UNDERSTANDING BIORETENTION HYDRAULICS AND CONSTRUCTION

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BIORETENTION HYDRAULICS

- Why the need to understand the hydraulics behind bioretention design?
  - –Currently, bioretention basins are the preferred best management practice for small sites.
  - –Highly urbanized areas require more hydraulic control.

WHO SHOULD UNDERSTAND BIORETENTION HYDRAULICS?

- –Engineers, architects, property owners, municipal officials, contractors, the community and including those who are:
  - preparing engineering plans.
  - designing and/or reviewing SWM/SWQ systems.
  - conducting water quality inspection and observation.
  - installing and maintaining bioretention basins.
  - trying to understand the expectations and maintenance of the surface runoff.
  - inspecting the operation of the bioretention basin.

WHERE CAN YOU FIND GUIDELINES TO DESIGN BIORETENTION BASINS?

- As of December 2006, the ODNR Rainwater and Land Development Manual has updated the expected minimum requirements for bioretention design.
  - –Reference materials.
  - –Many municipal jurisdictions, including the SWCD and Ohio EPA accept the current Rainwater and Land Development Manual for design reference.
  - –Stay current with post construction modern developments from other sources.

A FACTOR OFTEN CONFUSED FROM RAINWATER MANUAL FOR BIORETENTION DESIGN?

"k" Value

– **Planting Soil Mix (Chapter 2, pg 71)**

- **If you specify the soil mix on this page, the coefficient of permeability is:**

1.5 TO 2.6 IN/HR ⟹ 3 TO 5.2 FT/DAY

- **The Ohio EPA and other sources the EPA references have used 0.5 ft/day for calculating bioretention ponding area, but it does not stipulate 0.5 ft/day in the manual.**

WHAT DOES THIS MEAN TO YOU?

•**EX: Given:**

» **WQv=3000 ft^3 (Water Quality Volume)**
» **d_s=4.0 ft (Depth of Planting Soil)**
» **h_s=0.5 ft (Average Height of water above planting soil and mulch)**
» **t_s= 1.66 days (40 hours per EPA requirements)**

» **Determine size of bioretention ponding area using EPA recommended "k" value (0.5 ft/day) and the "k" value in Rainwater Manual (≈4.0 ft/day)**

$$A = \frac{(WQv)(ds)}{[(k)(hs+ds)(ts)]}$$

$$A = \frac{(3000)(4)}{[(0.5)(0.5+4)(1.66)]} \cong 3200 ft^2$$

$$A = \frac{(3000)(4)}{[(4.0)(0.5+4)(1.66)]} \cong 400 ft^2$$

A LARGE DIFFERENCE IN REQUIRED BIORETENTION PONDING AREA.

WHAT "k" VALUE SHOULD YOU USE?

– **A conservative approach would be to take a 0.5 ft/day assumed coefficient of permeability, which could be justified to account for:**
  – **the after settling and use of the planting soil.**
  – **contractor installation practices.**
  – **"real world" scenarios regarding validity of soil permeability data.**

– **The Rainwater Manual also indicates that a "k" value should be taken from lab values. (chapter 2, pg 74, item 5); this "k" value is only specified on the plans, but a 0.5ft/day "k" value is utilized in the bioretention basin sizing calculation.**

– **Note: If a soil provider is not contacted, the planting soil and coefficient of permeability in the odnr manual will still be specified on the plans, however, your calculations should utilize 0.5ft/day.**

HOW DOES THE DEPTH OF THE PLANTING SOIL EFFECT THE BIORETENTION SIZING CALUCATIONS?

- **EX: Given:**
  » **WQv=3000 ft^3 (Water Quality Volume)**
  » **k=0.5 ft/day (Coefficient of Permeability)**
  » **h_s=0.5 ft (Average Height of water above planting soil and mulch)**
  » **t_s= 1.66 days (40 hours per EPA requirements)**

  » **Determine size of bioretention ponding area if a planting soil depth is 2.5ft and 4.0 ft?**

$$A = \frac{(WQv)(ds)}{[(k)(hs+ds)(ts)]}$$

$$A - \frac{(3000)(2.5)}{[(0.5)(0.5+2.5)(1.66)]} \cong 3000 ft^2$$

$$A = \frac{(3000)(4.0)}{[(0.5)(0.5+4.0)(1.66)]} \cong 3200 ft^2$$

THE SMALLER THE PLANTING SOIL DEPTH, THE SMALLER THE REQUIRED BIORETENTION BASIN AREA .

WHAT DOES THIS MEAN TO YOU?

