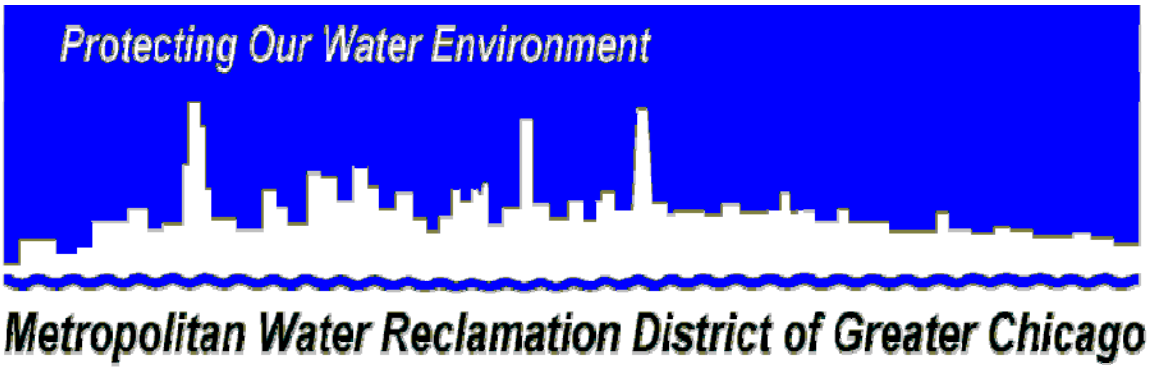

MONITORING AND RESEARCH DEPARTMENT

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PHOSPHORUS IN SERVICE AREAS OF THE STICKNEY, CALUMET AND NORTH SIDE WATER RECLAMATION PLANTS – TRACKING SOURCES AND FEASIBILITY OF RECOVERY TO MEET FUTURE EFFLUENT LIMITS

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Metropolitan Water Reclamation District of Greater Chicago
100 East Erie Street Chicago, Illinois 60611-2803 312-751-5600

PHOSPHORUS IN SERVICE AREAS OF THE STICKNEY, CALUMET AND NORTH SIDE WATER RECLAMATION PLANTS – TRACKING SOURCES AND FEASIBILITY OF RECOVERY TO MEET FUTURE EFFLUENT LIMITS

By

Kuldip Kumar
Associate Environmental Scientist

Albert Cox
Supervising Environmental Soil Scientist

Heng Zhang
Assistant Director of Monitoring and Research

Monitoring and Research Department
Thomas C. Granato, Director

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INTRODUCTION

The increasing use of phosphorus (P) in manufacturing, agricultural production and processing of food, and increased consumption of meat in the human diet has led to greater mobilization of P to the aquatic environment. Commercial production of fertilizer, including fertilizers containing P, began just before the middle of the nineteenth century, and the application of this fertilizer has been essential for the unprecedented rise of food production during the twentieth century. However, both industrialization and the current green revolution have caused many undesirable consequences, such as eutrophication and hypoxia, as excess P from industries, fertilizer, and animal manures eventually enter surface waters. Wastewater treatment plants also contribute as point sources of dissolved and particulate P to surface waters and aquatic ecosystems. It is estimated that as much as 70 percent of P-loading in the Upper Illinois River, 47 percent of P-loading in the Illinois Rivers, and ~ 5 percent of P-loading in the Mississippi River Basin may be due to effluent from the water reclamation plants (WRPs) in the greater Chicago area (David and Gentry, 2000; Bedore et al., 2008; Jacobson et al., 2011). The Mississippi River Gulf of Mexico Watershed Nutrient Task Force created an action plan in which goals for reducing nitrogen and P-loading by 45 percent were developed in an effort to reduce the size of the hypoxic zone (Mississippi River/Gulf of Mexico Watershed Nutrient Taskforce, 2008). To achieve these goals, there is pressure on the agriculture industry to reduce the non-point sources of nutrients. Also, stricter effluent nutrient limits are being imposed on WRPs in the Mississippi River Basin.

