Onondaga Ambient Lake Monitoring Program
Annual Report for 2008
Mass Balances

prepared for

Ecologic, L.L.C.

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Introduction

The development and structure of a mass-balance modeling framework for Onondaga Lake is described in previous lake monitoring reports (Ecologic et al., 2009). The framework facilitates computation and analysis of mass balances for nutrients and other water-quality components using hydrologic and water quality data collected in the Lake and its tributaries since 1986. Results provide a basis for:

- Estimating the magnitude and precision of loads from each source;
- Assessing long-term trends in load and inflow concentration from each source and source category (point, non-point, total);
- Evaluating the adequacy of the monitoring program, based upon the precision of loads computed from concentration and flow data;
- Developing and periodic updating of an empirical nutrient loading model that predicts eutrophication-related water quality conditions (as measured by nutrient concentrations, chlorophyll-a, algal bloom frequency, transparency, and hypolimnetic oxygen depletion) as a function of yearly nutrient loads, inflows, and lake morphometry (Walker, 2009; Ecologic et al., 2009).
- Developing simple input/output models for other constituents; and
- Developing data summaries to support integration and interpretation of monitoring results in each yearly AMP report.

This report updates the mass-balance framework to include data through 2008. Computations are linked directly to the AMP long-term water quality and hydrologic database (Figure 1). Recent mass balances for key water quality components are summarized. Long-term (1990-2008) and ten-year (1999-2008) trends are evaluated for each monitored inflow, as well as site aggregates (inflow vs. outflow, point vs. nonpoint, urban vs. rural watersheds, etc.).

With improvements to the monitoring program made since initiation of the AMP in 1999, the accuracy and precision of the load estimates and power for detecting trends has steadily improved. In this update, the ten-year base period used to evaluate recent trends (1999-2008) reflect AMP improvements.

With implementation of point-source phosphorus controls, non-point loads have become increasingly important as factors driving eutrophication-related water quality in the Lake. In 2006-2008, when Metro operated under a 120 ppb discharge permit, nonpoint sources accounted for 68-74% of the Total P load to the Lake, as compared with 25-60% in 1990-2005.   Evaluating trends in non-point source loads is complicated by random year-to-year variance, a high percentage of which is driven by variations in precipitation and streamflow, as opposed to variations in runoff water quality.   Trend analyses employ refined statistical methods that account for year-to-year variations in precipitation, as developed in last year's AMP report (Ecologic et al, 2009).

As described in the main report (Section 6, Figure 6-4), lake water quality improved significantly in 2008 in response to the cumulative reductions in TP point and nonpoint loads that have been accomplished since 1990. The summer-mean upper-layer lake TP concentration in 2008 (15 ppb) was significantly below those measured in previous years with Metro operating under a 120 ppb discharge permit (2006-2007, TP = 25 to 41 ppb), despite the fact that the total annual P loads were similar in those years.   A final section examines recent TP mass balances relative to the predictions of the Onondaga Lake Empirical Eutrophication Model (OLEEM; Walker, 2009). Potential mechanisms responsible for the favorable lake response are discussed.

Hydrology

Yearly variations in precipitation and watershed runoff are summarized in Figure 2. Over the 1990-2008 period, yearly runoff from the Onondaga Lake watershed varied from 31 to 75 cm and was strongly correlated with precipitation ($r^2 = 0.82$).   Runoff and precipitation were slightly above average in 2008.   Watershed runoff in 2008 (55 cm) was at the 50th percentile of the 1990-2008 data and precipitation (106 cm) was at the 70th percentile.   Increasing trends in both precipitation and runoff over the 1990-2008 period complicate interpretations of apparent trends in the tributary loads and lake responses in the most recent ten-year period.

Mass Balances

Historical variations in the mass balances of primary water quality components over the 1990-2008 period are summarized in the following figures:

Figure 3	Total Inflow & Outflow Concentrations
Figure 4	Total Inflow & Outflow Loads
Figure 5	Total Non-point & Total Metro Loads
Figure 6	Rainfall-Adjusted Non-Point Source Loads

The time series start in 1990 because that was the first year in which total phosphorus measurements were made in the lake tributaries. As indicated in Figure 6, trend analyses for some constituents are potentially influenced by variations in analytical detection limits over the years, in particular for Ammonia N, Nitrite N, SRP, and BOD-5 at sites with relatively low concentration ranges (Onondaga Creek, Ninemile Creek, and Harbor Brook).

The following tables describe lake mass balances for various constituents in the most recent 5-year period (2004-2008), as provided in previous annual reports:

Table 1	Chloride
Table 2	Total Nitrogen
Table 3	Ammonia Nitrogen
Table 4	Total Phosphorus
Table 5	Soluble Reactive Phosphorus
Table 6	Summaries for All Constituents

Because outlet samples measured at 2 feet are more heavily influenced by hydraulic exchanges with the Seneca River, outflow loads computed from 12-foot samples are considered more representative of net outflow from the Lake and are similar to those measured in the upper mixed layer at the Lake South station.

Since chloride and sodium are expected to be conservative, mass balances for these constituents provide a basis for testing the accuracy and completeness of the data and methods used to develop the mass balances. Whereas outflow loads typically exceeded inflow loads by ~5% historically, the mass balances gradually converged (inflow load ~ outflow load) over the 2000-2007 period, as described in the 2007 OLMP report. For both chloride and sodium, differences between inflow and outflow loads were not statistically significant in 2004-2008 (-0.4 +/- 2.2% and -0.3 +/- 2.4% of the total inflow loads, respectively). While the margins were not statistically significant, yearly inflow loads exceeded outflow loads for the first time both 2007 and 2008, as compared with 1990-2006 (Figure 4). Trends in the net retention of both sodium and chloride are correlated with increasing trends in loads from Metro, Harbor Brook, and Onondaga Creek (Table 9 below). The lower portion of Onondaga Creek (between Dorwin and Kirkpatrick) accounted for 35% of the total chloride load to the Lake in 2004-2008. This reach is influenced by salt springs (Kapel, 2003), although direct measurements of these sources are not available for this period. As discussed below, the apparent trend in Metro chloride loads is attributed to unusually high values in July-August 2008 associated with construction of CSO controls in the watershed (Figure 15)

Trends in Loads

Ten-year trends in annual loads and flow-weighted mean concentrations listed in Tables 7 and 8, respectively. Results are shown with and without adjustment for precipitation using the multiple regression technique described in the 2007 annual report (Ecologic et al, 2009). Table 9 lists adjusted trends in load expressed in mass units (i.e. kg/yr vs. %/yr); these reflect the relative impacts of the trends on the overall mass balance. Many of the apparent trends in load are removed when adjustments are made for the increasing trend in precipitation over the 1999-2008 period (Figure 2). While the multiple regression technique increases the power of the tests for trends in the long-term means, all results are subject to uncertainty because the technique does not necessarily eliminate the confounding effect of the trend in precipitation. Addition of data from future drought years to the time series will provide a basis for distinguishing between trends and variations driven by precipitation.

Consistent with treatment plant improvements, decreasing trends in load and/or concentration are indicated for some nitrogen species (TKN, Ammonia N, Nitrite N) and phosphorus species (TP, TDP) in the Metro discharge and in the lake outflow. The absence of Total N trends in the Metro discharge and total inflow reflects the fact that decreasing trends in the above species were offset by increasing trends in Nitrate N load (Figure 5), which were of similar magnitude but just above the significance level cutoff ($p = 0.11$ and 0.13 vs. 0.10). With the exception of Harbor Brook, nonpoint source loads were generally stable over the 1999-2008 period. Increasing trends in phosphorus, nitrogen, and carbon species are indicated for the lower portion of Harbor Brook, between the Velasko and Hiawatha sites. As discussed in the 2007 report, increases in loads from this urban sub-watershed partially offset reductions in loads due to Metro improvements. Identification of specific sources and development of remedies are recommended.

Increasing trends in sodium and chloride are indicated for the total inflow and for the lower portion of Onondaga Creek and the Metro discharge. Unusually high chloride and sodium loads from the Metro discharge occurred during July and August 2008 in conjunction with construction of CSO controls. This unusual event was largely responsible for the apparent trends in 1999-2008, since significant trends were not observed in the previous ten-year interval (1998-2007). While there were apparent increasing trends in outflow sodium and chloride loads (Figure 4), the trends were not strong enough to be statistically significant, particularly in the context of the trend in precipitation.

As observed in the previous ten-year interval, significant increasing trends in outflow silica concentration and load are not paired with corresponding trends in the lake inflows. This may be an indirect consequence of reduced algal productivity in the Lake resulting from decreases in phosphorus load. If diatom growth were increasingly limited by phosphorus levels, silica uptake by diatoms and subsequent sedimentation would also to decrease. Increases in lake nitrate concentrations would also be expected from this mechanism, but are potentially masked by the extreme variations in the nitrate load from Metro (Figure 5).

