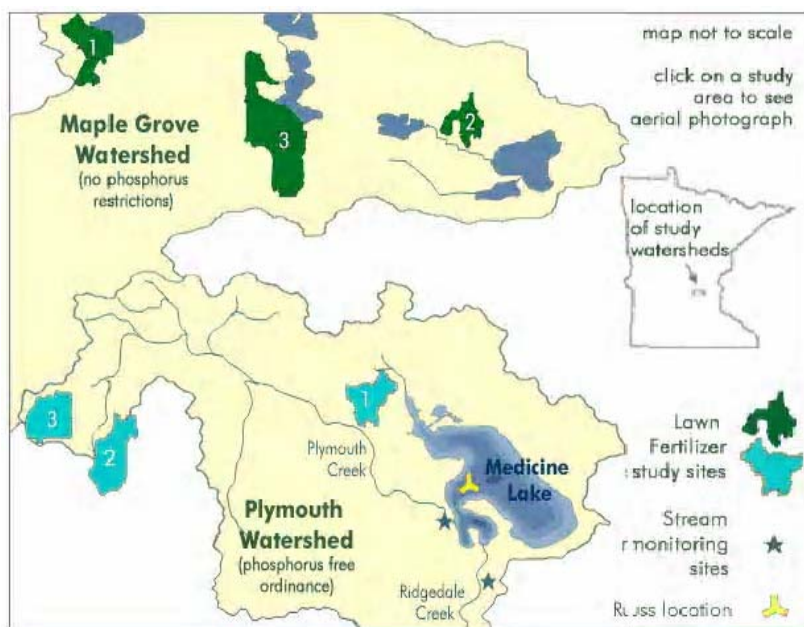


## II. Grass clippings

### Methods

Grass clippings from residential lawns have frequently been cited as a significant source of nutrients and organic matter transported to receiving waters from residential developments. Anecdotal evidence suggests that many residential homeowners blow grass clippings into city streets during normal lawn mowing operations. However, data showing the magnitude of this source of loading to receiving waters is lacking. From 2002 to 2006, the frequency, quantity and nutrient content of grass clippings blown into streets during mowing operations in six typical residential neighborhoods in Plymouth and Maple Grove, Minnesota was measured.



**Figure 1: Map showing the relative location of the study sub-watersheds in Plymouth (south) and Maple Grove (north), MN.**

Six residential neighborhoods comprising 327 residential lots with houses were selected for the grass clipping monitoring study, (Figure 1). The neighborhood size and number of housing units in each study area are shown on Table 1. The curb length along each lot was determined from the legal property description. The presence or absence of grass clippings in the street adjacent to each residential lot was recorded during each site inspection. The location of each lot with grass clippings blown into the street was recorded with a Global Positioning System (GPS) unit. The majority of site visits were scheduled randomly among the five days of the week. However, because mowing operations frequently occurred on weekends, Monday site visits were scheduled periodically throughout the mowing seasons to ensure adequate observations following known mowing events. Periodically, three site inspections were scheduled during a one week period when frequent mowing was observed due to rainy weather and rapid turf growth.

Table 1. Selected Parameters of residential neighborhoods in Plymouth and Maple Grove, MN.

Sample site	Size (Ha)	Number of lots	Curb length (m)
P1	5.1	46	1231.2
P2	6.8	47	1818.9
P3	5.6	40	1148.3
MG1	5.5	50	1666.5
MG2	3.5	36	1095.3
MG3	16	108	4106.7

Observed grass clippings were given a density rating from 1 to 3 based on the following criteria:

- 1 Only a few grass clippings visible on the street
- 2 Clippings covering approximately 50% of street surface along curb.
- 3 Clippings very dense, covering nearly 100 % of street along curb.

Grass clippings were collected from the street along ten percent of residential lots with visible clippings present. Clippings from a one square meter area were collected by sweeping all material into a sample container. The curb length associated with the sampled area was measured and recorded. The clippings were washed in the laboratory to remove street dirt, leaves, and other debris. The cleaned grass clippings were oven dried to 105° C and weighed to determine grass clipping mass. Samples were then digested and the phosphorus concentration per unit mass determined. The grass clipping mass and associated phosphorus mass per curb mile was then determined by multiplying the measured mass by the associated rating factor for each site with clippings present. .

## **Results:**

During the course of the study, each of the 327 lots was inspected on 32 occasions from June through September, for a total of 10,464 site observations. Multiple site visits during a given week were completed on five occasions during the study, and on three occasions, three site visits were completed in a seven day period.