The Metropolitan Water Reclamation District of Greater Chicago (District) operates seven WRPs in Cook County and serves a population equivalent to 10.35 million, which includes 5.25 million people, a commercial and industrial flow equivalent to 4.5 million people, and a combined sewer overflow equivalent to 0.6 million people. This report documents efforts to quantify the sources of P in wastewater influent at the District's three largest WRPs (Calumet, North Side and Stickney). In this study, the hypotheses were: 1) industries are a significant source of P-loading to WRP influent, and 2) there is an opportunity for source control by P harvesting from industry, which can significantly reduce this P-loading to District WRPs and subsequently reduce effluent P concentrations and P-loading to surface waters.

MATERIALS AND METHODS

Sources of P-loading to the District's WRPs include domestic sewage (human excreta), storm water, detergents, industries, dogs, drinking water, food waste, and recycle streams. To estimate industrial input into the District's three largest WRPs (Calumet, North Side, and Stickney WRPs), District staff collected samples (24-hour composites every day for four to seven days) and monitored the flow data of industrial effluent being discharged by 43 industries in the service area of these WRPs. The samples were analyzed for total P and soluble P by the District's Analytical Laboratories Division.

Sources of Phosphorus Loading

Contributions of P from other sources were determined based on the following assumptions:

Human. On average, humans eating a meat-based diet excrete 0.6 kg P/yr, those eating a vegetarian diet excrete 0.3 kg P/yr, and approximately 58.3 percent of P excreted is via urine (Heinonen-Tanski and van Wilk-Sijbesma, 2005). To be conservative, one can assume that the population of vegetarians is negligible, and 100 percent of the population in the service area of the three WRPs eats meat. In addition, we accounted for a net import of 182,957 people who may enter Cook County for a six-day work week, according to Chicago-Area commuting patterns (Soot et al., 2003), and assume that they contribute one-third (i.e. 0.2 kg P/yr) of their excreta to the Stickney service area. According to available Food Statistics – Soft Drink Consumption by Countries (http://www.nationmaster.com/graph/foo_sof_dri_con-food-soft-drink consumption) – per capita consumption of soda pop in the United States is 54 G/capita/yr, and 60 percent of the soda pop sold is dark colored, such as colas and root beers, which have phosphoric acid as an ingredient. Unpublished data from a District study showed that the average P concentration of these colas is about 250 mg/L. It is well established that our bodies do not utilize any of that P, and it is excreted in urine.

Dogs. According to the American Veterinary Medical Association, there are 0.6 dogs/household (AVMA, 2007). Dogs excrete between 0.3 - 0.8 kg P/yr (RCR, 2012). We assumed that 30 percent of feces are picked up and flushed in toilets, 20 percent are not picked up, and 50 percent of feces are picked up and disposed of in trash. Since the District's wastewater influent is from a combined sewer system, we assumed feces (30 percent flushed plus 25 percent of 20 percent which are not picked up) are conveyed to the WRPs.

Drinking Water. Calculations were made based on the service population of three WRPs and assuming water consumption of 170 gallon/capita/day and mean P concentration of tap water is 0.183 mg/L. The P concentration in drinking water is based on the analysis of tap water from five communities conducted by the District, which showed mean concentration was 0.183 mg/L and ranged between 0.15-0.27 mg/L.

Industry. Industrial loading was estimated based on the Toxic Release Inventory (TRI) Program of the United States Environmental Protection Agency based on 1997 phosphoric acid use by industry data in Cook County (http://www.epa.gov/tri/trichemicals/).

Food Waste. A family of four wastes 2,000 pounds of food annually (Emerson, 2012). It was assumed that 50 percent of households have garbage disposals, 10 percent of food waste is disposed of via garbage disposals, and the concentration of P in that waste is 0.075 percent (wet weight basis) (CEC, 2005; Zhang et al., 2007; WDNR, 2010).

Geese. According to data provided by Chicago Wilderness, it was estimated that approximately 50,000 geese live in the service area of the three WRPs for at least 245 days/yr. On average, a goose produces 0.396 lbs feces/day at a P concentration of 1.87 percent. We assumed that only 25 percent of the feces from geese will end up in our WRPs via storm water.