Baseline Phosphorus Loads

TP concentrations in the Metro discharge averaged 180 ppb in 2004-2008 (Table 4), but decreased steadily from 540 ppb in 2004 to 88 ppb in 2008 as a consequence of treatment improvements (Figure 5). Total P mass balances for 1999-2008 reflect a wider range of precipitation and runoff concentrations that would be representative of long-term average non-point loads (Table 10). Total P mass balances for 2006-2008 reflect Metro operation under a 120 ppb discharge limit (Table 11). These results can be used to refine the long-term average P budget to serve as a basis for evaluating future management scenarios and tracking trends:

TP Load (metric tons / yr)	1999-2008	2006-2008	Long-Term*
Total Non-point	26.5	29.2	26.5
Industrial	0.3	0.2	0.2
Metro Discharge (Outfall 1)	24.2	9.6	9.6
Metro Bypass (Outfall 2)	2.2	1.7	1.7
Atmospheric Deposition	0.4	0.4	0.4
Total	53.7	41.1	38.4

The third column (*) combines 1999-2008 non-point with 2006-2008 Metro and industrial loads. This would be representative of the long-term average loads with the existing Metro treatment capabilities and an average discharge concentration of 110 ppb, as observed in 2006-2008. If the 2008 Metro discharge concentration (88 ppb) were maintained, the projected load from Metro would decrease from 9.6 and 7.7 mt/yr at the 2006-2008 flow and the long-term load to the Lake would decrease from 38.4 to 36.5 mt/yr. Average Metro discharge concentrations similar to that measured in 2008 would be expected in order to maintain compliance with the recently-revised 12-month rolling-average permit limit (100 ppb).

Spatial variations in runoff and non-point phosphorus loads from each sub-watershed are shown in Figure 7. These results are based upon water and phosphorus balances for 1999-2008 listed in Table 10. Comparisons are made across sub-watersheds with respect to drainage area, total flow, load, concentration, runoff (flow per unit watershed area), and export (load per unit watershed area). Harbor Brook and Onondaga Creek are subdivided into upper (generally rural) and lower (generally urban) sub-watersheds. Phosphorus export rate from the three urban watersheds (lower Harbor, lower Onondaga, Ley) averaged 59 kg/km^2-yr and ranged from 54 to 127 kg/km^2-yr, as compared with a mean of 31 kg/km^2-yr and range of 15 to 38 kg/km^2-yr for the rural watersheds. Similarly, the urban watersheds had higher runoff concentrations (mean = 95 ppb, range = 91–535 ppb), as compared with rural watersheds (mean = 60 ppb, range = 41–67 ppb). Overall, urban watersheds accounted for 28% of the total non-point load, rural watersheds accounted for 66%, and un-gauged areas accounted for 6%.

Long-term trends in runoff, flow-weighted-mean TP concentration, and TP load from all non-point sources are shown in Figure 8 (1990-2008) and Figure 9 (1999-2008). Adjusting for variations in precipitation, decreasing trends in flow-weighted-mean concentration (-3.4% 0/- 1.0 %) and load (-3.0 +/-0.9 %) are indicated for the 1990-2008 period. Most of the apparent decreases occurred prior to ~2004. No significant trends are apparent for the most recent ten-year period (Figure 9), although the power of the regression test is limited by the increasing trend in precipitation (3.1 +/- 0.8 cm/yr, Figure 2).

Long-term (1990-2008) trends in precipitation-adjusted TP load from each source are shown in Figure 10. The overall reduction in nonpoint load is attributed to significant decreases in load from each tributary, with the exception of Harbor Brook, where TP loads have increased, particularly in recent years. The cumulative database provides a good baseline for evaluating the effects of implementing additional non-point source control measures in both the urban and rural portions of the watershed.

Mass Balance Modeling

TP concentrations in the upper and lower levels of Onondaga Lake responded dramatically to the decreasing external P loads over the 1990-2008 period (Figure 11), especially in the past few years. Despite the fact that annual TP loads were similar in 2006-2008, the lake and outlet TP concentrations were significantly lower in 2008. The flow-weighted-mean inflow concentration varied from 74 to 78 ppb as the outlet concentration decreased from 48 to 31 ppb and the summer-average concentration in the lake upper layer decreased from 41 to 15 ppb. The sharp decrease in lake TP in 2008 is unusual in the context of other lake restoration experiences, in which lake responses typically lagged behind load reductions due to storage and recycling of phosphorus within the lake and sediments (Sas, 1989)

The disproportionate lake TP response is inconsistent with assumptions of the phosphorus mass balance model (OLEEM = Onondaga Lake Empirical Eutrophication Model), which was updated in the previous AMP report (Ecologic, 2009; Walker, 2009). The model assumes that long-term annual-average TP removal per unit of lake surface area is proportional to the average outflow concentration. The proportion is reflected in the calibrated "settling rate" constant. A settling rate of 23 m/yr was calibrated to 2003-2007 data. Figure 12 shows yearly variations in settling rate computed from the measured P budgets over the 1990-2008 period. While random year-to-year variations in settling rate are expected due to uncertainty in the load estimates and lake dynamics, the 76 m/yr value in 2008 was well outside of the 7 to 50 m/yr range measured in previous years and approximately three times the 2003-2007 calibration. In contrast, the settling rate for Total N in 2008 (15 m/yr) was within the historical range (11 to 20 m/yr) and similar to the 2003-2007 calibration (16 m/yr).

The unusually high TP settling rate in 2008 could reflect deviations from one or more of the model assumptions discussed in the model calibration report (Ecologic et al, 2009). Potential contributing factors include:

1. Non-Steady-State Conditions. OLEEM was designed to predict the long-term-average response to a stable TP loading regime. Trends in the lake P data over the 2005-2008 period (Figure 11) indicate that P cycling within the lake was still responding to the recent load reductions.

2. Differences in lake response to P loads from Metro as compared with lake tributaries. Such differences could reflect differences in P speciation (dissolved vs. particulate) and/or hydrodynamics (plunging inflows from tributaries driven by density differences). As shown in Figure 12, the fraction of the TP load attributed to Metro was lowest in 2008 when the settling rate was highest. Conversely, the fraction of the load attributed to Metro was highest in 1995 when the settling rate was lowest. This factor does not explain variations in the past few years, however, when the fraction of the load from Metro decreased by small percentage as the settling rate more than tripled.

3. Decreases in the bioavailablity of P loads. Figure 13 shows long-term trends in phosphorus loads partitioned into three components: soluble reactive (SRP), dissolved organic (TDP - SRP) and particulate (TP – TDP). Time series are shown for non-point, municipal (Metro + Bypass), total inflow, and total outflow. While there was significant decrease in the SRP fraction of the Metro discharge in 2006-2008, the SRP fractions of the nonpoint and total loads were relatively constant over the 1999-2008 period, with the exception of 2004, when the SRP fractions in both the Metro and total inflow loads were unusually high. Trends in

bioavailability, as related to TP speciation, do not appear to explain the lake response in 2008.

4. Lower TP concentration in the Metro discharge and lake during winter and spring of 2008. As shown in Figure 14, TP concentrations in the Metro discharge and lake were significantly lower in January-April of 2008 (70 to 100 ppb), as compared with the same period in 2006 and 2007 (100 to 200 ppb). This would have provided less fuel for the spring and early summer algal blooms, as well as decreased the initial P concentration in the hypolimnion at the start of the stratified period in 2008.

5. Changes in the vertical distribution of the Metro discharge. The density of the Metro effluent increased during July and August of 2008, when chloride concentrations increased several fold as a result of loads from RTF de-watering facility (Figure 15). Depending on the magnitude of the density changes and initial mixing, the higher density would have created a tendency for the Metro discharge to pass through Lake below the upper mixed layer. This hypothesis is consistent with the bulge in conductivity that developed at the Lake South station between 6-10 meters after the chloride content of the Metro discharged increased in mid July of 2008. The conductivity bulge was much more pronounced than those observed in 2007 and previous years. Transport at the 6-10 meter level would have decreased the P supply to surface algal populations and helped to flush P accumulating in the thermocline and lower layer out of the Lake. Based upon preliminary data, the summer average lake TP concentration in 2009 was similar to that observed in 2008, however. This suggests that unusually high salinity in the Metro discharge may not have been the major factor responsible for high TP settling rate in 2008.

6. Decreased P recycling from bottom sediments controlled by oxidation-reduction potential. Nitrate N concentrations in the bottom and surface waters remained high (>1 ppm) throughout the stratified period, as compared with previous years,

when nitrate levels were depleted (Figure 14). Higher nitrate levels would have decreased redox-driven P releases from bottom sediments (Cooke et al, 2005).

7. As consequences of the above factors, there was significantly less P buildup in the lower layers during the summer stratified period in 2008 (maximum = 70 ppb), as compared with 2006-2007 (maximum 180-200 ppb, Figure 11). The corresponding decrease in the vertical TP gradient would have decreased diffusive transport from the lower to the upper layers in early and mid summer, as well as decreased transport associated with thermocline erosion in late summer and fall.