Grass clippings were present in the street adjacent to some lots during every site visit. A total of 978 positive observations (9.4%) were recorded during the study period. The number of sites (residential lots) with grass clippings present during each site visit averaged 30.6 (9.4 %), and ranged from a low of 9 (2.8 %) on 24 August 2005 to a high of 92 (28.1%) on 23 June 2006. The lowest number of positive observations occurred during the second of two visits in a single week. When multiple site visits occurred during a week, only fresh clippings were recorded. Old clippings that had been observed at the previous site visit were not recorded. No sites had two instances of positive

observations during any of the five or seven day multiple site visit periods. Although the timing of mowing operations relative to each site visit was not determined, visual observations of turf condition indicated that mowing operations typically occurred weekly. Because over 50% of homeowners in the study areas irrigated their turf, mowing operations occurred regularly throughout the May to September period.

The curb length along each site (residential lot) averaged 24.2 m (79.4) feet, with a range of 16.2 to 67.1 meters (53 to 220 feet). The longest curb length/lot occurred along corner lots, of which there were 35 in the study neighborhoods. During site inspections, each side of a corner lot was considered a separate curb section. The curb length of each side of corner lots averaged 25.1 m (82.4 feet). The shortest curb lengths were on the inside of cul-de-sac curves.

Of the 327 residential lots inspected during the study, 36.2% (119) had no instances where clippings were present along the curb, (Table 2). An additional 14.3% (47 lots) had only one instance when clippings were present during 32 site visits. Conversely, 52 lots (15.9%), had clippings present on five or more occasions, and were responsible for 47.5% of positive observations. The maximum number of positive observations at any given lot was nine,

Table 2. Number and percent of lots where grass clippings were present in the street in Maple Grove and Plymouth, MN in 2002, 2003, 2005 and 2006 during 32 site visits.

Frequency Clippings Observed	Number of Lots	Percent of Lots
<b>0</b>	<b>119</b>	<b>36.2</b>
<b>1</b>	<b>47</b>	<b>14.3</b>
<b>2</b>	<b>41</b>	<b>12.5</b>
<b>3</b>	<b>36</b>	<b>10.9</b>
<b>4</b>	<b>33</b>	<b>10</b>
<b>5</b>	<b>19</b>	<b>5.8</b>
<b>6</b>	<b>16</b>	<b>4.9</b>
<b>7</b>	<b>8</b>	<b>2.4</b>
<b>8</b>	<b>3</b>	<b>0.9</b>
<b>9</b>	<b>7</b>	<b>2.1</b>

There was no significant difference in the percent of lots in Plymouth (39%) and Maple Grove (34%) where clippings were never observed. Approximately half of all lots in the two communities, 49.9 % and 51.2% in Maple Grove and Plymouth respectively, had one or fewer recorded instances of clippings present in the street. Residential lots where clippings were absent during all 32 site visits were relatively equally distributed among the six neighborhoods (Table 3). Plymouth neighborhoods P2 and P3 included six of the seven lots where grass clippings were observed on 9 occasions.

Table 3. Observed grass clippings frequency in six neighborhoods in Plymouth and Maple Grove, MN 2003 to 2006.

Frequency  Clippings observed/Lot	Percent of Lots					
	MG1	MG2	MG3	P1	P2	P3
0	49	28	30	53	36	35
1	16	28	12	14	13	11
2	2	11	13	19	19	14
3	10	6	16	7	6	16
4	4	11	15	7	11	8
5	10	8	2	0	9	5
6	6	3	10	0	0	3
7	4	5	2	7	2	8
8	0	0	0	0	2	3
9	0	0	1	0	6	5

Of the 978 positive observations recorded during the study, 351 (36%) had a density rating of 1, 418 (43%) had a density rating of 2, and 209 (21%) had a density rating of 3, (Table 4). The frequency that clippings were observed on a given lot did not affect the rating category. Thirty percent of lots with only one positive observation had a density rating of 1, and 34% of observations at lots with 6 or more positive observations had a density rating of 1. There was no discernable relationship between the mass of grass clippings on the streets, as estimated by the assigned density ranking, and the time of year, weather patterns, day of the week, or timing of site visit (Table 5). None of these factors had a statistical effect on the ratio of density rankings.

As indicated above, grass clippings were collected from a square meter area and weighed to determine the mass of clippings in the street. The curb length associated with a square meter sample area varied widely, ranging from one meter to 15 cm, with an average of 49 cm, depending on how far clippings were blown into the street. As indicated by the curb length associated with collected samples, clippings at most sites were blown more than a meter into the street. Typically, sites with a Rating Density of 3 had clippings blown farther into the street than sites with a Rating Density of 1.