Detergents. Based on the service area for the three WRPs (population of 4.65 million, three persons per household) there were 1.55 million households. We assume that one in every three households has an automatic dishwasher, and an average household uses a dishwasher every other day. On average, P content of a detergent tablet used per run was 1.715 g (Burnside and McDowell, 2001). The remaining two-thirds of households wash dishes every day and use 2.5 g gel detergent, which has an average P concentration of 3.25 percent.

Storm Water. This includes runoff from impervious surfaces, managed and unmanaged turf, and open space. According to Land Cover of Illinois Statistical Summary (1999-2000) Data for Cook County (www.agr.state.il.us/gis/stats/landcover/counties/county.php?CNTY=Cook), there are 120,422, 262,989, and 105,673 acres of land under high population density, low/medium population density, and urban open space, respectively. We assumed that 90 percent of high density, 60 percent of low/medium density, and 20 percent of urban open land is impervious, and the rest is under managed or unmanaged turf. Annual P losses from impervious surfaces of 4.5 kg P/ac (Daniels et al., 2010), from managed turf of 8 kg P/ac, and from unmanaged open lands of 5 kg P/ac (Rosen et al., 2012, University of Minnesota, Personal Communication) were used to estimate P in storm water, apart from what was added by geese, dogs, and leaf fall. Fertilizer recommendations by an Extension Turf Specialist of the University of Illinois, Urbana, Champaign, were used to estimate P fertilizer use on managed turf. The losses from impervious surfaces, unmanaged lands, and managed turf were estimated from small-scale field studies and not the landscape-level studies; thus, we estimated the potential contributions from geese and leaf fall separately.

Leaf Fall. According to McPherson et al. (1994), there are 35.8 million trees in Cook County (4.1 m Chicago + 31.8 m Suburban Cook), and 46 percent of those trees are in residential and urban open land. Assumptions were made that 25 percent of the leaves enter storm drains during autumn, an average mass of leaves per tree is between 10 - 20 kg, and an average P concentration of leaves is 0.2 percent. These assumptions were made based on limited data collected by Monitoring and Research Department (M&R) staff during the fall of 2011 from two storm sewers, one located in a suburban area and the other located in the city of Chicago.

Recycle Stream. The contribution of recycled streams at the Calumet and Stickney WRPs were estimated by M&R (unpublished report).

RESULTS AND DISCUSSION

The service area, population flow, and P-loadings at the WRPs studied are given in Table 1. The amount of P which is presumed to be soluble P released via urine was relatively higher as compared to the particulate P released in feces. Human excreta accounted for as much as 84 percent of P-loading in the influent at the North Side WRP. This is due to the relatively small amount of industries in this service area. Assuming the 0.6 kg P excreted per capita per year and 170 G/day/capita water use, the theoretical concentration of P from human excretion in raw wastewater influent should be ~ 2.56 mg/L. The P concentration of raw influent at the North Side WRP of 2.96 mg/L is close to this theoretical concentration, indicating that a major proportion of the P at this WRP may be coming from domestic sources. However, for the Calumet and Stickney WRPs, which have greater industrial flow, human excreta accounted for only 30 percent and 22 percent, respectively, of influent P-loading (Table 1). Thus, a majority of P-loading in these WRPs may be due to industrial contribution, recycle streams, or other non-point sources. Additionally, the higher influent total P concentrations at the Calumet (5.60 mg/L) and Stickney (6.42 mg/L) WRPs, as compared to the North Side (2.96 mg/L) WRP, are also a strong indicator of industrial and non-point contributions to these two WRPs (Table 1).

The combined influent P-loading was 9,817 t/yr from the three WRPs (Table 1). We estimate that less than 29 percent of this total was from human excreta, and almost 23 percent was from industry (Table 2). The recycle streams at these WRPs are also a major source of P, contributing about 18 percent of the influent P. Other significant contributors are storm water (~15.4 percent), detergents (~5.9 percent), and food waste (~4.1 percent). Effective July 2010, use of detergents greater than 0.5 percent P is banned in Illinois (ENVIRONMENTAL SAFETY (415 ILCS 92/; Regulation of Phosphorus in Detergents Act) which is available online at: (http://www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=2905&ChapterID=36).