8. Changes in biological factors (Cooke et al, 2005), as described in the main report:
    a. Increasing populations of Zebra mussels, which can remove filter out algal cells and other particulate material containing phosphorus.
    b. Shifts in phytoplankton to species that have higher settling rates and are more subject to predation, as compared with bluegreens, which were dominant historically.
    c. Increases in zooplankton populations and grazing due to variations in fish populations.

Updating the Onondaga Lake Water Quality Model (QEA et al, 2006) to include data through 2009 would provide a basis for evaluating some of the above mechanisms and their sensitivity to treatment efficiency and watershed management. The Metro chloride spike in 2008 would provide a particularly good signal for testing hydrodynamic components of the model. The existing calibration of OLEEM based upon data through 2007 will provide a basis for evaluating changes in the overall P budget dynamics relative to historical conditions. In the past, the OLEEM calibration has typically been updated every three years. Depending on results for 2009-2010, another periodic update of the model may be appropriate.

One critical question is whether the low TP concentrations observed in 2008 will be sustained in the future with the current TP loading regimes, or whether they were due to unusual conditions. This question is most reliably assessed through continued monitoring and adaptive management. Meanwhile, maintaining high treatment efficiencies for ammonia and TP throughout the year and continuing to address non-point sources will increase the probability of achieving the lake TP goal on a consistent basis.

References

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List of Tables

Table 1 Chloride Balance for 2004-2008

Variable: **Chloride** **Average for Years: 2004 thru 2008**

							Percent of Total Inflow			Drain.		Export	
	Flow	Load	Std Error	Conc	RSE	Sampl	Flow	Load	Error	Area	Runoff	mt/	
Term	**10^6 m3**	**mt**	**mt**	**ppm**	**%**	**per yr**	**%**	**%**	**%**	**km2**	**cm**	**km2**	
Metro Effluent	91.12	40679	1785	446	4%	74	17%	20%	24%				
Metro Bypass	1.80	671	116	373	17%	4	0%	0%	0%				
East Flume	0.84	417	18	498	4%	27	0%	0%	0%				
Trib 5A	1.23	451	11	368	2%	27	0%	0%	0%				
Harbor Brook	12.59	3297	202	262	6%	28	2%	2%	0%	31.4	40.2	105.1	
Ley Creek	41.36	14261	1379	345	10%	26	8%	7%	14%	66.1	62.6	215.8	
Ninemile Creek	170.89	49409	775	289	2%	30	31%	24%	5%	298.1	57.3	165.8	
Onondaga Creek	188.68	88024	2357	467	3%	27	34%	42%	42%	285.1	66.2	308.7	
Nonpoint Gauged	413.53	154991	2846	375	2%	111	75%	75%	61%	680.7	60.8	227.7	
Nonpoint Ungauged	28.17	10557	1431	375	14%		5%	5%	15%	46.4	60.8	227.7	
NonPoint Total	441.69	165548	3185	375	2%	111	80%	80%	76%	727.0	60.8	227.7	
Industrial	2.06	868	21	420	2%	54	0%	0%	0%				
Municipal	92.91	41350	1789	445	4%	78	17%	20%	24%				
Total External	536.67	207765	3653	387	2%	243	98%	100%	100%	727.0	73.8	285.8	
Precipitation	12.72	13	1	1	9%		2%	0%	0%	11.7	108.7	1.1	
Total Inflow	549.39	207778	3653	378	2%	243	100%	100%	100%	738.7	74.4	281.3	
Evaporation	8.86						2%			11.7	75.7		
Outflow	540.53	208508	2648	386	1%		98%	100%	53%	738.7	73.2	282.2	
Retention	0.00	-729	4512		619%		0%	0%					0.0%
Alternative Estimates of Lake Outflow													
Outlet 12 Feet	540.53	208508	2648	386	1%	26	98%	100%	53%	738.7	73.2	282.2	
Outlet 2 Feet	540.53	191439	4114	354	2%	26	98%	92%	127%	738.7	73.2	259.1	
Upstream/Downstream Contrast- Harbor Brook													
Upstream - Velasko	11.00	2562	88	233	3%	28	2%	1%		27.0	40.8	95.0	
Downstream - Hiawatha	12.59	3297	202	262	6%	28	2%	2%		31.4	40.2	105.1	
Local Inflow	1.59	735	220	462	30%		0%	0%		4.4	36.1	166.8	
Upstream/Downstream Contrast - Onondaga Creek													
Upstream - Dorwin	146.86	15853	270	108	2%	46	27%	8%		229.4	64.0	69.1	
Downstream - Kirkpatrick	188.68	88024	2357	467	3%	27	34%	42%		285.1	66.2	308.7	
Local Inflow	41.82	72171	2372	1726	3%		8%	35%		55.7	75.0	1295.0	
Nonpoint Source Summary - Gauged Watersheds							Percent of Total Gauged Watershed						
Total Watershed	413.53	154991	2846	375	2%		100%	100%		680.69	60.8	227.7	
Upper/Rural Watersheds	328.75	67824	826	206	1%		79%	44%		554.45	59.3	122.3	
Lower/Urban Watersheds	84.77	87167	2753	1028	3%		21%	56%		126.24	67.2	690.5	

Upper Watersheds — Ninemile + Onondaga(Dorwin) + Harbor(Velasko) - Primarily Rural / Agric Land Uses

Lower Watersheds — Lower Watershed = Ley + Onondaga(Kirkpatrick-Dorwin) + Harbor (Hiawatha - Velasko) - Primarily Urban Land Uses

Lake Overflow Rate	46.20 m/yr	Calib. Settling Rate	-0.2 m/yr	RSE % = Relative Std. Error of Load & Inflow Conc. Estimates
Lake Residence Time	0.24 years	Calib. Retention Coef.	0%	Error % = Percent of Variance in Total Inflow Load Estimate

Table 2 Total Nitrogen Balance for 2004-2008

Variable: **Total Nitrogen** **Average for Years:** **2004** **thru** **2008**

Term	**Flow 10^6 m3**	**Load kg**	**Std Error kg**	**Conc ppb**	**RSE %**	**Sampl per yr**	**Percent of Total Inflow Flow %**	**Percent of Total Inflow Load %**	**Percent of Total Inflow Error %**	**Drain. Area km2**	**Runoff cm**	**Export kg/ km2**
Metro Effluent	91.12	1124192	30451	12338	3%	100	17%	61%	86%			
Metro Bypass	1.80	20072	797	11164	4%	4	0%	1%	0%			
East Flume	0.84	4730	126	5643	3%	27	0%	0%	0%			
Trib 5A	1.23	1816	125	1481	7%	27	0%	0%	0%			
Harbor Brook	12.59	25912	863	2057	3%	27	2%	1%	0%	31.4	40.2	826.2
Ley Creek	41.36	50627	2333	1224	5%	26	8%	3%	1%	66.1	62.6	765.9
Ninemile Creek	170.89	270300	7363	1582	3%	27	31%	15%	5%	298.1	57.3	906.8
Onondaga Creek	188.68	281670	7547	1493	3%	27	34%	15%	5%	285.1	66.2	987.9
Nonpoint Gauged	413.53	628510	10833	1520	2%	107	75%	34%	11%	680.7	60.8	923.3
Nonpoint Ungauged	28.17	42809	5811	1520	14%		5%	2%	3%	46.4	60.8	923.3
NonPoint Total	441.69	671319	12293	1520	2%	107	80%	36%	14%	727.0	60.8	923.3
Industrial	2.06	6546	178	3170	3%	54	0%	0%	0%			
Municipal	92.91	1144265	30461	12315	3%	104	17%	62%	86%			
Total External	536.67	1822129	32849	3395	2%	264	98%	99%	100%	727.0	73.8	2506.2
Precipitation	12.72	24164	2165	1900	9%		2%	1%	0%	11.7	108.7	2065.3
Total Inflow	549.39	1846294	32920	3361	2%	264	100%	100%	100%	738.7	74.4	2499.2
Evaporation	8.86						2%			11.7	75.7	
Outflow	540.53	1373248	29837	2541	2%		98%	74%	82%	738.7	73.2	1858.9
Retention	0.00	473046	44430		9%		0%	26%				
Alternative Estimates of Lake Outflow												
Outlet 12 Feet	540.53	1373248	29837	2541	2%	26	98%	74%	82%	738.7	73.2	1858.9
Outlet 2 Feet	540.53	1287248	29252	2381	2%	26	98%	70%	79%	738.7	73.2	1742.5
Upstream/Downstream Contrast- Harbor Brook												
Upstream - Velasko	11.00	22934	1347	2084	6%	27	2%	1%		27.0	40.8	850.7
Downstream - Hiawatha	12.59	25912	863	2057	3%	27	2%	1%		31.4	40.2	826.2
Local Inflow	1.59	2978	1600	1871	54%		0%	0%		4.4	36.1	675.9
Upstream/Downstream Contrast - Onondaga Creek												
Upstream - Dorwin	146.86	235229	28779	1602	12%	38	27%	13%		229.4	64.0	1025.4
Downstream - Kirkpatrick	188.68	281670	7547	1493	3%	27	34%	15%		285.1	66.2	987.9
Local Inflow	41.82	46441	29753	1110	64%		8%	3%		55.7	75.0	833.3
Nonpoint Source Summary - Gauged Watersheds							Percent of Total Gauged Watershed					
Total Watershed	413.53	628510	10833	1520	2%		100%	100%		680.69	60.8	923.3
Upper/Rural Watersheds	328.75	528463	29737	1607	6%		79%	84%		554.45	59.3	953.1
Lower/Urban Watersheds	84.77	100047	29887	1180	30%		21%	16%		126.24	67.2	792.5