The average weight of 79 grass clipping samples collected during the study was 7.37 g/m of curb. Twice as many clippings in Density Rating Category 2 and 3 were collected than in Category 1. The average weight of clippings in each rating category is shown in Table 4. There was a significant difference between the weight of clippings assigned a density rating of 3 and the weight of density rating 1 and 2. Differentiation between Density Rating Category 1 and 2, however, was less clear, and some overlap in the weights occurred. This may have been a result of the limited number of Category 1 samples collected.

Table 4. Number of observations and weight of grass clippings for each density rating category (g/m of curb) measured in Plymouth and Maple Grove samples in 2002, 2003 and 2005.

Density Rating	# of observations	Clippings weight (g/m)	# of Samples
1	351	1.95 ± 0.396	15
2	418	3.56 ± 0.44	31
3	209	13.42 ± 1.27	33

The total grass clipping mass accumulation on streets for each site visit was estimated with the following equation:

$$\text{Total Clippings (g)} = \sum (\# \text{ positive observation/rating factor} \times \text{weight/rating factor (g/m)} \times \text{average curb length/lot (m)}).$$

The estimated mass of grass clippings in the street observed during individual site visits averaged 1.2 kg, and ranged from a low of 0.4 kg to a maximum of 4.3 kg (Table 5). Weekly grass clipping mass accumulation was estimated from the intervals when three site visits occurred in a seven day time period; 6 July to 11 July 2005, 29 July to 4 August 2005, and 10 August to 15 August 2005. The grass clipping mass during these three weeks totaled 4.1 kg, 3.2 kg and 3.7 kg respectively.

The weight of phosphorus per kilogram of grass clippings in 36 samples averaged 2.85 g (0.29%), and ranged from 1.57 g to 5.65g or 0.16% to 0.57% respectively (Table 6). Grass clippings samples were collected from all six study neighborhoods, and tended to have similar percent of phosphorus in the grass tissue. Replication of results for Density Rating Category #1 was difficult because of the lack of adequate sample mass. The high and low values for the percent phosphorus in the grass tissue were both derived from Density Rating Category #1 samples. Results from Rating Category 2 and 3 samples tended to be more consistent because of the greater sample mass available for analysis.

Table 5. Grass clippings frequency of observations/Rating Category, total mass (kg), and phosphorus mass (g) for 32 site inspections at 327 residential lots in Plymouth and Maple Grove, MN.

Date	Rating 1	Rating 2	Rating 3	Clippings Mass (kg)	TP Mass (g)
7/19/2002	16	2	0	0.8	2.5
7/22/2002	17	9	2	1.3	3.8
8/2/2002	6	8	3	0.8	2.3
8/14/2002	15	18	2	1.7	4.8
8/26/2002	18	38	11	3.2	9.2
6/18/2003	0	10	7	0.8	2.3
7/1/2003	9	14	7	1.4	4.1
7/9/2003	10	22	20	2.5	7.1
8/15/2003	27	41	22	4.2	12.3
6/18/2003	9	5	2	0.8	2.2
6/17/2005	2	4	4	0.5	1.4
6/23/2005	4	4	1	0.4	1.2
6/30/2005	5	12	5	1.0	3.0
7/6/2005	17	13	10	1.9	5.5
7/8/2005	9	10	11	1.4	4.1
7/11/2005	6	8	3	0.8	2.3
7/21/2005	2	6	4	0.6	1.6
7/29/2005	10	14	16	1.9	5.5
8/1/2005	4	8	5	0.8	2.3
8/4/2005	1	5	4	0.5	1.4
8/10/2005	2	5	7	0.7	1.9
8/12/2005	10	9	7	1.2	3.6
8/15/2005	15	12	12	1.8	5.3
8/22/2005	11	11	4	1.2	3.6
8/24/2005	4	2	3	0.4	1.2
9/2/2005	4	6	6	0.8	2.2
9/14/2005	9	8	12	1.4	4.0
9/16/2004	3	13	6	1.0	3.0
9/23/2005	1	6	3	0.5	1.4
6/23/2006	52	36	4	4.3	12.6
6/30/2006	38	48	5	4.3	12.5
7/7/2006	15	11	1	1.3	3.7

Table 6. Mass (g) of phosphorus per mass of grass clippings (kg) collected from residential streets in Plymouth and Maple Grove, MN in 2005.

