

Mixing Things Up

Preventing short-circuiting in stormwater ponds.

By Jeffrey S. Glenn and Elizabeth M. Bartell

With growing concerns over pollutants making their way into our nation's surface waters, ground waters, and springs, water resource professionals throughout the U.S. are beginning to re-examine stormwater treatment techniques to find new ways to sustain our water supplies for years to come. In Florida, for example, the Department of Environmental Protection is considering a new statewide stormwater treatment rule that will increase the required amount of pollutants, or nutrients like nitrogen and phosphorus, removed by stormwater management facilities.

One way to treat stormwater runoff is to design a stormwater management pond that acts as a filter by removing nutrients through chemical reactions, biological uptake by indigenous plants, and the settlement of suspended solids before discharging to the receiving water body. For effective treatment, however, the runoff must remain within the pond for a long enough period of time to allow for adequate dispersion. If inflow to the pond flows directly to the outlet with little or no dispersion, then short-circuiting occurs resulting in the transfer of a potentially harmful level of pollutants to the downstream water body.

Although many municipalities and

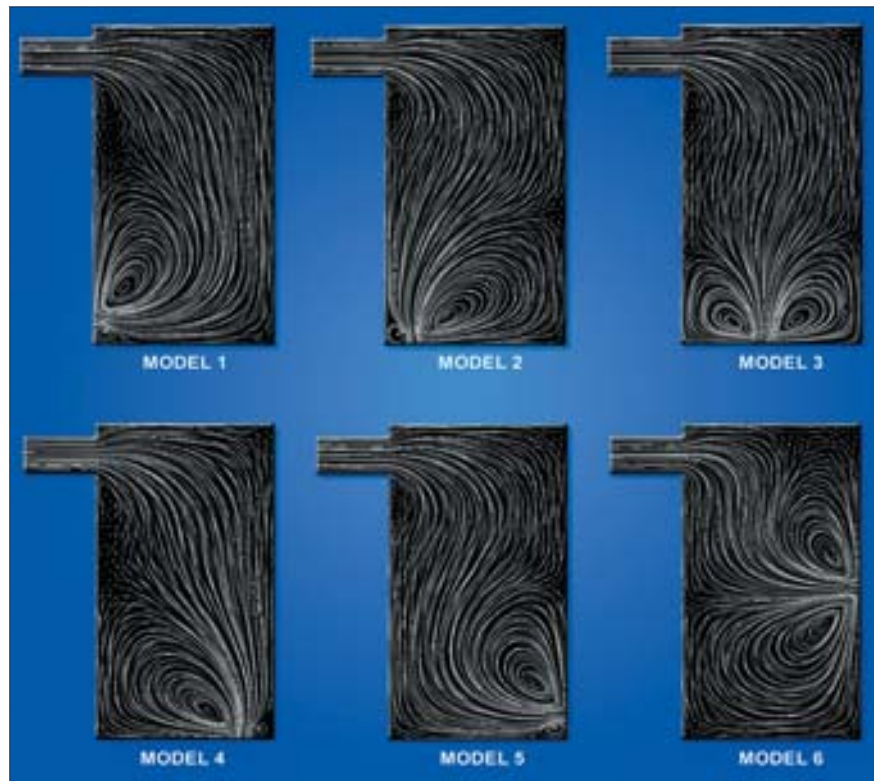
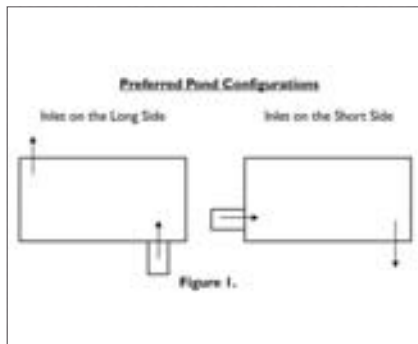


Figure 2. Flow Paths for Pond Models with Inlets on the Long Side

Model	Distance Traveled (ft)	Average Velocity (fps)	Travel Time (hrs)
1	1,113	0.053	5.8
2	931	0.058	4.5
3	674	0.051	3.7
4	672	0.065	2.9
5	1,123	0.041	7.6
6	855	0.085	2.8

Table 1. Shortest Flow Path Summary for Ponds with Inlets on the Long Side

regulatory agencies have developed design criteria intended to prevent short-circuiting from occurring in stormwater ponds, these regulations are generally limited and often vague.