Upper Watersheds Ninemile + Onondaga(Dorwin) + Harbor(Velasko) - Primarily Rural / Agric Land Uses
Lower Watersheds Lower Watershed = Ley + Onondaga(Kirkpatrick-Dorwin) + Harbor (Hiawatha - Velasko) - Primarily Urban Land Uses

Lake Overflow Rate 46.20 m/yr Calib. Settling Rate 15.9 m/yr RSE % = Relative Std. Error of Load & Inflow Conc. Estimates
Lake Residence Time 0.24 years Calib. Retention Coef. 26% Error % = Percent of Variance in Total Inflow Load Estimate

Table 3 Ammonia Nitrogen Balance for 2004-2008

Variable: **Ammonia Nitrogen** **Average for Years:** **2004** **thru** **2008**

							Percent of Total Inflow			**Drain.**		**Export**
	Flow	**Load**	**Std Error**	**Conc**	**RSE**	**Sampl**	**Flow**	**Load**	**Error**	**Area**	**Runoff**	**kg/**
Term	**10^6 m3**	**kg**	**kg**	**ppb**	**%**	**per yr**	**%**	**%**	**%**	**km2**	**cm**	**km2**
Metro Effluent	91.12	72755	1520	798	2%	361	17%	48%	22%			
Metro Bypass	1.80	9452	553	5257	6%	42	0%	6%	3%			
East Flume	0.84	382	21	456	5%	27	0%	0%	0%			
Trib 5A	1.23	196	26	160	13%	27	0%	0%	0%			
Harbor Brook	12.59	960	91	76	9%	27	2%	1%	0%	31.4	40.2	30.6
Ley Creek	41.36	11229	746	271	7%	26	8%	7%	5%	66.1	62.6	169.9
Ninemile Creek	170.89	37217	2495	218	7%	27	31%	25%	59%	298.1	57.3	124.9
Onondaga Creek	188.68	13828	843	73	6%	27	34%	9%	7%	285.1	66.2	48.5
Nonpoint Gauged	413.53	63233	2738	153	4%	108	75%	42%	71%	680.7	60.8	92.9
Nonpoint Ungauged	28.17	4307	609	153	14%		5%	3%	4%	46.4	60.8	92.9
NonPoint Total	441.69	67540	2805	153	4%	108	80%	45%	75%	727.0	60.8	92.9
Industrial	2.06	579	33	280	6%	54	0%	0%	0%			
Municipal	92.91	82208	1618	885	2%	404	17%	54%	25%			
Total External	536.67	150327	3238	280	2%	565	98%	99%	100%	727.0	73.8	206.8
Precipitation	12.72	1272	114	100	9%		2%	1%	0%	11.7	108.7	108.7
Total Inflow	549.39	151599	3240	276	2%	565	100%	100%	100%	738.7	74.4	205.2
Evaporation	8.86						2%			11.7	75.7	
Outflow	540.53	141777	6310	262	4%		98%	94%	379%	738.7	73.2	191.9
Retention	0.00	9822	7093		72%		0%	6%				
Alternative Estimates of Lake Outflow												
Outlet 12 Feet	540.53	141777	6310	262	4%	26	98%	94%	379%	738.7	73.2	191.9
Outlet 2 Feet	540.53	133728	6615	247	5%	26	98%	88%	417%	738.7	73.2	181.0
Upstream/Downstream Contrast- Harbor Brook												
Upstream - Velasko	11.00	508	35	46	7%	27	2%	0%		27.0	40.8	18.8
Downstream - Hiawatha	12.59	960	91	76	9%	27	2%	1%		31.4	40.2	30.6
Local Inflow	1.59	452	97	284	22%		0%	0%		4.4	36.1	102.7
Upstream/Downstream Contrast - Onondaga Creek												
Upstream - Dorwin	146.86	7169	363	49	5%	45	27%	5%		229.4	64.0	31.3
Downstream - Kirkpatrick	188.68	13828	843	73	6%	27	34%	9%		285.1	66.2	48.5
Local Inflow	41.82	6658	918	159	14%		8%	4%		55.7	75.0	119.5
Nonpoint Source Summary - Gauged Watersheds							Percent of Total Gauged Watershed					
Total Watershed	413.53	63233	2738	153	4%		100%	100%		680.69	60.8	92.9
Upper/Rural Watersheds	328.75	44894	2521	137	6%		79%	71%		554.45	59.3	81.0
Lower/Urban Watersheds	84.77	18339	1187	216	6%		21%	29%		126.24	67.2	145.3

Upper Watersheds — Ninemile + Onondaga(Dorwin) + Harbor(Velasko) - Primarily Rural / Agric Land Uses
Lower Watersheds — Lower Watershed = Ley + Onondaga(Kirkpatrick-Dorwin) + Harbor (Hiawatha - Velasko) - Primarily Urban Land Uses

Lake Overflow Rate 46.20 m/yr — Calib. Settling Rate 3.2 m/yr — RSE % = Relative Std. Error of Load & Inflow Conc. Estimates
Lake Residence Time 0.24 years — Calib. Retention Coef. 6% — Error % = Percent of Variance in Total Inflow Load Estimate

Table 4 Total Phosphorus Balance for 2004-2008

Variable: **Total Phosphorus** **Average for Years:** **2004** **thru** **2008**

							Percent of Total Inflow			Drain.		Export
	Flow	Load	Std Error	Conc	RSE	Sampl	Flow	Load	Error	Area	Runoff	kg /
Term	10^6 m3	kg	kg	ppb	%	per yr	%	%	%	km2	cm	km2
Metro Effluent	91.12	19792	283	217	1%	361	17%	38%	2%			
Metro Bypass	1.80	2048	73	1139	4%	42	0%	4%	0%			
East Flume	0.84	119	8	142	7%	27	0%	0%	0%			
Trib 5A	1.23	136	5	111	4%	27	0%	0%	0%			
Harbor Brook	12.59	1150	153	91	13%	28	2%	2%	1%	31.4	40.2	36.7
Ley Creek	41.36	3591	403	87	11%	26	8%	7%	4%	66.1	62.6	54.3
Ninemile Creek	170.89	9011	724	53	8%	30	31%	17%	12%	298.1	57.3	30.2
Onondaga Creek	188.68	13713	1841	73	13%	27	34%	26%	79%	285.1	66.2	48.1
Nonpoint Gauged	413.53	27465	2025	66	7%	112	75%	53%	96%	680.7	60.8	40.3
Nonpoint Ungauged	28.17	1871	287	66	15%		5%	4%	2%	46.4	60.8	40.3
NonPoint Total	441.69	29335	2045	66	7%	112	80%	57%	98%	727.0	60.8	40.3
Industrial	2.06	255	10	123	4%	54	0%	0%	0%			
Municipal	92.91	21841	292	235	1%	403	17%	42%	2%			
Total External	536.67	51431	2066	96	4%	569	98%	99%	100%	727.0	73.8	70.7
Precipitation	12.72	382	34	30	9%		2%	1%	0%	11.7	108.7	32.6
Total Inflow	549.39	51812	2066	94	4%	569	100%	100%	100%	738.7	74.4	70.1
Evaporation	8.86						2%			11.7	75.7	
Outflow	540.53	30429	896	56	3%		98%	59%	19%	738.7	73.2	41.2
Retention	0.00	21383	2252		11%		0%	41%				
Alternative Estimates of Lake Outflow												
Outlet 12 Feet	540.53	30429	896	56	3%	26	98%	59%	19%	738.7	73.2	41.2
Outlet 2 Feet	540.53	30526	992	56	3%	26	98%	59%	23%	738.7	73.2	41.3
Upstream/Downstream Contrast- Harbor Brook												
Upstream - Velasko	11.00	448	139	41	31%	28	2%	1%		27.0	40.8	16.6
Downstream - Hiawatha	12.59	1150	153	91	13%	28	2%	2%		31.4	40.2	36.7
Local Inflow	1.59	702	206	441	29%		0%	1%		4.4	36.1	159.3
Upstream/Downstream Contrast - Onondaga Creek												
Upstream - Dorwin	146.86	10437	1840	71	18%	46	27%	20%		229.4	64.0	45.5
Downstream - Kirkpatrick	188.68	13713	1841	73	13%	27	34%	26%		285.1	66.2	48.1
Local Inflow	41.82	3276	2603	78	79%		8%	6%		55.7	75.0	58.8
Nonpoint Source Summary - Gauged Watersheds							Percent of Total Gauged Watershed					
Total Watershed	413.53	27465	2025	66	7%		100%	100%		680.69	60.8	40.3
Upper/Rural Watersheds	328.75	19896	1982	61	10%		79%	72%		554.45	59.3	35.9
Lower/Urban Watersheds	84.77	7568	2642	89	35%		21%	28%		126.24	67.2	60.0

