Design Manual: Retention Basin

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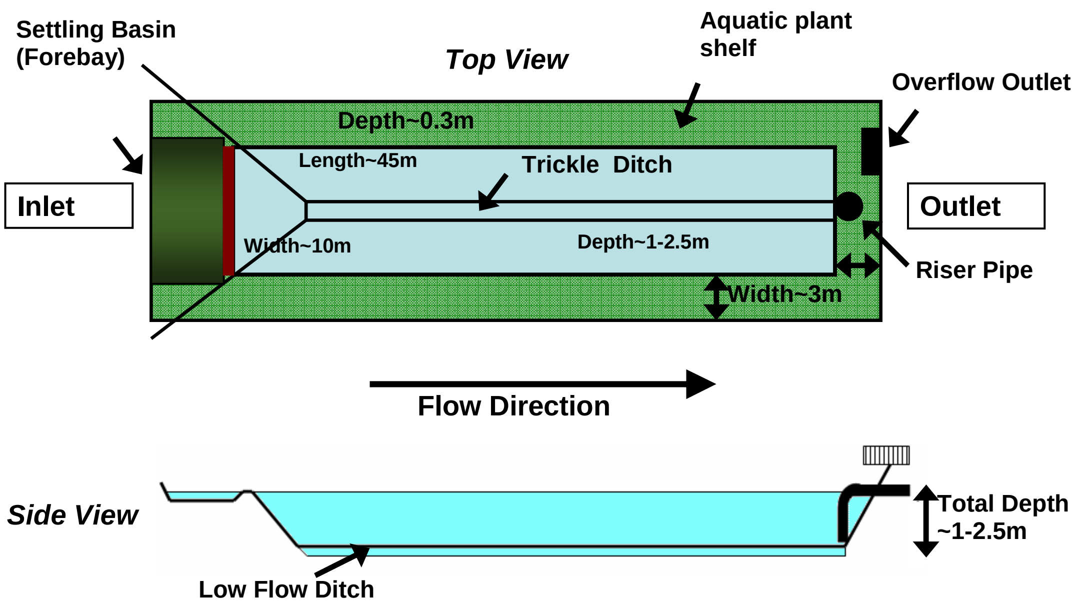
Description: Retention basins are a best management practice intended to mitigate storm water runoff. Essentially, water is detained in the basin while pollutants are treated by natural processes and water exits the basin slowly over time, or during the next storm. Processes such as mechanical settling of suspended sediments and biological processing of nutrients contribute to improved water quality.

Wet Basins

Purpose: Reduce volume of storm water, treat water through mechanical settling of suspended sediment, removal of metals, organic compounds, oil and grease, and biological processing of nutrients. Additional uses include removal of trash, groundwater recharge, recreation, or water supply.

Dry Basin

Diagram of a Typical Retention Basin



Ideal Location: Since the city of San Cristóbal de las Casas is initiating a stormwater treatment system, retention basins would be useful for rivers located upstream of the city. Because loss of forest in the surrounding sub-watersheds has increased stormwater runoff, retention basins would prevent large surges of stormwater from entering the city, and reduce overall loading on a municipal waste water treatment plant. Basins should be built at least 3 meters (10 ft) from the nearest basement wall, and at least 30 meters (100 feet) from the nearest water supply well. The total area for the estimated dimensions above is 950 m^2 with maintenance access.

Cost and Materials: The main costs for site excavation are labor and equipment rental. Depending on the type of basin desired, additional materials that may be needed include a polyethylene liner, outlet riser pipe, flood stage outlet, trash rack, cement trickle channel, or side slope stabilization materials. Construction costs are highly site specific, depending on topography, soils, subsurface conditions, the local labor rate, and other considerations. The annual cost of routine maintenance (especially sediment and vegetation removal) has been estimated at 3-5% of construction costs, and systems normally last longer than 20 years without major reconstruction.

Steps for Construction

1. **Consider primary goals and how they will affect design**

   NOTE: Some needs may conflict.

   a. Nutrient/Pollutant Removal – A detention basin with a permanent pool of water will effectively remove nutrients in addition to other pollutants. A dry detention basin is *not* effective at removing pollutants, and pollutants that may settle in the basin will be "picked up" by future floods. (A permanent pool will depend on availability of rainfall throughout the year and the existence of a liner.)

   b. Water supply – The basin should have a permanent pool and be physically accessible to users. A sediment forebay (a shallow depression at the inlet of the basin that captures large sediment particles) will help to pre-treat the water. Regular water quality testing should be done to assess designated uses.

   c. Groundwater recharge – The basin should not have a liner.

