding using the f_{design} as 5 in/hr, using the following formula:

$$d = t_p * \left(\frac{f_{design}}{12}\right)$$

5: Compare your results with the City of LA LID standards. If they are different than the standards use your engineering judgement to adjust it. To compare results, please see LA LID standard, Appendix F from Stormwater Quality Control Measure (from page F-2 to F-4).

*Calculations are based on the DWP_LID standards

LA Hydrocalc Calculations Results



Assumed Values to calculate $SWQD_v$

Numenclator	Values	Units
W	3	ft
L	3	ft
A_{land}	40	ft^2
d	6	in
SF	1.5	-
V_R	0	ft^3
f_{design}	5	in/hr

Tributary area

Storm Water Quality Design volume

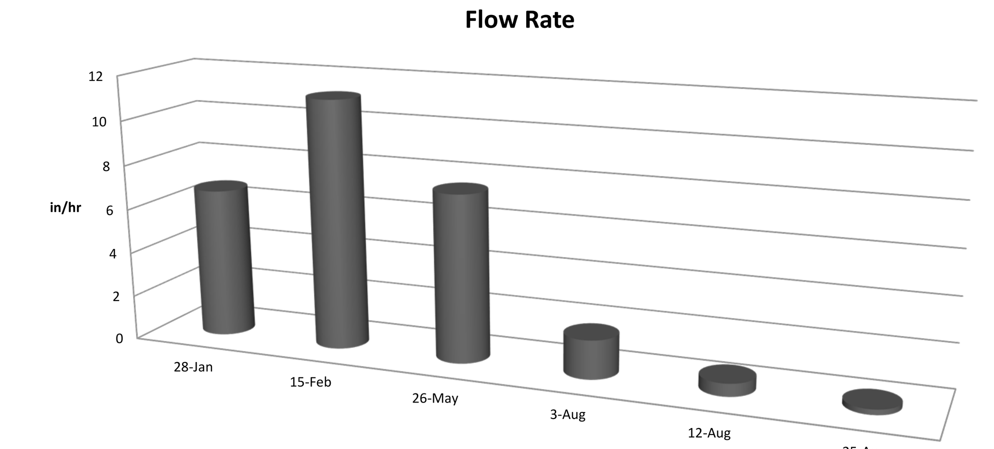
Calculations

V_B	4.5	ft^3
$SWQD_v$	3	ft^3
A	9	ft^2
t_p	1.2	hr

Field Results

Table 1. Cell topsoil media and infiltration rates

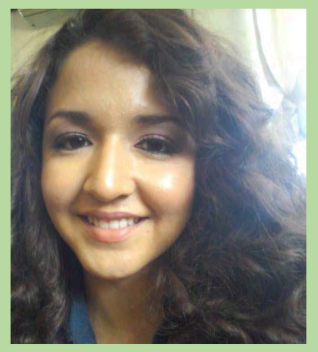
Media Mix	Date	Measured Infiltration Rate (Gravel) (in/hr)	Desired Infiltration Rate (Media mix & Gravel) (in/hr)
60% C, 40% S	Feb 15, 2017	10.22	5
60% C, 40% S	May 26, 2017	6.50	5
60% C, 40% S	Aug 3, 2017	1.73	5
60% C, 40% S	Aug 12, 2017	0.56	5
60% C, 40% S	Aug 25, 2017	0.23	5



Graph 1. *Flow rate comparison per date for cell 2.*

Summary

- The topsoil mixture combinations must provide high volume retention to achieve a maximum infiltration rate of 5 in/hr.
- Theoretically, the constructed cells will have the capacity to provide sufficient volume control for a tributary area of 40 ft^2.
- After observing the dramatic change in the infiltration rate results, the group hypothesizes the fine particles have clogged the effluent pipe. Future analysis and testing would require removing media particles from the geotextile fabric covering the pipes.



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