Article 73

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Performance of Two Wet Ponds in the Piedmont of North Carolina

How much storage in a wet pond is enough? Some interesting answers to this questions have been addressed by researchers in North Carolina (Wu, 1989). They examined the performance of two very dissimilar wet ponds located in the piedmont near Charlotte, NC. The first wet pond, Lakeside, was large and deep and had a permanent pool volume equivalent to 7.1 watershed-inches (Table 1). To put this in perspective, this storage volume is seven to 15 times greater than that typically required for stormwater quality treatment in most communities in the US.

The second pond, known as Runaway Bay, was shallow (average depth 3.8 feet), and despite the fact that it served a 435-acre watershed, had a smaller surface area than the Lakeside pond. Indeed, when the permanent pool volume of Runaway Bay was compared to Lakeside, it was found to be 20 times smaller (0.33 watershed inches of storage). The investigators examined the role of permanent pool volume on pollutant removal performance in these wet ponds.

Table 1: Characteristics of the Study Ponds

Pond characteristic	Lakeside Pond	Runaway Bay
Drainage area (acres)	65	437
Imperviousness	46%	38%
Pond area (acres)	4.9	3.3
Mean depth (ft.)	7.9	3.8
Volume (acre-ft.)	38.8	12.30
Equivalent watershed storage (in.)	7.1	0.33
Resident geese	30 to 40	none

Table 2: Pollutant Removal of Two Wet Ponds in the North Carolina Piedmont (Mean storm efficiency N= 11)

Water quality parameter	Lakeside Pond (%)	Runaway Bay (%)
Total Suspended Solids	93	62
Total Phosphorus	45	36
Total Kjeldahl Nitrogen (TKN)	32	21
Extractable Zinc	80	32
Extractable Iron	87	52
Pond Area/Watershed Area	7.5	2.3

Great performance was not expected for a number of reasons. To begin with, the two ponds were not originally designed for stormwater treatment. Each pond was fed by many inlet pipes, most of which were located near the outlet. Consequently, each pond experienced significant short-circuiting and was unable to delay downstream peak discharge by more than a few hours. Second, the soils in the watersheds were the trademark red clay soils of the Southern Piedmont.

An analysis of sediment particles in runoff showed that over 40% were less than three microns in diameter, and all were less than 26 microns (i.e, medium silt). As a result, the measured sediment settling velocity averaged less than an inch per hour, an uncommonly slow settling rate. Third, runoff concentrations of many pollutants produced from the two watersheds were quite low, when compared to those found in other cities and towns across the US. In particular, incoming runoff had relatively dilute concentrations of nitrogen and phosphorus. Monitoring of other ponds has often shown that pond performance declines when incoming pollutant concentrations are low. Lastly, one of the ponds (Lakeside) had its own internal nutrient loading source: a year-round population of 30 to 40 geese. Feeding on nearby turf, the geese were estimated to add some five to 7% to the pond's total nutrient load through droppings.

Wu and his colleagues monitored the performance of each pond during 11 storm events that ranged from 0.5 to 3.6 inches of rainfall. The results are shown in Table 2. As expected, the larger and deeper Lakeside pond performed better than the shallow and undersized Runaway Bay pond. Excellent removal of suspended sediment and some metals was observed at the Lakeside pond (greater than 80%). The performance of the larger Lakeside pond in removing nutrients, however, was surprisingly modest in comparison to the smaller Runaway Bay pond. Removal of phosphorus and nitrogen was only 10% higher at Lakeside, despite the fact that this pond had a permanent pool volume 20 times greater than Runaway Bay. Wu speculated that the population of geese at the Lakeside pond could have reduced its efficiency. Short-circuiting and low inflow concentrations were also cited as reasons for the modest performance at the Lakeside pond.

Another interesting facet of the study was Wu's analysis of the outflow from the ponds under dry weather conditions. Dry weather outflow from ponds is generally not measured in most monitoring studies, nor is it accounted for when pond pollutant removal rates are computed. The standard assumption is that both the volume of total runoff and the concentration of pollutants in dry weather flow are inconsequential in relation to those produced during storm events. Wu's data suggests that this assumption may be a dubious one (Table 3). Levels of total phosphorus and organic nitrogen in the outflow from each pond was actually higher during dry weather periods than during storm conditions.

Table 3: Comparison of Storm and Dry Weather Outflows From Lakeside (LS) and Runaway Bay (RB) Ponds

Water quality parameter (mg/l)	Mean storm inflow	Mean storm outflow	Dry weather outflow
Total P (LS)	0.14	0.08	0.15
Total P (RB)	0.12	0.08	0.18
TKN (LS)	0.86	0.59	1.20
TKN (RB)	0.79	0.63	0.80

To get a better handle on the ideal permanent pool volume for wet pond design, Wu used an EPA model of wet pond pollutant removal performance, using local data on pond geometry, rainfall/runoff relationships and sediment settling velocities (EPA, 1987). Wu found generally good agreement between the model results and his field monitoring data, although the model tended to slightly underpredict nutrient removal rates. Based on his results, Wu recommended that satisfactory pollutant removal performance could be achieved if wet ponds were sized to be at least 2% of the contributing drainage area, with an average depth of six feet. The study also reinforces the notion that treatment volume alone does not guarantee good performance. Other key design variables include providing good internal geometry and pondscaping to discourage large geese populations.

—TRS

References

Wu, J. 1989. *Evaluation of Detention Basin Performance in the Piedmont Region of North Carolina*. North Carolina Water Resources Research Institute. Report No. 89-248. Raleigh, NC. 46 pp.

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