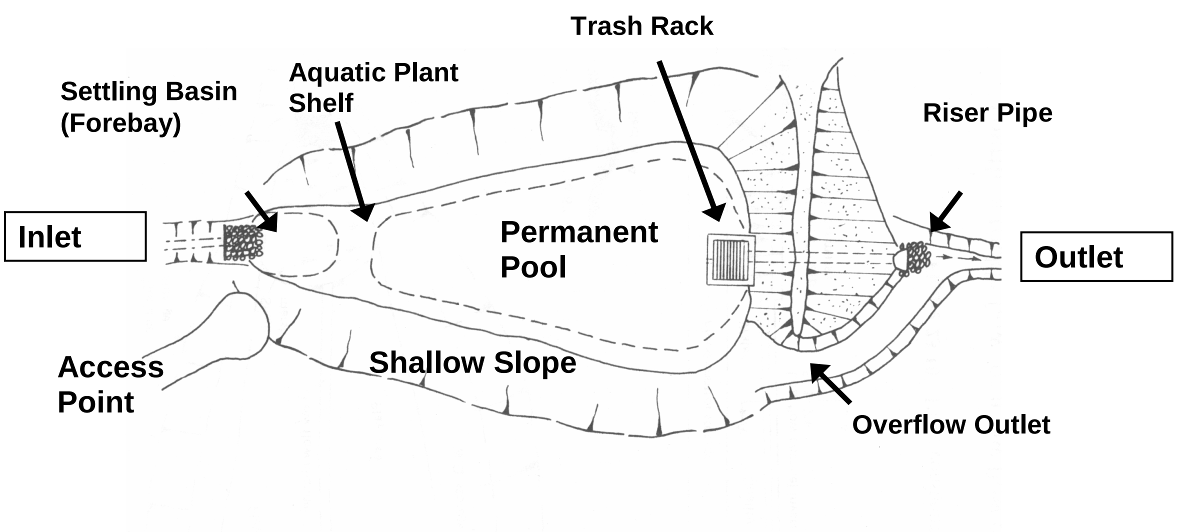
   d. Trash removal – A trash grate should be installed on the inlet and/or outlet of the basin. Regular trash removal will be required.

2. **Design considerations**

   a. Basins can either be dug out of the ground, or an embankment can be built up to enclose a low-lying area. The embankment *must* be substantial enough to withstand flood events.

   b. Shape: A length-to-width ratio of 2:1 or greater and a level bottom surface allow directional flow, maximize treatment time, and prevent the formation of stagnant areas which breed mosquitoes. Oblong structures with the inlet and outlet at opposite ends are generally best, although an elongated triangular shape with the inlet at its apex can be used as well (see example).

Triangular-Shaped Wet Retention Basin



c. Retention Time: The optimal removal of nutrients occurs with a retention time of 2-3 weeks for pools with 1-2 meter depth. In other words, one water drop on average should spend 2-3 weeks in the retention basin. A shorter amount of time will lead to insufficient natural processing of nutrients; while after a longer time, the basin can thermally stratify. The retention time can be calculated by:

$$T = VB/nVR$$

T is retention time, VB is the volume of the basin (volume = area x depth), n is the number of runoff events in a given period (i.e. one year), and VR is the volume of runoff in an average rain event for that period.

d. Depth: Depth should be shallow enough to maintain aerobic conditions by avoiding thermal stratification, yet deep enough to minimize algal blooms and the re-suspension of settled sediments from surface wind disturbances. Recommended optimal depth for maximizing biological water treatment is between 1-2.5 meters. Depths of 2-2.5 meters will prevent sunlight from penetrating the bottom of the pool, which prevents overgrowth of permanent aquatic vegetation into the designated open water area.

e. Aquatic Shelf: Surrounding the open water area, a shelf about 3 meters wide and 1/3 meter deep can be built to promote native wetland vegetation around the perimeter. Vegetation will reduce erosion and enhance nutrient uptake. The total area of the aquatic shelf should be no more than 25-50% of the permanent pool area.

f. Trickle Ditch: This structure channels water from the inlet to the outlet even during low flow, to prevent stagnation. During rain events, the water would simply overflow the channel and go into the rest of the basin. A concrete-lined channel is suggested for easy maintenance and self-cleansing.

