Costs and Benefits of the Proposed Nutrient Criteria Regulation
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Costs of Reducing Nutrients in Surface Waters

The nutrient criteria regulation under development by the Missouri Department of Natural Resources (MDNR) may have an impact on businesses that discharge phosphorus into surface waters. Sources of phosphorus include wastewater treatment plants, industrial point sources, agricultural runoff, and urban stormwater. The economic implications of phosphorus reduction are not uniform for all sources because of technology limits and differences in the output and scale of the operation.[1]

Methods used for reducing phosphorous concentrations in point and nonpoint sources are different and will therefore generate different costs. Moreover, it should be noted that point sources can be regulated under existing laws, while nonpoint sources, which are a significant contributor to water pollution problems, are largely left unregulated. Nonpoint sources are typically addressed through best management practices rather than treatment. Research indicates, however, that reductions from nonpoint sources should be considered to most effectively reduce phosphorous concentrations in surface waters.[2] See Table 1 below.

Table 1. Range of Phosphorus Reduction Costs (excerpted from Schleich, *et al.*)

Table 1. Range of Phosphorus Reduction Costs for the Five Major Sources

Source	Cost to Reduce a Kilogram of Phosphorus (1990 dollars)		
	Low	Average	High
Agriculture	4.32	26	670
Construction runoff	517	770	1637
Urban storm runoff	1704	2025	3866
Municipal treatment plants, industrial sources	75	169	1305

[1] Schleich, J., D. White, and K. Stephenson, Cost implications in achieving alternative water quality targets, *Water Resources Research*, Vol. 32, No. 9, pp. 2879-2884, September 1996.
[2] *Id.*

Costs of Point Source Phosphorus Reduction

Although nonpoint sources play a large role in the phosphorus loading that occurs during high flow conditions, point sources "contribute as much as 64% of total phosphorus to the river basin" during low flow conditions.[3] Point sources include wastewater treatment plants (WWTP) and the businesses that discharge wastewater to these facilities, such as metal phosphatizing operations and the meat packing and dairy industries.[4] Phosphorus reduction can be achieved through a variety of methods, but they usually fall within two categories: "restrictions on the use of phosphorus based products (source control) and strict control of phosphorus discharges (effluent permit limits)."[5] Enhanced biological phosphorus removal, chemical phosphorus removal, phosphorus detergent bans, wetlands or land treatment, and effluent limits are all methods of phosphorus reduction for a point source. The suitable approach to phosphorus removal will necessarily vary according to the size of the source and its current technology.[6,7]

In a 2004 trade publication article, the cost of reducing phosphorus to meet effluent limits of 1 mg/L TP was given for six Texas communities' WWTPs along the North Bosque River.[8] Costs per kilogram of phosphorous removed varied greatly with the size of the community. See Table 2 below. These figures reveal increased costs per unit of phosphorous removed at smaller WWTPs. Due to the disparity in cost of P removal, the potential for water quality trading is discussed in the article. The article also cites earlier work that estimated the cost of achieving a 1 mg/L TP effluent limit at WWTPs with flows over one mgd at $0.01 per person per day, whereas the cost for smaller plants might be $0.10 per person per day.[9]

Table 2. Size of Town, Plant and Cost of TP Removal

Community	Stephenville	Clifton	Meridian	Hico	Valley Mills	Iredell
Population	14921	3542	1491	1341	1123	360
WWTP size (mgd)	1.37	0.33	0.36	0.09	0.08	0.03
$ per kg TP removed	33.65	110.73	144.39	195.41	323.51	799
Monthly cost per house ($)	1.19	3.77	14.73	7.77	12.02	25.43

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3 Minnesota Technical Assistance Program, University of Minnesota, Cost Effective Pollution Prevention Strategies to Reduce Phosphorus in the Minnesota and Lower Mississippi River Basins, Jan. 31, 2002. Available at: http://www.mntap.umn.edu/potw/McKnight02.pdf.

4 *Id.*

5 Woods, N., L. Maldonado and G. Daigger, Phosphate Recovery: An Economic Assessment, Natural History Museum, Research and Curation. Available at: https://www.nhm.ac.uk/research-curation/projects/phosphate-recovery/daiggr/daiggr.htm.

6 Keplinger, K., *et al.*, Costs and Affordability of Phosphorus Removal at Small Wastewater Treatment Plants, *Small Flows Quarterly*, Fall 2004, Volume 5, Number 4, pp. 36-49.

7 Schleich, et al.

8 Keplinger, et al.

9 *Id.* at 37.

The Minnesota Pollution Control Agency has prepared an extensive report on water quality issues relating to phosphorous discharges.[10] Section 3.6 of the report describes the costs for WWTPs of different sizes, phosphorus discharge requirements, and method of treatment (chemical or biological). The results of are summarized in Table 3 below. Most of the cost figures provided in this study appear to reflect only operation and maintenance costs, thus explaining the variation from the figures for the Texas study, which also included capital costs.