Upper Watersheds Ninemile + Onondaga(Dorwin) + Harbor(Velasko) - Primarily Rural / Agric Land Uses
Lower Watersheds Lower Watershed = Ley + Onondaga(Kirkpatrick-Dorwin) + Harbor (Hiawatha - Velasko) - Primarily Urban Land Uses

Lake Overflow Rate 46.20 m/yr Calib. Settling Rate 32.5 m/yr RSE % = Relative Std. Error of Load & Inflow Conc. Estimates
Lake Residence Time 0.24 years Calib. Retention Coef. 41% Error % = Percent of Variance in Total Inflow Load Estimate

Table 5 Soluble Reactive Phosphorus Balance for 2004-2008

Variable: **Soluble Reactive P** **Average for Years: 2004 thru 2008**

							Percent of Total Inflow			Drain.		Export
	Flow	Load	Std Error	Conc	RSE	Sampl	Flow	Load	Error	Area	Runoff	kg /
Term	**10^6 m3**	**kg**	**kg**	**ppb**	**%**	**per yr**	**%**	**%**	**%**	**km2**	**cm**	**km2**
Metro Effluent	91.12	5907	724	65	12%	29	17%	54%	82%			
Metro Bypass	1.80	477	185	265	39%	4	0%	4%	5%			
East Flume	0.84	43	4	51	10%	27	0%	0%	0%			
Trib 5A	1.23	38	2	31	6%	27	0%	0%	0%			
Harbor Brook	12.59	420	42	33	10%	28	2%	4%	0%	31.4	40.2	13.4
Ley Creek	41.36	575	40	14	7%	26	8%	5%	0%	66.1	62.6	8.7
Ninemile Creek	170.89	1473	178	9	12%	30	31%	13%	5%	298.1	57.3	4.9
Onondaga Creek	188.68	1545	213	8	14%	27	34%	14%	7%	285.1	66.2	5.4
Nonpoint Gauged	413.53	4013	284	10	7%	112	75%	37%	13%	680.7	60.8	5.9
Nonpoint Ungauged	28.17	273	41	10	15%		5%	2%	0%	46.4	60.8	5.9
NonPoint Total	441.69	4287	287	10	7%	112	80%	39%	13%	727.0	60.8	5.9
Industrial	2.06	80	5	39	6%	54	0%	1%	0%			
Municipal	92.91	6384	748	69	12%	33	17%	58%	87%			
Total External	536.67	10751	801	20	7%	198	98%	98%	100%	727.0	73.8	14.8
Precipitation	12.72	191	17	15	9%		2%	2%	0%	11.7	108.7	16.3
Total Inflow	549.39	10942	801	20	7%	198	100%	100%	100%	738.7	74.4	14.8
Evaporation	8.86						2%			11.7	75.7	
Outflow	540.53	14909	1484	28	10%		98%	136%	344%	738.7	73.2	20.2
Retention	0.00	-3967	1687		43%		0%	-36%				
Alternative Estimates of Lake Outflow												
Outlet 12 Feet	540.53	14909	1484	28	10%	26	98%	136%	344%	738.7	73.2	20.2
Outlet 2 Feet	540.53	13841	1006	26	7%	26	98%	126%	158%	738.7	73.2	18.7
Upstream/Downstream Contrast- Harbor Brook												
Upstream - Velasko	11.00	116	17	11	15%	28	2%	1%		27.0	40.8	4.3
Downstream - Hiawatha	12.59	420	42	33	10%	28	2%	4%		31.4	40.2	13.4
Local Inflow	1.59	304	46	191	15%		0%	3%		4.4	36.1	69.0
Upstream/Downstream Contrast - Onondaga Creek												
Upstream - Dorwin	146.86	845	112	6	13%	34	27%	8%		229.4	64.0	3.7
Downstream - Kirkpatrick	188.68	1545	213	8	14%	27	34%	14%		285.1	66.2	5.4
Local Inflow	41.82	700	241	17	34%		8%	6%		55.7	75.0	12.6
Nonpoint Source Summary - Gauged Watersheds							Percent of Total Gauged Watershed					
Total Watershed	413.53	4013	284	10	7%		100%	100%		680.69	60.8	5.9
Upper/Rural Watersheds	328.75	2434	211	7	9%		79%	61%		554.45	59.3	4.4
Lower/Urban Watersheds	84.77	1579	248	19	16%		21%	39%		126.24	67.2	12.5

Upper Watersheds: Ninemile + Onondaga(Dorwin) + Harbor(Velasko) - Primarily Rural / Agric Land Uses

Lower Watersheds: Lower Watershed = Ley + Onondaga(Kirkpatrick-Dorwin) + Harbor (Hiawatha - Velasko) - Primarily Urban Land Uses

Lake Overflow Rate	46.20 m/yr	Calib. Settling Rate	-12.3 m/yr
Lake Residence Time	0.24 years	Calib. Retention Coef.	-36%

RSE % = Relative Std. Error of Load & Inflow Conc. Estimates

Error % = Percent of Variance in Total Inflow Load Estimate

Table 6 Average Loads by Source & Constituent, 2004-2008

Summary of Point & NonPoint Source Loads For Various Constituents Period: 2004 thru 2008

