



To: Chris Grammier (GAI), Vijay (Devo Eng)

From: Bob Casper (Devo Eng)

Date: February 3, 2009

Re: **MODELING A POND WITH A SHARED BOUNDARY**

Consider the example in Figure 1 below where a series of pond cells are situated such that a portion of the perimeters are shared.

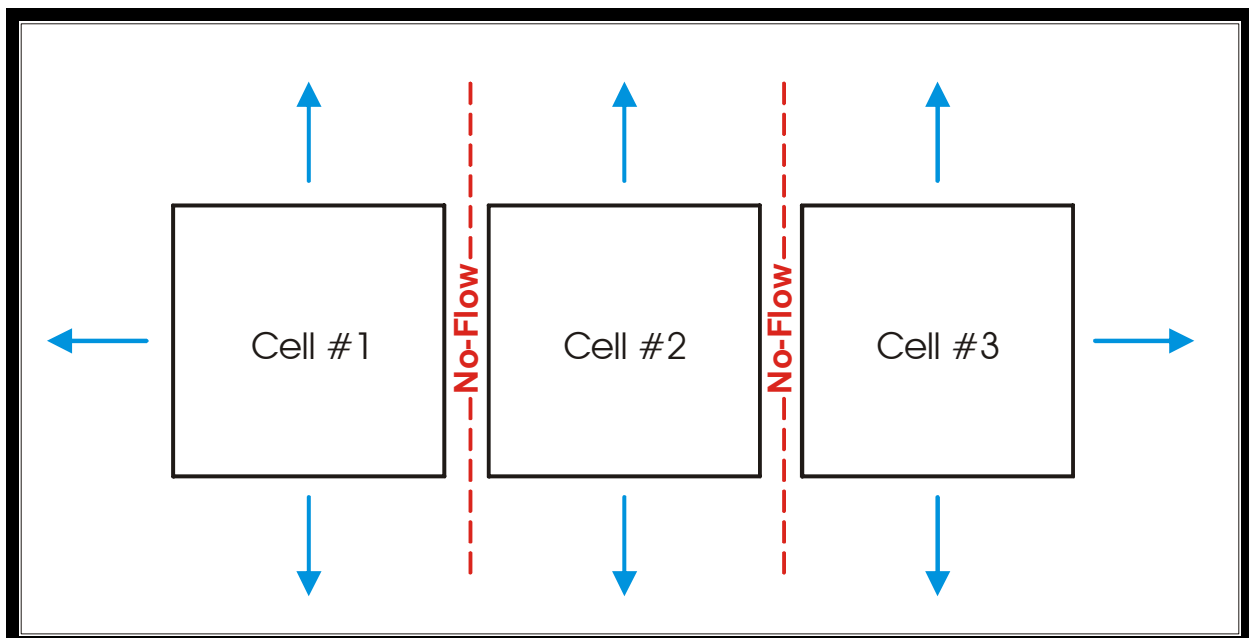


Exhibit 1. Assumed flow domains for retention pond cells

One way to model this is to assume that the shared perimeter becomes a no flow boundary, and that no horizontal flow can occur through that boundary. This reduces the length of perimeter which is available for saturated horizontal infiltration, so the “effective” (i.e., non-shared) perimeter should be used for modeling. An effective pond length and width are then chosen which will generate the same length of effective perimeter.

However, note the following.

The stage versus area data for the pond define how much storage capacity is available in the pond. Normally, when the water level drops below the pond bottom, the storage in the soil voids beneath the pond is calculated using the soil porosity times the **“nominal” pond area, i.e., the effective length times the effective width**. However, if the shared perimeter is omitted from the effective length and width, then the nominal pond area will decrease, and the soil storage beneath the pond will also decrease (artificially). As a result, when the water level drops below the pond bottom (during saturated horizontal infiltration) the water level will fall at an exaggerated rate, because there appears to be less soil storage than in reality. For example, consider the recovery plot below, which shows an exaggerated drop in stage once the water level falls below the pond bottom.