In addition, effective July 2011 there is also a ban on P containing fertilizers for lawn and turf by amending the Illinois Fertilizer Act of 1961 (HB6099): (http://www.ilga.gov/legislation/BillStatus.asp?DocNum=6099&GAID=10&DocTypeID=HB&SessionID=76&GA=96).

Taking into consideration these bans on detergents and lawn fertilizers, the P-loadings in the raw influent may decrease significantly in the coming years. Since most of the detergent P and fertilizer P in runoff is in the form of soluble P, the decline in effluent P may be even greater. A separate analysis on how these declines may affect effluent P at the North Side WRP is presented below.

TABLE 1: SERVICE POPULATION, WASTEWATER FLOWS, AND CONTRIBUTION OF HUMAN EXCRETA TO TOTAL PHOSPHORUS LOAD IN THREE METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO INFLUENT WASTEWATER STREAMS

WRP	Population (million)	Flow[2] (mgd)	Influent TP[3] (mg/L)	P load (t)	% P-Loading from			Other Sources (%)
					Urine	Feces	T. Excreta	
North Side	1.349	236	2.96	964	49	35	84	16
Calumet	1.025	265	5.60	2,047	17	13	30	70
Stickney	2.276 (+0.183)[1]	717	6.42	6,806	13	9	22	78
Total	4.833	1,218	-	9,817	-	-	-	-

[1]Net import of commuters and tourists for six days/week contributing one-third of P (0.2 kg/yr) excreted in service area.
[2]Based on annual average flow obtained from WRP operations data for years 2009 and 2010.
[3]Annual average flow weighted concentration for years 2009 and 2010.

TABLE 2: ANNUAL TOTAL PHOSPHORUS LOAD FOR 2010 FOR NORTH SIDE, CALUMET, AND STICKNEY WATER RECLAMATION PLANTS AND ESTIMATES OF SOURCE CONTRIBUTIONS

Source	P load (t)	% of Total P Load
Total P Load (Table 1)	9,817	-
Human excreta	2,822	28.7
(Soda Pop)	(150)	(1.5)
(Drinking Water)	(200)	(2.0)
Industry[1]	2,268	23.1
Recycle streams	1,783	18.2
Storm water	1,358	13.8
(Geese)	(10)	(0.1)
(Leaves)	(150)	(1.5)
(Lawns and open space)	(680)	(6.9)
(Impervious surfaces)	(518)	(5.3)
Dogs	250	2.5
Detergents	582	5.9
Food waste	400	4.1
Total	9,463	96.4

[1]Estimated from TRI database (1997).

Out of a total P-loading of 9,817 tons/year (t/yr) from three WRPs (Table 2), we estimated that ~ 23 percent, or 2,268 t, was industrial contribution. Results from the intensive sampling of industrial discharge appear to validate this estimate. Data from this sampling showed that concentrations of P in the effluent of 25 of the 43 industries sampled was relatively high, ranging from 5 mg/L to > 600 mg/L (Table 3). These industries were divided into four broad categories for the Stickney WRP: (i) food and beverage, (ii) chemical manufacturing, (iii) metal anodizers, finishers, and plating, and (iv) metal and steel manufacturing (Table 4). The mean total P concentration in the effluent of industrial categories was generally in the order: metal anodizers, finishers, and plating (88.68 mg/L) > food and beverage industry (33.09 mg/L) > metal and steel manufacturing (15.99 mg/L) > chemical manufacturing (9.32 mg/L) (Table 4). Mean annual total P-loading was in the order: food and beverage industry (11.93 t) > metal anodizers, finishers, and plating (5.70 t) > chemicals manufacturing (4.52 t) > metal and steel manufacturing (0.45 t) (Table 4). In most of the influent sampled, most of the P-loading was in the form of soluble P (Tables 3 and 4). This trend in P concentration and P-loading among categories of industries sampled was also observed for both the Calumet and North Side WRPs (Table 4).