- **Benefits of minimum planting soil depth:**

SOIL DEPTH ⇓ AREA REQUIRED ⇓ COST ⇓ EXCAVATION ⇓

  - **Bioretention sizing formula is based on Darcy's Law.**
  - **Darcy's Law is a simple proportional relationship between the instantaneous discharge rate through a porous medium, the viscosity of the fluid and the pressure drop over a given distance.**
  - **Since Darcy's Law fundamentally revolves around the concept of flow, it would make sense that a shorter depth of planting soil would allow the flow to pass the soil quicker, therefore reducing the required cross sectional area required to pass the flow.**

MINIMUM ISN'T ALWAYS BETTER

WHY USE A DEEPER PLANTING SOIL DEPTH?

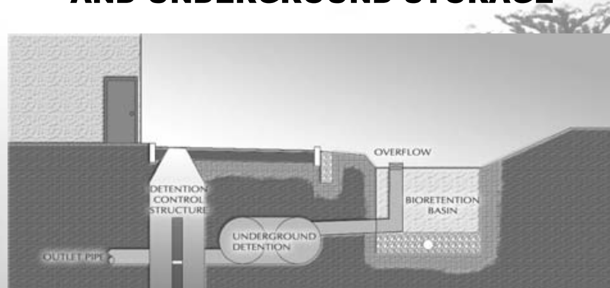
SOIL DEPTH ⇑ POLLUTANT REMOVAL EFFICIENCY ⇑

THE PURPOSE OF THE BIORETENTION BASIN IS TO MAXIMIZE THE POLLUTANT REMOVAL EFFICIENCY.

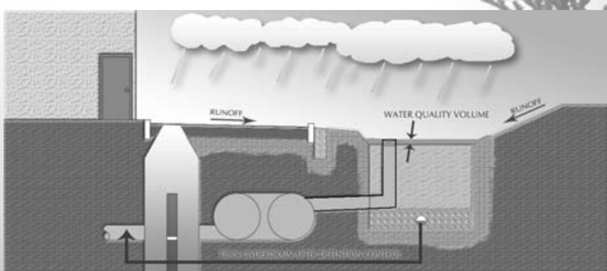
STORMWATER DETENTION AND BIORETENTION

- **What are good practice design considerations?**
  - **Proper overflow inlet capacity.**
  - **Culvert analysis of connected overflow risers.**
  - **Berm heights.**
  - **Grading techniques.**
  - **Pipe locations and depths.**

EX: DIAGRAM OF BIORETENTION AND UNDERGROUND STORAGE



EVERYDAY STORM EVENTS

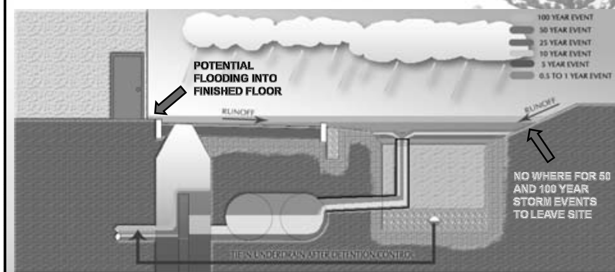


•Flow from underdrain should be taken directly to outlet pipe, and not before the detention outlet control to avoid backup of runoff into bioretention basin once detention system begins to store runoff.

WHAT EFFECTS THE ROUTING OF WATER IN THE SYSTEM?

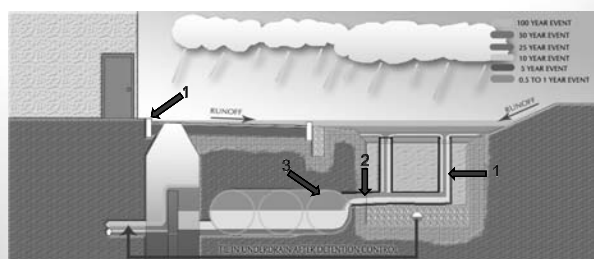
1. INLET CAPACITY
2. WEIR TO ORIFICE FLOW
3. RISER DIAMETER
4. CULVERT PIPE

EX: WHAT HAPPENS DURING LARGER STORM EVENTS?



In this example, the engineer was required to store the 25 year post, to the 1 year pre. Note, the engineer did not account for the 50 and 100 year event.

POSSIBLE SOLUTION!



1. Add a riser to reduce head above bioretention basin (in addtition, consider a grate which can accept additional flow and/or increase size of riser).
2. If you add a riser, ensure your conveyance pipe to detention can carry the total flow to the detention system (size up the pipe).
3. Ensure detention system has the ability to contain additional flow at a quicker rate while still releasing required release rate (add extra storage).