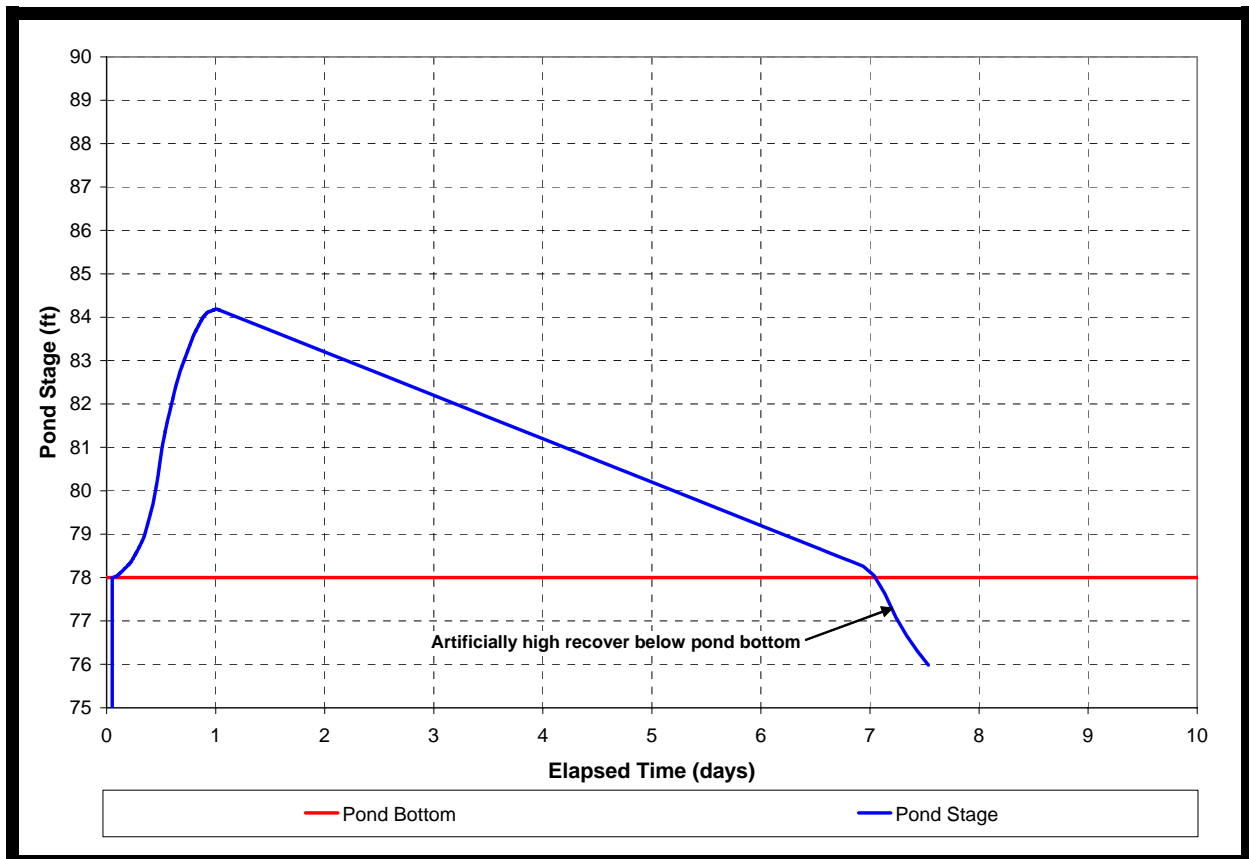


Exhibit 2. Pond Recovery Curve

Of course, once the water level falls below the pond bottom, then the pond is “recovered” and what happens beyond that point may or may not be of very much interest.

However, there is an alternative representation for the stage vs area relationship which can help to preserve the soil void volume beneath the pond bottom. In this representation, the soil void volume is directly incorporated into the "pond" stage vs area data. The stage vs area data then contains the soil void volume and the open pond volume.