Data in Table 3 show that total P-loadings from the industries sampled in the Stickney, Calumet and North Side WRP service areas were 183 t (28 industries), 54 t (seven industries), and 9 t (eight industries), respectively. Therefore, the 43 industries sampled in the service area of these three WRPs contributed 245 t of total P-loading, which represents approximately 11 percent of the original estimated 2,268 t/year industrial P-loading to three WRPs. These 43 industries also represent 9 percent of the number of industrial units (IUs) which discharge > nine million gallons per year (MGY) flow to these three WRPs (Table 5). This similarity in the percent of total P-loading and percent of IUs sampled represented by the sampling suggests that our estimate of the industrial P-loading is reliable and shows the potential for source control and recovery of P as a resource directly from the industry.

Results from this study also indicate that the recovery of P from both industrial effluents and from the recycle streams at the three WRPs will not only provide a resource harvesting opportunity but will also reduce the point source P discharge from our WRPs, which may be needed to meet regulations in the future.

TABLE 3: ANNUAL LOADING OF TOTAL PHOSPHORUS, SOLUBLE PHOSPHORUS, AND PERCENT OF TOTAL PHOSPHORUS AS SOLUBLE PHOSPHORUS FROM INDUSTRIAL EFFLUENT SAMPLED IN THE SERVICE AREA OF THREE WATER RECLAMATION PLANTS

Industry	Flow	P Concentration, mg/L		P-Loading, t/yr		
	MGPY	Total P	Soluble P	Total P	Soluble P	% Soluble P
Stickney Water Reclamation Plant						
Food and Beverage Industry (FBI)						
FBI - 1	1496.8	16.22	12.35	91.76	69.87	76
FBI - 2	9.3	177.00	170.15	6.25	6.01	96
FBI - 3	35.3	33.11	19.30	4.42	2.58	58
FBI - 4	12.5	42.65	40.95	1.54	1.47	96
FBI - 5	34.4	7.48	3.77	0.97	0.49	50
FBI - 6	131.7	2.83	1.97	0.95	0.66	70
FBI - 7	87.5	2.60	1.79	0.86	0.59	69
FBI - 8	9.4	14.93	14.26	0.53	0.50	96
FBI - 9	18.1	0.98	0.28	0.07	0.02	28
Chemicals Manufacturing (CM)						
CM - 1	1149.2	1.94	1.64	8.49	7.14	84
CM - 2	8.7	16.70	16.25	0.55	0.54	97
Metal Anodizers, Finishers, and Plating (MAFP)						
MAFP - 1	21.8	290.59	285.35	23.90	2.35	98
MAFP - 2	18.8	310.46	229.87	22.10	16.37	74
MAFP - 3	65.5	39.43	38.78	9.76	9.60	98
MAFP - 4	5.4	318.01	308.12	6.52	6.32	97

TABLE 3 (Continued): ANNUAL LOADING OF TOTAL PHOSPHORUS, SOLUBLE PHOSPHORUS, AND PERCENT OF TOTAL PHOSPHORUS AS SOLUBLE PHOSPHORUS FROM INDUSTRIAL EFFLUENT SAMPLED IN THE SERVICE AREA OF THREE WATER RECLAMATION PLANT

Industry	Flow	P Concentration, mg/L		P-Loading, t/yr		
	MGPY	Total P	Soluble P	Total P	Soluble P	% Soluble P
Stickney Water Reclamation Plant						
Metal Anodizers, Finishers, and Plating (MAFP)						
MAFP - 5	5.8	9.89	9.82	0.22	0.21	99
MAFP - 6	27.1	0.09	0.06	0.01	0.01	68
MAFP - 7	16.7	1.55	0.08	0.10	0.01	6
MAFP - 8	7.5	0.45	0.36	0.01	0.01	81
MAFP - 9	0.1	2.37	1.02	0.01	0.00	43
MAFP - 10	6.8	0.63	0.56	0.02	0.01	89
MAFP - 11	2.3	2.04	1.27	0.02	0.01	62
Metal and Steel Manufacturing (MSM)						
MSM - 1	11.8	32.50	29.86	1.45	1.33	92
MSM - 2	179.1	1.35	0.36	0.92	0.24	27
MSM - 3	46.5	0.34	0.22	0.06	0.04	65
MSM - 4	0.9	18.51	17.84	0.06	0.06	96
MSM - 5	0.4	1.27	0.78	0.01	0.01	51
MSM - 6	1.2	41.94	41.32	0.19	0.19	99
Total Loading	**3409.6**			**182.67**	**148.53**	**82**