CALCULATIONS?

- **Previously mentioned analysis calculations requires interconnected ponds, and the study of runoff through a hydraulically routed system which works in series.**
- **Recommend utilizing software which allows you to calculate interconnected ponds.**

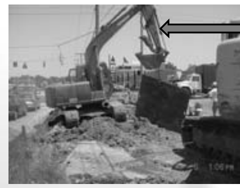
ITEMS TO NOTE DURING BIORETENTION CONSTRUCTION

BE SURE TO STABILIZE SOIL WALLS TO AVOID WASHOUT INTO GRAVEL AND PLANTING SOIL DURING CONSTRUCTION

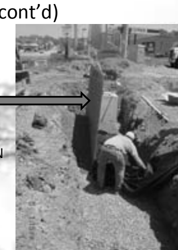
BIORETENTION BASIN SHOULD NOT BE INSTALLED UNTIL SITE IS 90% STABILIZED AND THERE IS MINIMAL SEDIMENT LAIDEN RUNOFF

FUEL TANKS; UNDERSTAND WHEN A BASIN SHOULD HAVE A LINER FOR REASONS OTHER THAN GROUNDWATER

ITEMS TO NOTE DURING BIORETENTION CONSTRUCTION (cont'd)



UNDERSTAND THE EQUIPMENT AND SPACE REQUIRED TO PERFORM CONSTRUCTION



UNDERSTAND THE COMPLEXITY OF CONSTRUCTION AND WHAT YOU SPECIFYING.

ITEMS TO NOTE DURING BIORETENTION CONSTRUCTION (cont'd)

- COMPACTION SHOULD BE KEPT TO A MINIMUM; LIGHT COMPACTION RECOMMENDED.
- SOIL SHOULD BE PLACED IN 12" TO 18" LOOSE LIFTS.
- WATERING THE PLANTING SOIL DURING INSTALLATION HELPS ACHIEVE COMPACTION WITHOUT EXCESSIVE MECHANICAL COMPACTION.

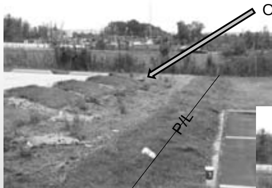
BE CONSCIENCIOUS WHERE THE MATERIALS ARE BEING STORED PRIOR TO INSTALLATION.

DESIGN CONSIDERATIONS

GRADING DESIGN MUST CONSIDER SURROUNDING CONDITIONS TO INSURE SAFETY.

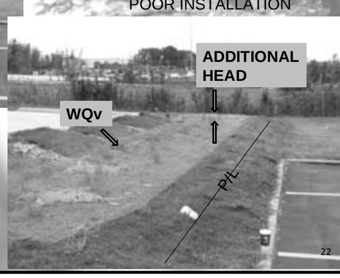
BE INNOVATIVE AND CONSIDER MULTIPLE BASINS WHICH MAY BE STEPPED TO MATCH GRADE. THIS EXAMPLE HAS THREE BASINS IN SERIES WHICH DROP APPROXIMATE 1 TO 2 FEET IN GRADE BETWEEN BASINS.

DESIGN CONSIDERATIONS



OVERFLOW

POOR INSTALLATION



GOOD EXAMPLE ILLUSTRATING THE IMPORTANCE OF UNDERSTANDING WHERE LARGER STORM EVENTS WILL END UP

PLANTINGS

IN ADDTION TO SPECIFYING PLANTS WHICH CAN TOLERATE SATURATED CONDITIONS, SPECIFY PLANTS WHICH ADD AESTHETIC VALUE TO THE PROPERTY.

ENSURE PLANTINGS ARE TAKING AND GROWING. THE ROOTS OF THE PLANTS PROVIDE FOR MUCH OF THE POLLUTANT REMOVAL.

BIORETENTION IN ACTION

CONSIDER BIORETENTION BASIN IS WORKING PROPERLY WHEN:

- THERE IS NO STANDING WATER.
- LITTER DID NOT MAKE IT INTO CITY STORM SEWER.
- PLANTS ARE HEALTHY AND GROWING.

BIORETENTION IN ACTION

(click on movie)

- ELIMINATING CURB HELPS DISSAPATE CONCENTRATED FLOW.
- ELIMINATING CURB HELPS WITH LOCALIZED PONDING IN BASIN.

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FOR ADDITIONAL CONSULTATION

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