Date	g TP/kg (dry weight) clippings					
	P1	P2	P3	MG1	MG2	MG3
6/17/2005	2.78	2.48	3.22			
6/17/2005	2.49	3.38	3.42			
6/17/2005	5.65	2.99	3.48			
6/17/2005	2.81	2.45				
6/23/2005			3.61	2.37		2.91
6/23/2005			3.98	2.4		2.93
6/23/2005				2.56		3.17
7/8/2005					1.57	
7/8/2005					1.75	
7/8/2005					1.94	
7/23/2005		1.97				
7/23/2005		2.37				
7/29/2005			2.5	2.81	4.41	2.46
7/29/2005			2.47	2.99	4.08	2.44
8/10/2005						2.88
8/10/2005						2.56
8/12/2005	2.24					
8/12/2005	2.25					

Total phosphorus mass accumulation on the streets during each site visit was estimated as the product of the grass clipping mass multiplied by the average percent total phosphorus in the clippings (0.29%). The phosphorus mass averaged 4.2 g per site visit with a minimum of 1.2 g, and a maximum of 12.6 g. On an aerial loading basis, this amounted to an average of 0.1 g/ha of phosphorus per site visit, assuming that all clippings wash off of the street during rainfall events.

### **Discussion:**

The study results indicate that a minority of property owners (16%) were responsible for approximately half (48%) of the grass clippings observed on municipal streets in residential areas of Minnesota. These property owners showed a persistent propensity to blow grass clippings onto the street during mowing operations. Conversely, over half of homeowners had one or no instances when clippings were observed on the street. It appears that these infrequent incidents of improper mowing operations were isolated events, and these homeowners typically do not blow clippings onto streets.

Careless mowing patterns tended to occur along individual blocks of the study neighborhoods. For instance, in the Maple Grove 1 (MG1) neighborhood, lots 1 through 5, which are directly adjacent to each other, all had multiple instances of observed clippings while lots 17 to 23 had either one or no positive observations. It appears that neighbor expectations may guide behavior to some degree. Targeted education campaigns in these areas could reduce the incidence of improper mowing.

Lawns in Minnesota are typically dominated by cool season grass species. It was anticipated, therefore, that the frequency of grass clippings observed on streets, and the density of clippings would decrease during the hot, dry late July and August time period when turf growth slowed. However, neither the frequency of positive observations nor the clippings density appeared to decrease during July and August. The majority of homeowners water their turf routinely and grass growth appeared to be relatively uniform throughout the growing season. A previous study completed by Three Rivers Park District staff, documented lawn watering by over half of homeowners in the Maple Grove and Plymouth area.

One objective of the study was to estimate the annual phosphorus loading from grass clippings blown onto municipal streets and potentially carried into receiving waters with rainfall runoff water. The phosphorus loading associated with improper mowing operations was estimated in two ways:

The total mass of grass clippings estimated from the instances when three site inspections were performed in a seven day time period was used as the weekly average for the growing season. The phosphorus associated with the weekly average clippings mass (3.67 kg grass clipping/week from Table 5) was multiplied by the weeks of the mowing season (25 weeks) to estimate the annual phosphorus load.

The average phosphorus loading for each site visit from Table 5, was assumed to be the daily average during the mowing season. This quantity was multiplied by the number of days in the average turf mowing season (175 days).

For both estimates, it was assumed that all clippings blown onto streets were washed off into the stormwater system. Using the weekly grass clippings mass, the estimated annual phosphorus loading was calculated to be 0.26 kg, or 0.006 kg/ha. Assuming that the average site visit grass clippings mass was deposited on the streets daily throughout the mowing season, the calculated annual phosphorus load from grass clippings was 0.73 kg or 0.017 kg/ha. These estimates likely represent the minimum and maximum loading rates from grass clippings.

Typical phosphorus exports rates from urban residential areas range from 0.56 to 0.9 kg/ha annually (Brach, *Protecting Water Quality in Urban Area*; Corsi, Graczyk, Ownes and Bannerman, *Unit-Area Loads of Suspended Sediment, Suspended Solids, and Total Phosphorus From Small Watersheds in Wisconsin*). The loading associated with grass clippings therefore represents between 1 and 3 percent of the estimated annual load.



Although the phosphorus export from grass clippings blown into residential streets from improper turf mowing practices appears to be minimal, it is nevertheless a source easily addressed. Educational programs targeting neighborhood areas where grass clippings are frequently observed on streets could reduce phosphorus export for minimal cost.

### **Conclusions:**

A four year study of two suburban municipalities in Minnesota found that approximately half of 327 homeowners routinely blow grass clippings into residential streets during mowing operations. The mass of clippings measured on the streets averaged 1.2 kg during 32 site visits. The grass clipping mass had an average of 4.2 g of associated phosphorus mass. This amounted to approximately 1 to 3 percent of the estimated annual phosphorus export from typical urban residential areas. Educational programs targeted at neighborhoods where clippings are frequently observed could reduce loading from this source.