TABLE 3 (Continued): ANNUAL LOADING OF TOTAL PHOSPHORUS, SOLUBLE PHOSPHORUS, AND PERCENT OF TOTAL PHOSPHORUS AS SOLUBLE PHOSPHORUS FROM INDUSTRIAL EFFLUENT SAMPLED IN THE SERVICE AREA OF THREE WATER RECLAMATION PLANTS

Industry	Flow	P Concentration, mg/L		P-Loading, t/yr		
	MGPY	Total P	Soluble P	Total P	Soluble P	% Soluble P
Calumet Water Reclamation Plant						
Food and Beverage Industry(FBI)						
FBI - 10	57.1	46.66	41.88	10.07	9.04	90
Auto Manufacturing (AM)						
AM - 1	321.9	26.44	20.83	32.18	25.35	79
Chemicals Manufacturing (CM)						
CM - 3	45.0	65.91	61.70	11.20	10.49	94
Tanker and Truck Wash (TTW)						
TTW - 1	15.6	5.58	3.28	0.33	0.19	59
TTW - 2	7.5	3.99	2.30	0.11	0.06	56
TTW - 3	19.2	0.61	0.36	0.04	0.03	60
Metal Anodizers, Finishers, and Plating (MAFP)						
MAFP - 12	37.2	0.25	0.07	0.04	0.01	28
TOTAL LOADING	**503.5**			**53.98**	**45.18**	**84**

TABLE 3 (Continued): ANNUAL LOADING OF TOTAL PHOSPHORUS, SOLUBLE PHOSPHORUS, AND PERCENT OF TOTAL PHOSPHORUS AS SOLUBLE PHOSPHORUS FROM INDUSTRIAL EFFLUENT SAMPLED IN THE SERVICE AREA OF THREE WATER RECLAMATION PLANTS

Industry	Flow	P Concentration, mg/L		P-Loading, t/yr		
	MGPY	Total P	Soluble P	Total P	Soluble P	% Soluble P
North Side Water Reclamation Plant						
Food and Beverage Industry (FBI)						
FBI - 11	36.5	25.07	14.76	3.46	2.03	59
Metal Anodizers, Finishers, and Plating (MAFP)						
MAFP - 13	91.3	8.43	4.31	2.91	1.49	51
MAFP - 14	5.6	3.88	1.91	0.08	0.04	50
MAFP - 15	10.8	16.82	15.47	0.67	0.63	94
MAFP - 16	25.8	1.04	0.93	0.10	0.07	66
MAFP - 17	0.5	11.94	11.45	0.02	0.02	96
MAFP - 18	3.5	5.64	4.77	0.08	0.06	85
Drinking Water Treatment Plant (DWTP)						
DWTP - 1	25.8	14.74	3.87	1.44	0.34	26
Total Loading	**199.0**			**8.75**	**4.24**	**54**
Grand Total for Three WRPs				**245.40**	**197.95**	**81**

*Any discrepancy in totals or percentages may be due to rounding.
**Only small fraction of IUs sampled (see Table 4).

TABLE 4: ANNUAL LOADING OF TOTAL PHOSPHORUS, SOLUBLE PHOSPHORUS, AND PERCENT OF TOTAL PHOSPHORUS AS SOLUBLE PHOSPHORUS FROM INDUSTRIAL EFFLUENT SAMPLED IN THE SERVICE AREA OF THREE WATER RECLAMATION PLANTS. THE INDUSTRIES WERE GROUPED BASED ON TYPE OF INDUSTRY

