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Pollutant Removal by Constructed Wetlands in an Illinois River Floodplain

Rivers and their floodplains have been dramatically altered by man in the interest of flood control or navigation. Nowhere is this more evident than the urbanized Midwest. The Des Plaines River, located near Chicago, is an excellent example. The riparian ecology of this river and its floodplain has been severely altered by channelization over the last 50 years. Important functions such as flood control, wildlife habitat, wetlands and pollutant removal have all been sharply diminished.

Over the last 10 years, Hey and his colleagues (Hey *et al*., 1994a, 1994b; Mitsch *et al.*, 1995; Sanville and Mitsch, 1994) have embarked on an ambitious effort to restore the drainage characteristics and habitat quality of the river, primarily through the construction of off-line wetlands within the river's floodplain. The wetlands were designed to mimic the complex interaction between a river and its floodplain. As part of the Des Plaines River Demonstration Project (Table 1), Hey and Mitsch have independently analyzed the capability of the off-line wetlands to reduce sediment and nutrient levels found in river runoff.

The Des Plaines River drains a watershed of 200 square miles, 80% of which is agricultural and the remainder urban. Four experimental wetlands (EWs) were placed in linear succession along the western bank of the river containing dense emergent wetland vegetation (Table 2). Ranging in size from five to 8.6 acres, and with maximum depths of five feet, each wetland received water diverted from the river through a pump and irrigation pipeline system. EWs three and five were subjected to high flow conditions (13.4 to 38.2 in/wk), while EWs four and six received lower flows (2.8 to 6.3 in/wk).

Pollutant levels were measured from flows entering and leaving each wetland. Since the wetlands received water from the same river source, only one inlet location was necessary to determine pollutant concentrations. All total suspended solids (TSS) and nitrate-nitrogen measurements reported by Hey *et al.* (1994a) were taken during the 1990 and 1991 growing seasons (April through September–Table 3). Phosphorous data reported by Mitsch *et al*. covered the 1990-1992 growing seasons.

Table 1: The Des Plaines River Demonstration Project

Location:	Upper Des Plaines River, Wadsworth, IL (35 miles north of Chicago)
Land use:	80% agriculture, 20% urban
Watershed:	200 mi^2
Objectives:	• restore presettlement flora and fauna • restore drainage characteristics associated with original creeks and floodplains • create diverse wetland habitat
Parties involved:	Wetland Research, Inc. IL Dept. of Energy & Natural Resources U.S. Fish & Wildlife Service Lake County Forest Preserve District
Wetlands:	8 man-made wetlands ranging in size from 4.0 to 11.2 acres in size (data from 4 wetlands are in this Technical Note)
Pollutants:	Point and nonpoint; primarily sediment and nutrients
Final products:	• design manual laying out the conditions for creating wetlands • operations manual describing methods and procedures for managing recreated wetlands (water level controls, public health, and posts) • hour-long documentary on before and after conditions • living example of the benefits wetlands can provide to a modern society

Figure 1: Location and Flow Conditions of Four Experimental Wetlands at the Des Plaines River Wetlands Demonstration Project (Arrows Indicate Direction of Flow) (Hey *et al.,* 1995)

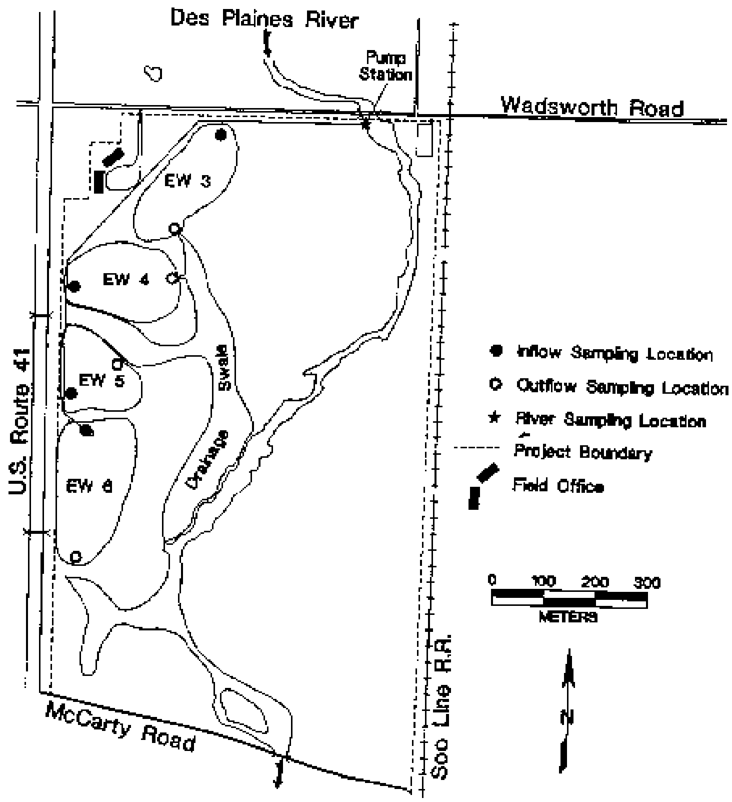

Table 2: Dominant Vegetation in Four Illinois Constructed Wetlands (Mitsch *et al.*, 1995)