	Flow	Total Phosphorus	Total Dissolved P	Soluble Reactive P	Total Nitrogen	Total Kjeldahl N	Ammonia Nitrogen	Nitrate Nitrogen	Nitrite Nitrogen	5-Day BOD	Total Org Carbon	Filtered Total Org C	Calcium	Chloride	Sodium
Annual Loads	hm3	kg	kg	kg	kg	kg	kg	kg	kg	mt	mt	mt	mt	mt	mt
Ley	41.4	3591	1012	575	50627	32841	11229	16997	790	132	290	265	4329	14261	8618
Ninemile	170.9	9011	3282	1473	270300	100795	37217	166027	3478	378	548	487	31909	49409	17365
Harbor - Upper	11.0	448	176	116	22934	4304	508	18486	144	25	26	22	2253	2562	1433
Harbor - Lower	1.6	702	327	304	2978	1926	452	1004	48	7	8	8	222	735	440
Harbor - Total	12.6	1150	503	420	25912	6230	960	19490	192	32	34	30	2475	3297	1874
Onondaga - Upper	146.9	10437	1665	845	235229	68349	7169	144181	4304	317	422	382	11982	15853	10028
Onondaga - Lower	41.8	3276	1146	700	46441	20980	6658	43160	697	117	133	114	8904	72171	45025
Onondaga - Total	188.7	13713	2812	1545	281670	89329	13828	187341	5000	435	555	497	20886	88024	55053
Total Nonpoint Gauged	413.5	27465	7609	4013	628510	229195	63233	389854	9460	977	1426	1279	59599	154991	82909
Rural Watersheds	328.8	19896	5124	2434	528463	173448	44894	328694	7926	721	995	891	46144	67824	28826
Urban Watersheds	84.8	7568	2485	1579	100047	55747	18339	61161	1534	256	431	387	13455	87167	54083
Ungauged	28.2	1871	518	273	42809	15611	4307	26554	644	67	97	87	4059	10557	5647
Total NonPoint	441.7	29335	8127	4287	671319	244806	67540	416408	10105	1044	1524	1366	63658	165548	88556
Total Industrial	2.1	255	111	80	6546	1582	579	4138	779	7	10	9	270	868	545
Metro STP	91.1	19792	9268	5907	1124192	170619	72755	944847	8727	501	727	637	12528	40679	23832
Bypass	1.8	2048	682	477	20072	16875	9452	2994	203	89	27	21	180	671	424
Total Municipal	92.9	21841	9951	6384	1144265	187493	82208	947842	8930	590	754	658	12709	41350	24255
Precipitation	12.7	382	254	191	24164	12718	1272	10175	1272	0	13	13	64	13	13
Total Inflow	549.4	51812	18443	10942	1846294	446599	151599	1378562	21086	1641	2300	2045	76700	207778	113369
Total Outflow	540.5	30429	20424	14909	1373248	370179	141777	980699	22369	1147	2041	1881	70917	208508	113710
Retention	0.0	21383	-1981	-3967	473046	76420	9822	397863	-1283	494	260	164	5784	-729	-341
Unit Area Loads	cm	kg /km2	kg /km2	kg /km2	kg/km2	kg/km2	kg/km2	kg /km2	kg /km2	mt/km2	mt/km2	mt/km2	mt/km2	mt/km2	mt/km2
Ley	63	54.3	15.3	8.7	765.9	496.8	169.9	257.1	12.0	2.0	4.4	4.0	65.5	215.8	130.4
Ninemile	57	30.2	11.0	4.9	906.8	338.1	124.9	557.0	11.7	1.3	1.8	1.6	107.0	165.8	58.3
Harbor - Upper	41	16.6	6.5	4.3	850.7	159.7	18.8	685.7	5.4	0.9	1.0	0.8	83.6	95.0	53.2
Harbor - Lower	36	159.3	74.1	69.0	675.9	437.1	102.7	227.9	10.9	1.6	1.9	1.9	50.4	166.8	99.9
Harbor - Total	40	36.7	16.0	13.4	826.2	198.6	30.6	621.4	6.1	1.0	1.1	1.0	78.9	105.1	59.7
Onondaga - Upper	64	45.5	7.3	3.7	1025.4	297.9	31.3	628.5	18.8	1.4	1.8	1.7	52.2	69.1	43.7
Onondaga - Lower	75	58.8	20.6	12.6	833.3	376.5	119.5	774.4	12.5	2.1	2.4	2.1	159.8	1295.0	807.9
Onondaga - Total	66	48.1	9.9	5.4	987.9	313.3	48.5	657.0	17.5	1.5	1.9	1.7	73.2	308.7	193.1
Total Nonpoint Gauged	61	40.3	11.2	5.9	923.3	336.7	92.9	572.7	13.9	1.4	2.1	1.9	87.6	227.7	121.8
Rural Watersheds	59	35.9	9.2	4.4	953.1	312.8	81.0	592.8	14.3	1.3	1.8	1.6	83.2	122.3	52.0
Urban Watersheds	67	60.0	19.7	12.5	792.5	441.6	145.3	484.5	12.2	2.0	3.4	3.1	106.6	690.5	428.4
Percent of Total Gauged NonPoint Load															
Ley	10%	13%	13%	14%	8%	14%	18%	4%	8%	14%	20%	21%	7%	9%	10%
Ninemile	41%	33%	43%	37%	43%	44%	59%	43%	37%	39%	38%	38%	54%	32%	21%
Harbor - Upper	3%	2%	2%	3%	4%	2%	1%	5%	2%	3%	2%	2%	4%	2%	2%
Harbor - Lower	0%	3%	4%	8%	0%	1%	1%	0%	1%	1%	1%	1%	0%	0%	1%
Harbor - Total	3%	4%	7%	10%	4%	3%	2%	5%	2%	3%	2%	2%	4%	2%	2%
Onondaga - Upper	36%	38%	22%	21%	37%	30%	11%	37%	45%	32%	30%	30%	20%	10%	12%
Onondaga - Lower	10%	12%	15%	17%	7%	9%	11%	11%	7%	12%	9%	9%	15%	47%	54%
Onondaga - Total	46%	50%	37%	38%	45%	39%	22%	48%	53%	44%	39%	39%	35%	57%	66%
Total Nonpoint Gauged		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Rural Watersheds	79%	72%	67%	61%	84%	76%	71%	84%	84%	74%	70%	70%	77%	44%	35%
Urban Watersheds	21%	28%	33%	39%	16%	24%	29%	16%	16%	26%	30%	30%	23%	56%	65%
FWM Concentrations		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppm	ppm	ppm	ppm	ppm
Ley	-	87	24	14	1224	794	271	411	19	3	7	6	105	345	208
Ninemile	-	53	19	9	1582	590	218	972	20	2	3	3	187	289	102
Harbor - Upper	-	41	16	11	2084	391	46	1680	13	2	2	2	205	233	130
Harbor - Lower	-	441	205	191	1871	1210	284	631	30	4	5	5	140	462	277
Harbor - Total	-	91	40	33	2057	495	76	1547	15	3	3	2	197	262	149
Onondaga - Upper	-	71	11	6	1602	465	49	982	29	2	3	3	82	108	68
Onondaga - Lower	-	78	27	17	1110	502	159	1033	17	3	3	3	213	1726	1077
Onondaga - Total	-	73	15	8	1493	473	73	993	27	2	3	3	111	467	292
Total Nonpoint Gauged	-	66	18	10	1520	554	153	943	23	2	3	3	144	375	200
Rural Watersheds	-	61	16	7	1607	528	137	1000	24	2	3	3	140	206	88
Urban Watersheds	-	89	29	19	1180	658	216	722	18	3	5	5	159	1028	638
Ungauged	-	66	18	10	1520	554	153	943	23	2	3	3	144	375	200
Total NonPoint	-	66	18	10	1520	554	153	943	23	2	3	3	144	375	200
Total Industrial	-	123	54	39	3170	766	280	2004	377	3	5	4	131	420	264
Metro STP	-	217	102	65	12338	1873	798	10370	96	6	8	7	137	446	262
Bypass	-	1139	380	265	11164	9386	5257	1666	113	50	15	11	100	373	236
Total Municipal	-	235	107	69	12315	2018	885	10201	96	6	8	7	137	445	261
Precipitation	-	30	20	15	1900	1000	100	800	100	0	1	1	5	1	1
Total Inflow	-	94	34	20	3361	813	276	2509	38	3	4	4	140	378	206
Total Outflow	-	56	38	28	2541	685	262	1814	41	2	4	3	131	386	210

Table 7 Total Phosphorus Balance for 1999-2008

Variable: **Total Phosphorus** **Average for Years:** **1999** **thru** **2008**

Term	**Flow 10^6 m3**	**Load kg**	**Std Error kg**	**Conc ppb**	**RSE %**	**Sampl per yr**	**Percent of Total Inflow: Flow %**	**Percent of Total Inflow: Load %**	**Percent of Total Inflow: Error %**	**Drain. Area km2**	**Runoff cm**	**Export kg / km2**
Metro Effluent	90.14	24185	206	268	1%	363	18%	45%	3%			
Metro Bypass	2.00	2230	53	1116	2%	45	0%	4%	0%			
East Flume	0.65	99	5	153	5%	27	0%	0%	0%			
Trib 5A	1.91	245	6	129	3%	27	0%	0%	0%			
Harbor Brook	10.79	961	92	89	10%	30	2%	2%	1%	31.4	34.4	30.6
Ley Creek	39.02	3542	279	91	8%	30	8%	7%	5%	66.1	59.0	53.6
Ninemile Creek	149.89	8288	416	55	5%	30	30%	15%	12%	298.1	50.3	27.8
Onondaga Creek	169.39	12086	1051	71	9%	32	34%	23%	77%	285.1	59.4	42.4
Nonpoint Gauged	369.09	24877	1168	67	5%	123	74%	46%	95%	680.7	54.2	36.5
Nonpoint Ungauged	25.14	1694	181	67	11%		5%	3%	2%	46.4	54.2	36.5
NonPoint Total	394.23	26571	1182	67	4%	123	79%	49%	97%	727.0	54.2	36.5
Industrial	2.56	345	8	135	2%	55	1%	1%	0%			
Municipal	92.14	26415	213	287	1%	408	18%	49%	3%			
Total External	488.93	53331	1201	109	2%	585	98%	99%	100%	727.0	67.2	73.4
Precipitation	11.70	351	22	30	6%		2%	1%	0%	11.7	100.0	30.0
Total Inflow	500.63	53682	1201	107	2%	585	100%	100%	100%	738.7	67.8	72.7
Evaporation	8.86						2%			11.7	75.7	
Outflow	491.77	33680	712	68	2%		98%	63%	35%	738.7	66.6	45.6
Retention	0.00	20002	1396		7%		0%	37%				
Alternative Estimates of Lake Outflow												
Outlet 12 Feet	491.77	33680	712	68	2%	26	98%	63%	35%	738.7	66.6	45.6
Outlet 2 Feet	491.77	32493	741	66	2%	26	98%	61%	38%	738.7	66.6	44.0
Upstream/Downstream Contrast- Harbor Brook												
Upstream - Velasko	9.74	400	91	41	23%	30	2%	1%		27.0	36.1	14.8
Downstream - Hiawatha	10.79	961	92	89	10%	30	2%	2%		31.4	34.4	30.6
Local Inflow	1.05	561	129	535	23%		0%	1%		4.4	23.8	127.2
Upstream/Downstream Contrast - Onondaga Creek												
Upstream - Dorwin	131.65	8759	962	67	11%	41	26%	16%		229.4	57.4	38.2
Downstream - Kirkpatrick	169.39	12086	1051	71	9%	32	34%	23%		285.1	59.4	42.4
Local Inflow	37.74	3327	1425	88	43%		8%	6%		55.7	67.7	59.7
Nonpoint Source Summary - Gauged Watersheds							Percent of Total Gauged Watershed					
Total Watershed	369.09	24877	1168	67	5%		100%	100%		680.69	54.2	36.5
Upper/Rural Watersheds	291.29	17447	1052	60	6%		79%	70%		554.45	52.5	31.5
Lower/Urban Watersheds	77.81	7430	1457	95	20%		21%	30%		126.24	61.6	58.9