g. Inlet: A shallow depression near the inlet concentrates the majority of sediment deposition in a smaller, more easily accessible area for removal. Many pollutants are attached to suspended solids, so this structure facilitates a simple primary treatment of storm water. The inlet structure should be able to dissipate flow energy and prevent erosion, and may incorporate vegetation, cement, or rock.

h. Outlet: A riser pipe at the outlet will draw out the cooler bottom water for discharge, to avoid thermal impacts on receiving surface waters. For a wet basin, flow through the pipe is driven by the natural water pressure. In addition, an overflow outlet structure at a higher stage should be installed to release water during large storm events, and prevent overtopping of the embankment. Release rate should be consistent with the original natural stream flow at that site. Changing the size of the opening is the easiest way to decrease flow rate.

Outlet of a Retention Basin

Trash Rack

3. **Sizing**
   a. First, the desired hydraulic retention time (T) should be determined:
      - A larger basin will generally provide better pollutant removal, but larger basins cost more to construct.
      - To allow a retention time of 2-3 weeks, as suggested, the volume of the basin should be about 3-4 times the volume of runoff from a typical rainfall event.
   b. Method 1: Estimate the area of land that will drain to the basin and calculate volume to hold half an inch of runoff for each acre.
   c. Method 2: Calculate volume needed to store runoff from a 2-year storm event.
   d. After determining volume in m^3, divide by 2m (depth) to obtain surface area of open water, and divide again by 10m (width) to obtain the length.

4. Potential Problems and Solutions:

Problem:	Solution:
Human safety	Build side slopes no steeper than 4:1 (vertical to horizontal distance) to prevent accidents
Mosquito breeding	Eliminate stagnant areas with a low flow ditch and a level bottom surface
Embankment overtopping	An engineer should be consulted when constructing an embankment, to ensure that it will withstand pressure from a full volume of water in the basin.
Seepage to groundwater	If water quality in the basin is a concern, use a liner to prevent seepage to underlying aquifers
Sediment/Trash Build-up	To promote more frequent maintenance, site basin in an accessible and highly visible area. Hire laborers or commit volunteers to a regular schedule.

5. Steps for Construction

a. Locate a site and determine an appropriate design given the goals of the project.
b. Make a blueprint including calculation of volume, width, depth, length, outflow rate, maximum pressure from full water volume, retention time, surface area of open pond and area of aquatic shelf.
c. Excavate area and build embankment.
d. (Optional) Lay down liner and cover with a thin layer of clay or soil.
e. Construct outlet and inlet; install trash grates if desired.
f. (Optional) Seed aquatic shelf with native, noninvasive wetland plants.

6. Sample Maintenance Schedule

Activity: Inspection	Suggested Frequency:
Inspect to ensure bank stability, sufficient vegetation growth and expected drainage	After the first three post-construction storm events
Inspect for invasive vegetation, trash and debris, clogging of inlet/outlet structures, excessive erosion, sediment buildup in basin or outlet, cracking or settling of the dam, bank stability, tree growth on dam or embankment, vigor and density of the grass turf on the basin side slopes and floor, differential settlement, leakage, subsidence, damage to the emergency spillway, mechanical component condition, graffiti, excessive algal growth, signs of pollution such as oil sheens, discolored water, or unpleasant odors, and signs of flooding.	Twice a year and after large storm events
Inspect stream conditions above and below the basin.	Once a year
Remove sediment from outlet structure, remove trash and debris, repair eroded areas	Twice a year
Mow side slopes or re-seed if needed to maintain vegetation; remove vegetation from bottom of wet pond area	Once a year
Remove sediment from the forebay and re-grade when the accumulated sediment volume exceeds 10-20% of the forebay volume. Clean in early spring so vegetation damaged during cleaning has time to re-establish.	Every five years
Remove sediment if a) the permanent pool volume is reduced significantly (sediment accumulation exceeds 25% of depth), b) if resuspension of sediment is observed, or c) the pond becomes eutrophic (signaled by high nitrogen and phosphorus levels, low dissolved oxygen and excessive algal growth).	Every five years or as needed

7. Cost Worksheet

Item	Estimated Cost	Actual Cost
Excavation (earth-moving) Equipment Rental		
Labor		
Polyethylene liner (if needed)		
Cement for Trickle Channel (if needed)		
Outlet riser pipe		
Trash Rack (if needed)		
Cement or trash rack for emergency outlet (spillway)		
Rocks or other soil stabilization materials (if needed)		
Plants or seeds		
Maintenance		