Cattails
Reed canarygrass
Knotweed
Northern water plantain
Muskgrass
Red rooted spikerush
Water or marsh purslane
Sago pondweed
Broad-leaf arrowhead
Softstem bulrush*

* introduced to EWs 3 and 4 in 1989; flourishes in deepwater areas

Table 3: Average Inlet and Outlet Pollutant Concentrations for Four Constructed Wetlands Along the Des Plaines River, Illinois (Data from 9-25 Samples)

	TSS (mg/L)	Nitrate-N (mg/L)
1990		
Inlet	78.1	1.87
EW3	6.8	0.54
EW4	13.7	0.24
EW5	5.8	0.53
EW6	8.1	0.32
1991		
Inlet	102.1	1.22
EW3	7.2	0.23
EW4	7.3	0.10
EW5	4.9	0.18
EW6	6.3	0.18

The experimental wetlands showed great promise. Outlet concentrations of each pollutant were significantly lower than the concentrations found in the river water prior to wetland treatment (Table 3). Despite variable nutrient loading rates each year, the pollutant removal efficiencies were rather high, often greater than 80% (Table 4). Sediment settled out within the confines of the wetland, and of the TSS not removed through wetland processes, an average of 36% was converted to volatile compounds.

High removal rates were also reported for phosphorous, with 1992 data showing greater removal efficiency in the low-flow wetlands. Biological uptake and settling of phosphorous-bound solids accounted for the majority of its removal during the study. One factor believed to contribute to total phosphorus (TP) and TSS outlet concentrations was the resuspension of sediments by foraging fish. This speculation is partially supported by generally lower outlet TSS and TP concentrations during the 1991 growing season, after carp had been removed from the sites. The constructed wetlands also showed an ability to remove nitrate-N. Outlet concentrations from the constructed wetlands were comparable to concentrations observed in a natural system.

The high mass removal and consistently low outlet concentrations led Hey *et al.* (1994a) to reason that the experimental wetlands had not yet been loaded to full saturation capacity. Based on 1990 hydraulic loading rates to the experimental wetlands, Hey *et al.* (1994b) estimated that similar water quality improvement could be achieved in other northeastern Illinois watersheds if one to 5% of the watershed could be devoted to off-line wetlands located in the floodplain.

However, 1992 data revealed a slight decrease in phosphorus removal efficiencies, causing Mitsch *et al.* to cautiously raise the question of whether the wetland sediments might be beginning to experience phospho-

Table 4: Pollutant Removal Efficiency (%) of Four Constructed Wetlands, Based on Mass Balance and Flux Analysis

	1990				1991				1992
	TSS*	Nitrate-N*	TP*	TP**	TSS*	Nitrate-N*	TP*	TP**	TP**
EW3	79	79	66	63	95	86	89	86	53
EW4	77	39	52	81	94	95	98	98	87
EW5	92	80	75	63	99	92	99	96	78
EW6	~100	99	99	99	~99	99	~100	99	83

* Hey *et al.*, 1994a

** Mitsch *et al.,* 1995

rous saturation. In the future, researchers plan to increase hydraulic loading rates to the wetlands in an effort to more fully ascertain their long-term pollutant removal potential. Such continued efforts can help resolve the questions of whether constructed wetlands have a limited life span for consistently treating pollutant-laden waters and how much watershed area should be devoted to floodplain wetlands to protect water quality. Long-term monitoring of pollutant removal and changes in wetland plant communities will be useful to managers considering riverine "floodplain" wetlands as a large-scale watershed protection technique in rivers dominated by nonpoint source pollution.

The Des Plaines River experience suggests that reconnecting a river to its floodplain via constructed wetland systems can be an effective watershed protection technique in developed communities where rivers have been extensively channelized in the past and little land area is available for wetland construction in the headwaters of the watershed. In addition to significant pollutant removal, the wetlands can also provide greater fish and wildlife habitat, and possibly greater flood control storage. However, such systems need to be carefully designed so that they do not increase local flood elevations. In addition, they may require constant maintenance and power to direct river water into the floodplain, and then back into the river.

-RLO/TRS

References

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