Upper Watersheds Ninemile + Onondaga(Dorwin) + Harbor(Velasko) - Primarily Rural / Agric Land Uses
Lower Watersheds Lower Watershed = Ley + Onondaga(Kirkpatrick-Dorwin) + Harbor (Hiawatha - Velasko) - Primarily Urban Land Uses

Lake Overflow Rate	42.03 m/yr	Calib. Settling Rate	25.0 m/yr	RSE % = Relative Std. Error of Load & Inflow Conc. Estimates
Lake Residence Time	0.26 years	Calib. Retention Coef.	37%	Error % = Percent of Variance in Total Inflow Load Estimate

Table 8 Total Phosphorus Balance for 2006-2008

Variable: **Total Phosphorus** **Average for Years: 2006 thru 2008**

Term	Flow 10^6 m3	Load kg	Std Error kg	Conc ppb	RSE %	Sampl per yr	Percent of Total Inflow Flow %	Load %	Error %	Drain. Area km2	Runoff cm	Export kg / km2
Metro Effluent	86.83	9599	182	111	2%	362	16%	23%	0%			
Metro Bypass	1.36	1692	72	1244	4%	47	0%	4%	0%			
East Flume	0.77	103	10	134	10%	26	0%	0%	0%			
Trib 5A	0.80	87	4	108	5%	27	0%	0%	0%			
Harbor Brook	12.81	1292	212	101	16%	28	2%	3%	1%	31.4	40.9	41.2
Ley Creek	40.85	3405	505	83	15%	26	8%	8%	3%	66.1	61.8	51.5
Ninemile Creek	167.63	8996	1007	54	11%	32	31%	22%	14%	298.1	56.2	30.2
Onondaga Creek	184.93	13629	2425	74	18%	27	34%	33%	80%	285.1	64.9	47.8
Nonpoint Gauged	406.22	27322	2682	67	10%	113	76%	67%	98%	680.7	59.7	40.1
Nonpoint Ungauged	27.67	1861	371	67	20%		5%	5%	2%	46.4	59.7	40.1
NonPoint Total	433.89	29183	2708	67	9%	113	81%	71%	99%	727.0	59.7	40.1
Industrial	1.57	190	11	121	6%	53	0%	0%	0%			
Municipal	88.19	11291	195	128	2%	409	16%	28%	1%			
Total External	523.64	40664	2715	78	7%	575	98%	99%	100%	727.0	72.0	55.9
Precipitation	12.95	388	45	30	12%		2%	1%	0%	11.7	110.7	33.2
Total Inflow	536.59	41053	2715	77	7%	575	100%	100%	100%	738.7	72.6	55.6
Evaporation	8.86						2%			11.7	75.7	
Outflow	527.74	20381	784	39	4%		98%	50%	8%	738.7	71.4	27.6
Retention	0.00	20672	2826		14%		0%	50%				
Alternative Estimates of Lake Outflow												
Outlet 12 Feet	527.74	20381	784	39	4%	26	98%	50%	8%	738.7	71.4	27.6
Outlet 2 Feet	527.74	22009	937	42	4%	26	98%	54%	12%	738.7	71.4	29.8
Upstream/Downstream Contrast- Harbor Brook												
Upstream - Velasko	10.69	416	152	39	36%	28	2%	1%		27.0	39.7	15.4
Downstream - Hiawatha	12.81	1292	212	101	16%	28	2%	3%		31.4	40.9	41.2
Local Inflow	2.13	876	260	412	30%		0%	2%		4.4	48.2	198.7
Upstream/Downstream Contrast - Onondaga Creek												
Upstream - Dorwin	144.40	10095	1975	70	20%	55	27%	25%		229.4	62.9	44.0
Downstream - Kirkpatrick	184.93	13629	2425	74	18%	27	34%	33%		285.1	64.9	47.8
Local Inflow	40.53	3534	3128	87	88%		8%	9%		55.7	72.7	63.4
Nonpoint Source Summary - Gauged Watersheds							Percent of Total Gauged Watershed					
Total Watershed	406.22	27322	2682	67	10%		100%	100%		680.69	59.7	40.1
Upper/Rural Watersheds	322.72	19507	2222	60	11%		79%	71%		554.45	58.2	35.2
Lower/Urban Watersheds	83.50	7815	3179	94	41%		21%	29%		126.24	66.1	61.9

Upper Watersheds: Ninemile + Onondaga(Dorwin) + Harbor(Velasko) - Primarily Rural / Agric Land Uses
Lower Watersheds: Lower Watershed = Ley + Onondaga(Kirkpatrick-Dorwin) + Harbor (Hiawatha - Velasko) - Primarily Urban Land Uses

Lake Overflow Rate	45.11 m/yr	Calib. Settling Rate	45.7 m/yr	RSE % = Relative Std. Error of Load & Inflow Conc. Estimates
Lake Residence Time	0.24 years	Calib. Retention Coef.	50%	Error % = Percent of Variance in Total Inflow Load Estimate

Table 9 Trends in Loads, 1999-2008

Load Trends (% / yr) 1999 to 2008 Precip Trend = 3.1 +/- 0.8 cm/yr

Term	FLOW	TP	TDP	SRP	TN	TKN	NH3N	NO2N	NO3N	TOC	TOC_F	TIC	SIO2	ALK	CA	CL	NA	TSS	BOD5
Metro		-14	-18	-34		-24	-34	-27	14	-5	-5				3	5	4	-7	-15
Bypass					-8				-10										
E Flume	11				8			7	11	8	8	12	9	11	13	13	13	12	12
Trib5A	-17	-21	-22	-28	-21	-17	-18	-15	-23	-14	-14	-15	-15	-14	-17	-19	-19		-12
Harbor/Velasko	5			9	4		-6	5	5			5	5	6	5	6	7		5
Harbor/Lower	36	11	58	18	28				60	14	15	18	13	17	30	9	8	39	
Harbor/Hiawatha	7	7	12	16	6		-4	5	7			6	7	7	6	7	7		7
Onondaga/Dorwin	5	7		11	5	5		10				5	6	5	6	2	3	13	6
Onondaga/Lower	3					-4						4	4	4	5	5	6		
Onond./Kirkpatrick	4	4		6	4		-4	7	5			5	5	5	6	5	5	8	
Ley/Park	3												4	3	4	5	6		6
Ninemile/Rt48	6	4		9							6	6	6	6					7
NonPoint Gauged	5	3		7				4	5			5	5	5	4	3	4	6	5
Total Gauged	4					-13	-23	-14	10			4	4	4	3	3	4	5	
Total NonPoint	5	3		7				4	5			5	5	5	4	3	4	6	5
Total Industrial	-9	-12	-13	-18		-7	-8			-7	-7	-8	-7	-7	-10	-9			
Total Municipal		-13	-16	-25		-23	-32	-27	14	-6	-5				3	5	3	-6	-14
Total Inflow	4					-13	-23	-13	10			4	4	4	3	3	4	5	
NonPoint_Rural	5	5		10				6				5	6	6	3			9	6
NonPoint_Urban	3											4	4	4	5	5	5		
Outlet2	4		-9	-11		-8	-16	-7	9			5	10	5	4	3	4	9	
Outlet12	4	-7	-11	-14		-10	-18	-8	8			4	10	5	3	2	3	9	

Load Trends (% / yr), Adjusted for Variations in Rainfall

Term	FLOW	TP	TDP	SRP	TN	TKN	NH3N	NO2N	NO3N	TOC	TOC_F	TIC	SIO2	ALK	CA	CL	NA	TSS	BOD5
Metro		-19	-26			-25	-39	-36		-7	-6			-5		6	6		-17
Bypass																			
E Flume																			10
Trib5A	-17	-19	-22	-26	-18	-17	-20		-19	-15	-15	-16	-15	-16	-18	-21	-20		
Harbor/Velasko							-10									6	7		
Harbor/Lower		17		19	54				58	19	17	25		21					23
Harbor/Hiawatha	5	8	9	14				8								6	7		6
Onondaga/Dorwin																			
Onondaga/Lower			9													5	5		
Onond./Kirkpatrick				7			-7									4	4		
Ley/Park			-8			-6													
Ninemile/Rt48																			
NonPoint Gauged							-5									3	3		
Total Gauged						-15	-25	-17								3	4		
Total NonPoint							-5									3	3		
Total Industrial		-14	-16	-20		-10	-13					-10		-9	-12				
Total Municipal		-17	-23			-24	-36	-35		-7	-6			-5		6	6		-15
Total Inflow						-14	-25	-16								3	4		
NonPoint_Rural																			
NonPoint_Urban						-5										5	5		
Outlet2		-11	-15	-19		-11	-17	-12					11						
Outlet12		-13	-17	-21		-12	-17	-12					12						

NonPoint_Rural = Ninemile + Harbor (Velasko) + Onondaga (Dorwin)

NonPoint_Urban = Harbor (Hiawatha - Velasko) + Onondaga (Kirkpatrick- Dorwin) + Ley

Based upon linear regression of annual values; trend magnitudes shown for significance level $p < 0.1$, two-tailed test.