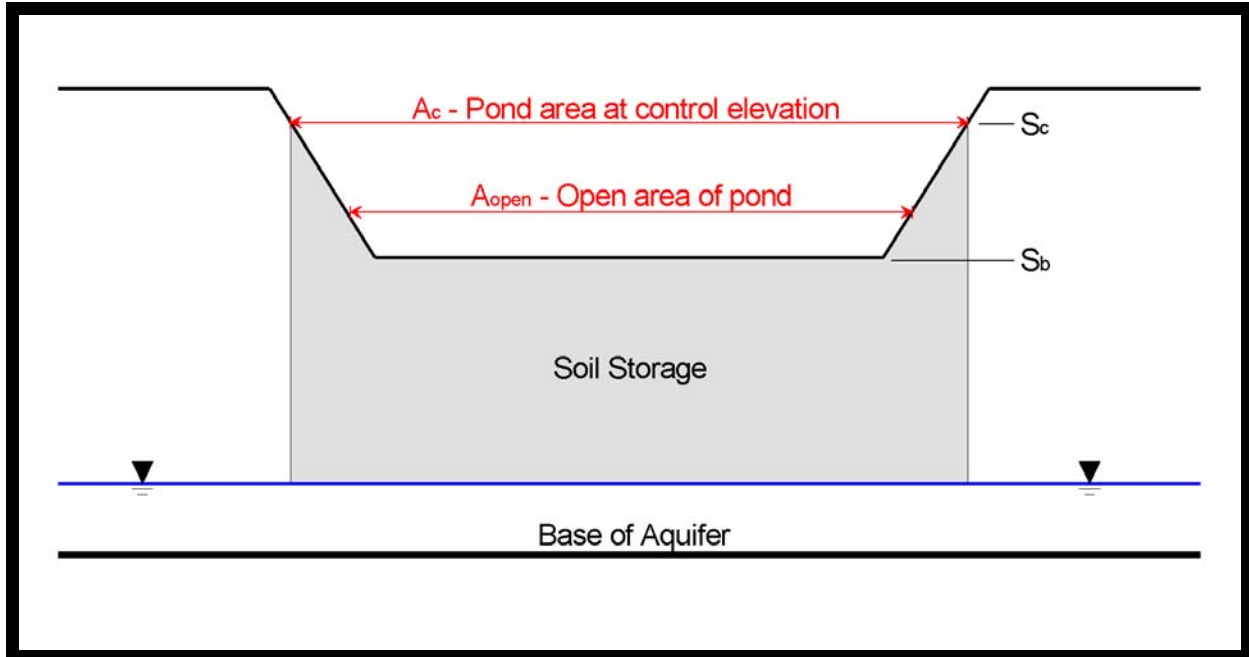


Exhibit 3. Alternate Stage vs Area

The equivalent pond areas are calculated as described in Table I.

Table I. Formulation of Alternate Stage vs. Area Relationship	
Stage	Area
$S > S_c$	A_{open}
$S_b \leq S \leq S_c$	$A_{open} + (A_c - A_{open}) * n$
$S < S_b$	$A_c * n$

where

S is an arbitrary elevation

S_c is the control elevation of the pond

S_b is the elevation of the (actual) pond bottom

A_{open} is the open cross sectional area at a given elevation

A_c is the cross sectional pond area at the control elevation

n is the fillable porosity of the soil voids

In this representation, the prism of soil which is included could be extended down to the water table, or down to the base of aquifer, depending on the needs of the particular model.

However, note that this alternative representation will not work for unsaturated infiltration, for several reasons. Primarily due to the fact that unsaturated infiltration will proceed until the soil voids are filled, and the program can no longer distinguish between soil voids and pond using this alternative relationship. So the alternate stage vs storage representation will only work for saturated infiltration.

If you need to analyze both unsaturated and saturated infiltration, then this can be accomplished in a two phase approach.

- ① Analyze the unsaturated infiltration using the stage vs area data of the pond alone (no soil voids included). Determine when the analysis transitions from unsaturated to saturated infiltration.
- ② Determine the stage in the pond at the time when the solution transitions from unsaturated to saturated infiltration. Analyze the pond for saturated infiltration only, by slugging in a volume of water sufficient to bring the initial pond stage to the stage at the transition between unsaturated and saturated infiltration (from step one above). Analyze using the alternative representation of the stage vs area.