Parameters	Flow	P Concentration, mg/L		P-Loading, t/yr		
	MGPY	Total P	Soluble P	Total P	Soluble P	% Soluble P
Stickney Water Reclamation Plant						
Food and Beverage Industry (n = 9)						
Mean	203.9	33.09	29.42	11.93	9.13	71
Median	34.4	14.93	12.35	0.97	0.66	70
Minimum	9.3	0.98	0.28	0.07	0.02	28
Maximum	1496.8	177.00	170.15	91.76	69.87	96
Chemicals Manufacturing (n = 2)						
Mean	578.9	9.32	8.95	4.52	3.84	91
Median	578.9	9.32	8.95	4.52	3.84	91
Minimum	8.7	1.94	1.64	0.55	0.54	84
Maximum	1149.2	16.70	16.25	8.49	7.14	97
Metal Anodizers, Finishers, and Plating (n = 11)						
Mean	16.2	88.68	79.57	5.70	3.17	74
Median	7.5	2.37	1.27	0.10	0.01	81
Minimum	0.1	0.09	0.06	0.01	0.01	6
Maximum	65.5	318.01	308.12	23.90	16.37	99

TABLE 4 (Continued): ANNUAL LOADING OF TOTAL PHOSPHORUS, SOLUBLE PHOSPHORUS, AND PERCENT OF TOTAL PHOSPHORUS AS SOLUBLE PHOSPHORUS FROM INDUSTRIAL EFFLUENT SAMPLED IN THE SERVICE AREA OF THREE WATER RECLAMATION PLANTS. THE INDUSTRIES WERE GROUPED BASED ON TYPE OF INDUSTRY

Parameters	Flow	P Concentration, mg/L		P-Loading, t/yr		
	MGPY	Total P	Soluble P	Total P	Soluble P	% Soluble P
Stickney Water Reclamation Plant						
Metal and Steel Manufacturing (n = 6)						
Mean	40.0	15.99	15.06	0.45	0.31	72
Median	6.5	9.93	9.31	0.13	0.13	79
Minimum	0.4	0.34	0.22	0.01	0.01	27
Maximum	179.1	41.94	41.32	1.45	1.33	99
Calumet Water Reclamation Plant						
Food and Beverage Industry (n = 1)	57.1	46.66	41.88	10.07	9.04	90
Auto Manufacturing (n = 1)	321.9	26.44	20.83	32.18	25.35	79
Chemicals Manufacturing (n = 1)	45.0	65.91	61.70	11.20	10.49	94

TABLE 4 (Continued): ANNUAL LOADING OF TOTAL PHOSPHORUS, SOLUBLE PHOSPHORUS, AND PERCENT OF TOTAL PHOSPHORUS AS SOLUBLE PHOSPHORUS FROM INDUSTRIAL EFFLUENT SAMPLED IN THE SERVICE AREA OF THREE WATER RECLAMATION PLANTS. THE INDUSTRIES WERE GROUPED BASED ON TYPE OF INDUSTRY

Parameters	Flow	P Concentration, mg/L		P-Loading, t/yr		
	MGPY	Total P	Soluble P	Total P	Soluble P	% Soluble P
Calumet Water Reclamation Plant						
Tanker and Truck Wash (n = 3)						
Mean	14.1	3.39	1.98	0.16	0.093	58
Median	15.6	3.99	2.30	0.11	0.06	59
Minimum	7.5	0.61	0.36	0.04	0.03	56
Maximum	19.2	5.58	3.28	0.33	0.19	60
Metal Anodizers, Finishers, and Plating (n = 1)						
	37.2	0.25	0.07	0.04	0.01	28
North Side Water Reclamation Plant						
Food and Beverage Industry (n= 1)						
	36.5	25.07	14.76	3.46	2.03	59
Metal Anodizers, Finishers, & Plating (n = 6)						
Mean	22.9	7.96	6.47	0.64	0.39	74
Median	8.2	7.04	4.54	0.09	0.07	76
Minimum	0.5	1.04	0.93	0.02	0.02	50
Maximum	91.3	16.82	15.47	2.91	1.49	96

TABLE 4 (Continued): ANNUAL LOADING OF TOTAL PHOSPHORUS, SOLUBLE PHOSPHORUS, AND PERCENT OF TOTAL PHOSPHORUS AS SOLUBLE PHOSPHORUS FROM INDUSTRIAL EFFLUENT SAMPLED IN THE SERVICE AREA OF THREE WATER RECLAMATION PLANTS. THE INDUSTRIES WERE GROUPED BASED ON TYPE OF INDUSTRY

Parameters	Flow	P Concentration, mg/L		P-Loading, t/yr		
	MGPY	Total P	Soluble P	Total P	Soluble P	% Soluble P
North Side Water Reclamation Plant						
Drinking Water Treatment Plant (n = 1)						
	25.8	14.74	3.87	1.44	0.34	26

*Any discrepancy in totals or percentages may be due to rounding.
**Only small fraction of IUs sampled.