Standards frequently include a specified minimum pond surface area, baffle systems, and energy dissipaters at pond inlets. Many agencies also require a minimum length-to-width ratio of 2:1 for

rectangular shaped ponds, which is necessary to provide adequate area for a longer flow path based on studies of pond parameters on hydraulic performance.

Recently, facilities and infrastructure consulting firm RS&H (www.rsandh.com) conducted a study that suggests different inlet and outlet configurations of stormwater ponds may also have a significant impact on preventing short-circuiting. By configuring ponds in a way that maximizes the distance and time it takes for stormwater runoff to travel from the inlet to the outlet, design engineers could more effectively prevent short-circuiting by ensuring the adequate dispersion of runoff within the pond before it discharges to the downstream water body. These optimal configurations could also be adopted by municipalities and regulatory agencies as they prepare or improve their stormwater pond requirements in the coming years.

Modeling Stormwater Ponds

Applying the standard length-to-width ratio of 2:1, the study team created a rectangular pond using Version 9.2.4 of Surface Water Modeling System (SMS) and Version 4.56 of RMA2, a two-dimensional, depth-averaged, finite element, hydraulic modeling computer program and interface distributed by Environmental Modeling Systems, Inc. (EMS-I, www.ems-i.com). Parameters to reflect real-world conditions, such as tall grass and disturbed soil and debris, were also included.

The team ran the models using one of two pond inlet locations: an inlet at the end of the longer side of the pond (referred to as the long side) and one at the end of the shorter side (referred to as the short side). Six different locations for the pond outlet were also modeled to investigate the unique flow patterns within the pond for the varying inlet and outlet configurations (See Figure 1.)

Short-circuiting in the ponds is dependent upon the shortest distance traveled by a particle from the inlet to the outlet. Using the particle tracing routine in SMS, the team placed massless particles at one-foot increments across the pond inlet. Flow paths of the

particles, which included flow visualizations and quantified distances and velocities, were then traced for all pond configurations. For each configuration, the team identified the particle with the shortest flow path from the inlet to the outlet and then recorded the corresponding distance and average velocity to determine the travel time, or the amount of time the particle remained within the pond (See Figures 2 and 3).

The distance traveled by the particles with the shortest flow paths and their

travel time were then used to determine the optimal pond inlet and outlet configurations for preventing short-circuiting within the ponds. For both inlet locations, the optimal pond outlet location is the one that produces the greatest distance for the particle with the shortest flow path from the inlet to outlet, maximizing the time that particle remains within the pond to allow for adequate dispersion of the stormwater runoff.

