Article 94

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Pollutant Removal Capability of a "Pocket" Wetland

Many stormwater engineers now employ small pocket ponds or wetlands to treat stormwater runoff generated by smaller development sites. The term "pocket" refers to a pond or wetland that has a such a small contributing drainage area that little or no baseflow is available to sustain water elevations during dry weather. Instead, water elevations are heavily influenced and, in some cases, maintained by a locally high water table. Until recently, very little was known about the pollutant removal performance of pocket wetlands or ponds. However, recent research and monitoring by Betty Rushton and Craig Dye in southern Florida has greatly increased our understanding of these systems. They recently completed a comprehensive analysis of a "pocket" wetland draining a six-acre office park near Tampa Bay, Florida. Their monitoring study examined storm dynamics and pollutant behavior at the facility over a two-year interval. In addition, they examined local groundwater interactions, accumulation of priority pollutants in pond sediments, and the pollutant chemistry of rainfall.

Constructed in 1986, the pond had a very small surface area (0.32 acres), was sized to provide a half-inch of runoff storage for water quality treatment, and had additional temporary detention of larger storms for peak-shaving purposes. Although the authors did not report the impervious cover for the site, they did compute a storm runoff coefficient of 0.32.

Runoff to the pond was conveyed by a 200 foot long grassed drainage channel, which may have provided partial pretreatment. The shallow pond (maximum depth of 18 inches) was sandwiched between two adjacent forested wetlands and had a flat bottom (see Figure 1). Pond water levels fluctuated during the year, drying out entirely during the dry season and then filling to the full 18 inch depth in the normally wetter "summer" season. Originally planted with arrowhead and pickerelweed, nearly 95% of the wetland surface area is now covered by cattail and algal mats.

For these reasons, the study pond can probably best be described as a pocket wetland, although it is technically considered a wet detention pond under Florida design guidelines. Hydrologic monitoring indicated that the pocket wetland had a mean residence time of 3.7 days on an annual basis, and a slightly shorter residence time (2.1 days) during the summer "rainy season." Physical monitoring indicated that the pocket wetland was strongly influenced by biological activity. For example, summer sampling showed a pronounced diurnal swing in dissolved oxygen in the pocket wetland, with complete nighttime anoxia followed by a partial daytime recovery to about four to five mg/l.

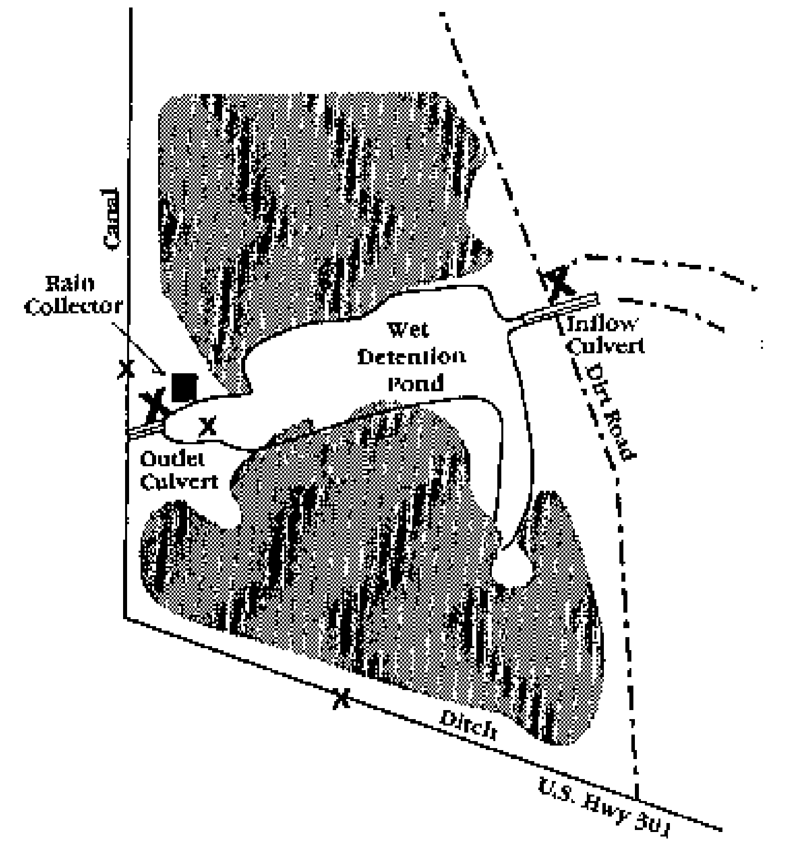

Figure 1: Plan View of the Pocket Wetland (Rushton and Dye, 1993)