Then plot the recovery by combining the results of the two steps above. Up to the transition period, plot the stage from Step 1. After the transition period, plot the stage from Step 2 (making sure to add an appropriate offset in the elapsed time).

Exhibit 4 below shows the composite recovery curve for the same example shown in Exhibit 2 above, but using the two step composite analysis (i.e., separate analyses for unsaturated and saturated infiltration).

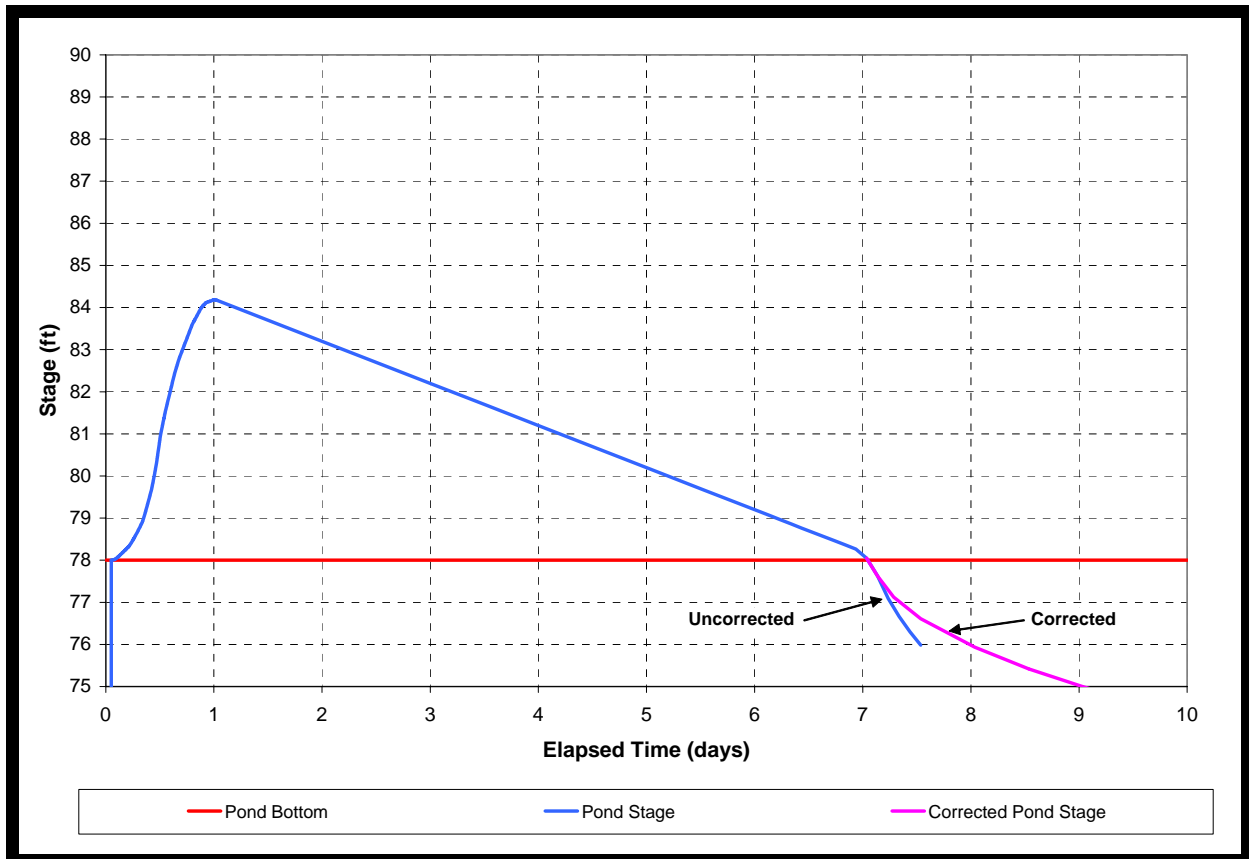


Exhibit 4. Composite recovery curve