For configurations with the inlet on

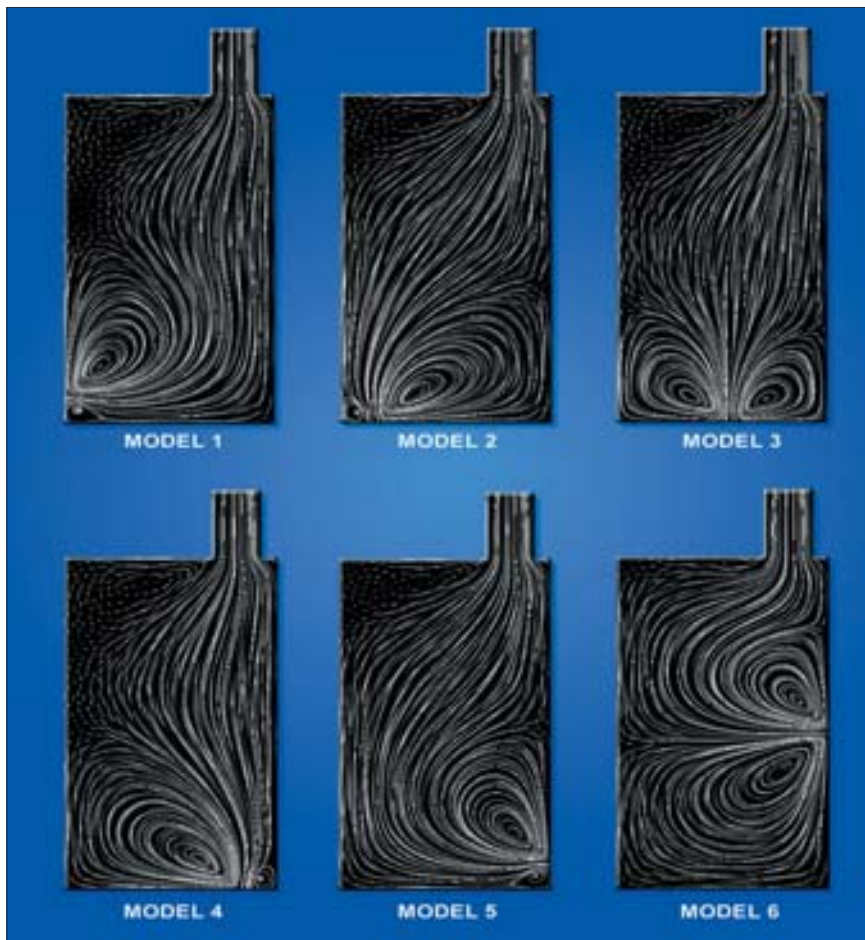


Figure 3. Flow Paths for Pond Models with Inlets on the Short Side

Model	Distance Traveled (ft)	Average Velocity (fps)	Travel Time (hrs)
1	870	0.048	5.0
2	856	0.049	4.9
3	922	0.047	5.5
4	959	0.050	5.3
5	1,325	0.054	6.8
6	870	0.075	3.2

Table 2. Shortest Flow Path Summary for Ponds with Inlets on the Short Side

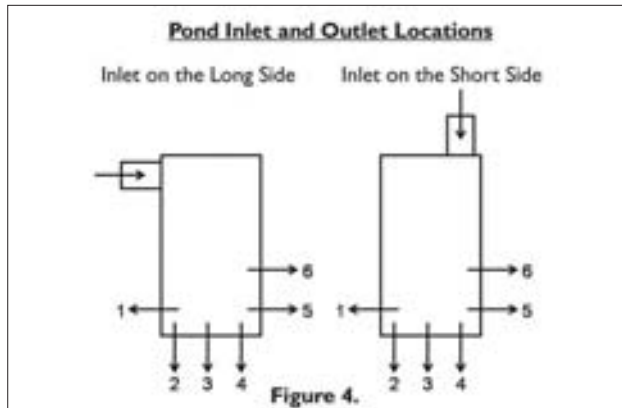


Figure 4.

the long side of the pond, the longest travel distance for the particle with the shortest flow path occurred when the outlet was positioned on the opposite side of the inlet at the furthest corner from the inlet, or Model 5. The travel time for the particle in Model 5 was also considerably longer than travel times of models with comparable flow path distances. Therefore, the pond configuration for Model 5 is preferred for ponds with inlets on the long side (Table 1).

For configurations with the inlet on the short side of the pond, the longest travel distance for the particle with the shortest flow path occurred when the outlet was positioned on the closest adjacent side to the inlet at the furthest corner from the inlet, also Model 5. The

results showed that the travel time for Model 5 was also considerably longer than the travel times of the other models. Therefore, the pond configuration for Model 5 is preferred when the inlet is located on the short side (Table 2).

The results of the study demonstrate the importance of the locations of the pond inlet and outlet in rectangular stormwater ponds that utilize a 2:1 length-to-width ratio. While the minimum length-to-width ratio criteria is necessary to provide adequate area for a longer flow path, the location of the outlet relative to the location of the inlet ultimately determines the travel time from the inlet of the pond to its outlet (See Figure 4).

Appropriate design requirements to prevent short-circuiting in stormwater ponds could be adopted by jurisdictional regulatory agencies to prevent stormwater pollutant loads from degrading the water quality and/or exceeding the established Total

Maximum Daily Load of downstream receiving water bodies. To promote the adoption of these regulations by agencies and municipalities, these findings are currently being presented to international audiences urging them to reevaluate their current stormwater design standards.

These findings are also being discussed locally with a variety of agencies, such as the Florida Water Management Districts, the Florida Department of Environmental Protection, and several municipalities. Benefits of updating their current stormwater design criteria to include the results of this study could help municipalities meet their National Pollution Discharge Elimination System requirements and improve the quality of water bodies in their area. Adopting these new and advanced design criteria will reduce the occurrence of short-circuiting in stormwater ponds and ultimately increase the recreational, biological, and aesthetic values of our surface water bodies.



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