Rushton and Dye collected flow-weighted composite samples from the inflow and outflow of the pocket wetland over 39 storm events over a three-year period. The computed removal efficiency of the pocket wetland is described in Table 1, and is expressed in terms of both concentration and mass load reduction. In general, the pocket wetland exhibited moderate to high capability to remove pollutants in stormwater runoff. Sediment, phosphorus and nitrate removal ranged from 50 to 70%. Removal of ammonia, organic nitrogen and zinc, however, was relatively modest, ranging from zero to 50%. This low removal may merely reflect the fact the incom-

Table 1: Measures of Pollutant Removal Performance of the Tampa Bay Office Park "Pocket Wetland" (Rushton and Dye, 1993)

Parameter	Sampling Interval: Summer 1989	6/90 to 6/91	6/90 to 6/91
Number of Storms	8-11	23-27	23-27
Removal Method	Change in EMC	Change in EMC	Mass Load
TSS	71	57	55
Total Phosphorus	46	57	65
Ortho-phosphorus	55	66	67
Nitrate-Nitrogen	70	67	65
Organic-Nitrogen	(-20)	3	59
Ammonia-Nitrogen	44	20	39
Zinc	5	42	51

Notes: EMC = event mean concentration. Cadmium and Copper were also measured, but were not detected frequently enough to calculate removal efficiency.

Table 2: Mean Outflow Concentrations From Tampa Bay Office Park "Pocket Wetland"

Parameter (mg/l)	Summer 1989	6/90 to 6/91	Background*
TSS	7.7	11.8	32
Total Phosphorus	0.18	0.17	0.19
Ortho-phosphorus	0.13	0.10	0.08
Nitrate-nitrogen	0.10	0.08	0.35
Organic-nitrogen	1.32	0.93	1.29
Zinc	0.035	0.030	0.033**

* Mean values for stormwater wetland effluent concentration from article 65.

** Mean Florida pond/wetland zinc effluent concentration reported by Kehoe *et al.* (1993).

Table 3: Comparison of Pollutant Concentrations in Rainfall and Runoff at the Tampa Bay Office Park "Pocket Wetland"

Parameter (No. of samples)	Rainfall/Runoff EMC*
TSS (19)	6 %
Total Phosphorus (19)	2 %
Ortho-Phosphorus (26)	4 %
Nitrate-Nitrogen (28)	121%
Organic Nitrogen (TKN-26)	33%
Total Nitrogen (26)	45%
Ammonia-Nitrogen (28)	366%
Total Zinc (21)	68%

* Rainfall concentration as a percentage of stormwater runoff concentration

ing pollutant concentrations were quite low, often very close to the "irreducible" concentration (Table 2). A comparison of the pocket wetland's effluent concentration with other national and regional estimates of the "irreducible" concentration appears to confirm this. In general, the authors reported pollutant removal rates for the pocket wetland that generally fell within the mid-range of pollutant removal estimates for other larger wet ponds previously monitored in Florida.

Priority pollutant scans of bottom sediments at both the inlet and the outlet generally indicated that this relatively young wetland (three to five years old) had not yet accumulated high levels of pollutants within its sediments. Only eight of 83 priority pollutants were detected in the two sediment samples. Low level detections included several automotive-derived PAHs, (pyrene, flouranthene, benzo (b/k) floranthene, and di-n-octyl-pthalate), as well as several priority pollutants commonly associated with plastics or treated paper, and one persistent insecticide.

On-site samplers also recorded the chemistry of rainfall at the site, which allowed for a direct comparison of the concentration of pollutants present in rainfall with those found in storm runoff. Table 3 presents their findings. As can be seen, rainfall is often a primary, if not dominant, source of many pollutants of concern. For example, rainfall concentrations of ammonia, nitrate, and zinc approach, and, in some cases exceed, those found in stormwater runoff. As might be expected, these pollutants did not often exhibit a pronounced "first flush behavior," although phosphorus and some metals often did exhibit declining concentrations during the course of the storm. Highest sediment concentrations coincided with peak of the hydrograph.

Although the pocket wetland performed reasonably well, it did not achieve the 80% removal rate target set forth for Florida waters. To further enhance its performance, the authors recommend designing ponds to achieve a minimum 14-day residence time, maintaining aerobic bottom sediments (e.g., through greater depth or physical aeration), improving pretreatment, and eliminating dead storage areas. The pocket wetland has been significantly redesigned in the last two years to attempt to improve its performance. Initial results appear very promising, and a final monitoring assessment should be completed by the end of 1996.

–TRS

References

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