TABLE 5: INDUSTRIAL UNITS WITH FLOW GREATER THAN NINE MILLION GALLONS PER YEAR IN THE SERVICE AREA OF THREE WATER RECLAMATION PLANTS AND NUMBER OF INDUSTRIES SAMPLED FOR PHOSPHORUS STUDY

WRP	Number of IUs > 9 MGY flow[1]	IUs Sampled for P Study[2]	Percent of IUs Sampled
Stickney	298	28	9
Calumet	74	7	9
North Side	94	8	9
Total	**466**	**43**	**9**

[1]Based on 2009 data.
[2]Some IUs sampled have flow < 9MGY.

POTENTIAL OF REDUCING EFFLUENT PHOSPHORUS CONCENTRATION BELOW 1 mg/L – CASE STUDY FOR NORTH SIDE WATER RECLAMATION PLANT

In this evaluation, we explore the potential of reducing effluent P concentrations at the North Side WRP to below 1 mg/L without much change in plant operations. The mean annual effluent concentration of total P and soluble P are 1.37 mg/L and 1.24 mg/L, respectively (Table 6). It is estimated that out of a total annual P-loading of 964 t at the North Side WRP, 809 t comes from human excreta, 56 t from detergents, 45 t from stormwater, 11 t from food waste, 18 t from dogs, and approximately 25 t from industry.

The General Assembly, State of Illinois, has instituted a ban on detergents with P content exceeding 0.5 percent from July 2010 and a ban on P containing fertilizers for lawn and turf by amending the Illinois Fertilizer Act of 1961, effective July 2011. It is estimated that due to a P fertilizer ban, there will be a 36 t P/yr reduction in stormwater P-loading at the North Side WRP. In addition, detergent bans may lead to a reduction of 56 t P/yr. These bans on detergents and lawn fertilizers can result in significant reductions in the P-loadings in the raw influent in the coming years. Since most of the detergent P and fertilizer P in runoff is in the form of soluble P, the decline in effluent P-loading may be as much as 92 t/yr (Table 6). This in turn may reduce the total P and soluble P concentration in effluent by as much as 0.28 mg/L. However, even after realizing these potential reductions, the effluent P concentrations may still be close to 1 mg/L (Table 6). Industrial source control may be a viable option for the North Side WRP. According to 2012 data provided by the District's Industrial Waste Division, there are 47 running industrial units in the service area, which consist of 23 metal anodizers, finishers, and plating units; ten manufacturing units; six food and beverage units; two pharmaceuticals and consumer chemical units; and six others. Based on our results from the small number of industries sampled (Tables 3 and 4), these industries may be contributing significant P-loading.

It is estimated that for every 25 t reduction in soluble P-loading in influent, the resulting decline in total P and soluble P in effluent will be by 0.08 mg/L.

TABLE 6: EFFLUENT PHOSPHORUS CHARACTERISTICS OF NORTH SIDE WATER RECLAMATION PLANT AND POTENTIAL REDUCTIONS THAT MAY BE ACHIEVED BY DETERGENT BAN, LAWN PHOSPHORUS FERTILIZER BAN, AND INDUSTRIAL SOURCE CONTROL

	Flow MGD	Effluent P Load		Effluent P Conc.	
		Total P (t/yr)	Soluble P (t/yr)	Total P (mg/L)	Soluble P (mg/L)
Average of 2009 & 2010	236	446	404	1.37	1.24
		Potential Reductions Due to Bans			
Detergent & fert. ban (- 92 t P/yr) Detergent ban (- 56 t P/yr) P fertilizer ban (- 36 t P/yr)		354	312	1.09	0.96
		Potential Reductions Due to Source Control			
Industry source cont. (- 25 t P/yr)[1]		329	287	1.01	0.88

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