Table 3. Size of Plant, Method of Removal, and Cost of TP Removal

WWTP Name	**Size (MGD)**	**P Effluent Limit (mg/L)**	**Method**	**Cost ($ per kg TP)**
Ely	0.70	0.30	Biological & Chem.	48.24
Bemidji	1.15	0.30	Chemical	7.84
St. Croix Valley	3.40	0.80	Chemical	2.31
Mankato	6.00	2.41	Chemical	4.10
St. Cloud	10.60	Monitoring only	Biological (EBPR)	----
Rochester	14.00	1.00	Chemical	4.24
Durham	20.00	0.07	Biological & Chem.	1.13
Rock Creek	24.00	0.07	Biological & Chem.	----

Prior to implementing biological treatment (EBPR), the Durham facility only used chemical treatment (alum) for phosphorus removal. Significant cost savings were observed once enhanced biological phosphorus removal was implemented at the Durham facility (i.e., the chemical costs for alum were cut by one third). Phosphorus influent to the Ely plant was significantly reduced in the early 1980s by educating the public on limiting the use of phosphorus in detergents. As estimated by the Ely WWTP superintendent, phosphorus in its influent was reduced from 12 to 15 mg/L prior to public education to approximately 5 mg/L after public education.

The focus of a study by the University of Minnesota was on pollution prevention rather than wastewater treatment and pretreatment. Point sources such as wastewater treatment plants and industrial dischargers were targeted for implementation of pollution prevention practices and technologies to help them operate more efficiently. The project resulted in reductions in phosphorous discharges and lowered water consumption.[11] It also rendered unnecessary extra treatment equipment.[12] Over a two year period, the project resulted in phosphorus reductions of 30,796 pounds and $2.8 million in avoided costs.

[10] Minnesota Pollution Control Agency, Detailed Assessment of Phosphorous Sources to Minnesota Watersheds (Feb. 2004). Available at: http://www.pca.state.mn.us/hot/legislature/reports/phosphorus-report.html
[11] Minnesota Technical Assistance Program, *supra* note 3.
[12] *Id*.

Costs of Nonpoint Source Phosphorus Reduction

Schleich, *et al.* looked at the costs of reducing nutrient loads from various sources to Green Bay in northeast Wisconsin.[13] This research found that the cost of reducing phosphorous in Green Bay differed dramatically depending on how the reductions were allocated within the watershed. An approach that sought out the cheapest reductions regardless of the location within the watershed (and that relied largely on non-point source reductions) was roughly one-fourth the cost of an approach that required equal reductions from all sub-watersheds. One drawback of the lower cost approach, however, is that it would not ensure that nutrient reduction will be distributed across the whole watershed and may not reduce negative impacts in all waters.

Reduction of nonpoint source runoff was achieved by the Delaware Department of Natural Resources and the Nutrient Management Commission in the Inland Bays.[14] They supported the implementation of 114 best management practices for reducing stormwater runoff which have reduced TP by 0.68 kg/day and TN by 9.91 kg/day at an annual cost of $938,698.

Other studies indicate that riparian wetlands play an important role in protecting water quality.[15]

Benefits of Phosphorus Reduction

"Phosphorus and nitrogen can cause excessive algae growth, loss of submerged aquatic vegetation, oxygen depletion, and water clarity problems. These problems, in turn, adversely affect the commercial, recreational and aesthetic values associated with the water resources."[16] The reduction of phosphorus from point and nonpoint sources leads to benefits for the environment and for individual companies through reduced "use of raw materials, water, and energy," and an improved public image.[17]

Obrecht's study on the responses of the upper James River Arm on Table Rock Lake, Missouri, to point-source phosphorus reduction demonstrates that water quality can be improved through phosphorous effluent limits.[18] Implementation of such effluent limits in southwest Missouri caused a decrease in TP concentrations and an increase in Secchi depth. "Phosphorus reductions were sufficient . . . to shift trophic state classifications from hyper- to eutrophic and eu- to mesotrophic, respectively."[19]

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13 *Id.*

14 EPA, "Delaware's Inland Bays Watershed." Available at: http://www.epa.gov/reg3wapd/nps/successstories/DE/inland_bays.htm

15 *See, e.g.*, Weller, C., M. Watzin, and D. Wang, Role of Wetlands in Reducing Phosphorous Loading to Surface Water in Eight Watersheds in the Lake Champlain Basin, *J. Env. Mgmnt*, Vol. 20, No. 5, pp.731-739 (1996).

16 Schleich, *et al*.

17 Sano, D., A. Hodges, and R. Degner, Economic Analysis of Water Treatments for Phosphorus Removal in Florida. Available at: http://edis.ifas.ufl.edu/FE576

18 Obrecht, D.V., A.P. Thorpe and J.R. Jones, Responses in the James River Arm of Table Rock Lake, Missouri (USA) to point-source phosphorus reduction, *Verh. Internat. Verein. Limnol*, 29: 1043-1048 (2005).

19 *Id.*

A study by the University of Florida looked at the socio-economic and recreational benefits that would result from facilities adopting phosphorus removal systems.[20] The socio-economic benefits were derived from the increased availability of clean water mitigating the effects of population growth and possible water shortages in southern Florida. The study used willingness to pay for water during water shortages to determine its value. The other benefits the study proposed are recreational: the provision of water to those hunting and fishing in the area.

Additional References

State of Vermont, *The Clean and Clear Action Plan, 2005 Annual Report*, (Jan. 2006). Available at http://www.anr.state.vt.us/cleanandclear/rep2005/CleanAndClear2005Rpt.pdf This report describes a successful program for removal of phosphorous loading into Lake Champlain. It provides capital cost figures, reductions in P loading, and achievable effluent limits.

[20] Daisuke Sano, Alan Hodges, and Robert Degner. "Economic Analysis of Water Treatments for Phosphorus Removal in Florida." http://edis.ifas.ufl.edu/FE576