Trend tests at sites in low concentration range influenced by variations in detection limits (NH3-N, NO2 N, TSS, BOD5)

Table 10 Trends in Flow-Weighted-Mean Concentration, 1999-2008

Concentration Trends (% / Yr)

Precip Trend = 3.1 +/- 0.8 cm/yr

Term	TP	TDP	SRP	TN	TKN	NH3N	NO2N	NO3N	TOC	TOC_F	TIC	SIO2	ALK	CA	CL	NA	TSS	BOD5
Metro	-14	-19	-34		-24	-34	-28	14	-6	-5		1	-2	3	5	4	-7	-15
Bypass			17	-4	-3	-3		-6										
E Flume	-5	-10	-10	-3	-8	-12			-3	-3						2		
Trib5A	-4	-6	-12	-4				-7			2	2	2		-3	-3	12	4
Harbor/Velasko						-10							1			2		
Harbor/Lower	-25		-18		-31	-40		24	-22	-21	-18	-23	-19		-27	-28		-25
Harbor/Hiawatha		5	9		-4	-11								-1				
Onondaga/Dorwin			6			-8								1	-2	-2	8	
Onondaga/Lower					-7	-8								2				
Onond./Kirkpatrick		-5			-2	-9								1				
Ley/Park		-7	-3	-3	-4	-6	-6							1				
Ninemile/Rt48	-2		4	-2	-3	-7	-4							-4	-6	-5		1
NonPoint Gauged			2		-3	-7								-1				
Total Gauged	-7	-10		-3	-17	-27	-18	7	-4	-4								-8
Total NonPoint			2		-3	-7								-1				
Total Industrial	-3	-4	-9	5			14	4			1	2	2			4	9	5
Total Municipal	-13	-16	-25		-23	-32	-27	14	-6	-5		1	-2	3	5	3	-6	-14
Total Inflow	-7	-10		-3	-17	-26	-17	6	-4	-3								-8
NonPoint_Rural			5		-2	-7								-2	-5	-3		1
NonPoint_Urban				-2	-5	-7								1				
Outlet2	-9	-12	-14	-2	-12	-19	-11	5	-3	-3		6	1		-1		5	-3
Outlet12	-11	-15	-18	-3	-14	-22	-11	5	-3	-3		7	1		-2		5	-3

Concentration Trends, Adjusted for Variations in Rainfall (%/Yr)

Term	TP	TDP	SRP	TN	TKN	NH3N	NO2N	NO3N	TOC	TOC_F	TIC	SIO2	ALK	CA	CL	NA	TSS	BOD5
Metro	-19	-25			-25	-39	-35		-6	-5	-4		-5	2	7	7		-17
Bypass				-4				-9				-8	-4					
E Flume	-8	-11	-12	-6	-10	-14		-5	-5	-5								
Trib5A			-10												-4	-3	13	4
Harbor/Velasko						-12									4	5		
Harbor/Lower								29										
Harbor/Hiawatha		5	10			-7					-2							
Onondaga/Dorwin						-8					-1		-1					
Onondaga/Lower		11												4	7	7		
Onond./Kirkpatrick			7			-7					-1				4			
Ley/Park		-7		-4	-6	-4			-4	-4					6	6		
Ninemile/Rt48					-4	-6									-3			
NonPoint Gauged			4		-3	-5												
Total Gauged	-7				-15	-26	-18	9	-5	-4	-1		-1		3	4		-7
Total NonPoint			4		-3	-5												
Total Industrial	-4	-6	-10											-2		3	9	5
Total Municipal	-16	-22			-23	-35	-34		-6	-5	-4		-5	2	7	7		-14
Total Inflow	-7				-15	-25	-16	9		-4	-1		-1		3	4		-7
NonPoint_Rural						-6									-2			
NonPoint_Urban		3	6		-4									2	6	6		
Outlet2	-11	-16	-20	-2	-11	-18	-12		-4	-4		10					4	-4
Outlet12	-14	-18	-21		-13	-17	-12		-5	-4		11						-4

NonPoint_Rural = Ninemile + Harbor (Velasko) + Onondaga (Dorwin)

NonPoint_Urban = Harbor (Hiawatha - Velasko) + Onondaga (Kirkpatrick- Dorwin) + Ley

Based upon linear regression of annual values; trend magnitudes shown for significance level $p < 0.1$, two-tailed test.

Trend tests at sites in low concentration range influenced by variations in detection limits (NH3-N, NO2 N, TSS, BOD5)

Table 11 Trends in Load Expressed in Mass Units Per Year, 1999-2008

Term	FLOW	TP	TDP	SRP	TN	TKN	NH3N	NO2N	NO3N	TOC	TOC_F	TIC	SIO2	ALK	CA	CL	NA	TSS	BOD5
Units	hm^3	kg	kg	kg	kg	kg	kg	kg	kg	mt	mt	mt	mt	mt	mt	mt	mt	mt	mt
Metro		-4675	-2700			-109874	-108611	-7523		-56	-43			-871		2375	1368		-148
Bypass																			
E Flume																			0
Trib5A	0	-46	-23	-25	-536	-160	-62		-370	-1	-1	-12	-2	-45	-47	-154	-72		
Harbor/Velasko							-55									143	89		
Harbor/Lower		95		45	1150				344	1	1	13		44					1
Harbor/Hiawatha	1	82	37	46				13								177	113		2
Onondaga/Dorwin																			
Onondaga/Lower			102													3342	2073		
Onond./Kirkpatrick				97			-1043									3456	2061		
Ley/Park			-84			-2075													
Ninemile/Rt48																			
NonPoint Gauged							-3117									3748	2577		
Total Gauged						-100721	-89694	-5205								6165	3962		
Total NonPoint							-3329									4003	2753		
Total Industrial		-48	-26	-26		-188	-86					-10		-37	-39				
Total Municipal		-4499	-2501			-108321	-102660	-7480		-61	-47			-900		2367	1364		-145
Total Inflow						-100286	-89148	-5072								6423	4138		
NonPoint_Rural																			
NonPoint_Urban						-2908										4171	2568		
Outlet2		-3498	-3392	-2982		-51805	-41746	-2887					166						
Outlet12		-4392	-4132	-3667		-61741	-46319	-3137					185						

NonPoint_Rural = Ninemile + Harbor (Velasko) + Onondaga (Dorwin)

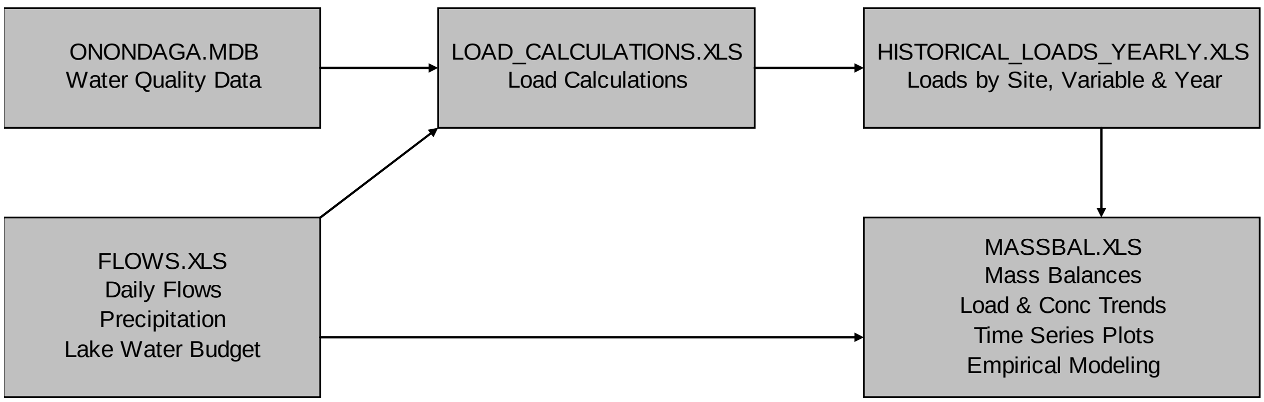
NonPoint_Urban = Harbor (Hiawatha - Velasko) + Onondaga (Kirkpatrick- Dorwin) + Ley

Based upon linear regression of annual values, adjusted for variations in rainfall; trend magnitudes shown for significance level $p < 0.1$, two-tailed test.

Trend tests at sites in low concentration range influenced by variations in detection limits (NH3-N, NO2 N, TSS, BOD5)

List of Figures

Figure 1
Mass Balance Computations Integrated with AMP Long-Term Database



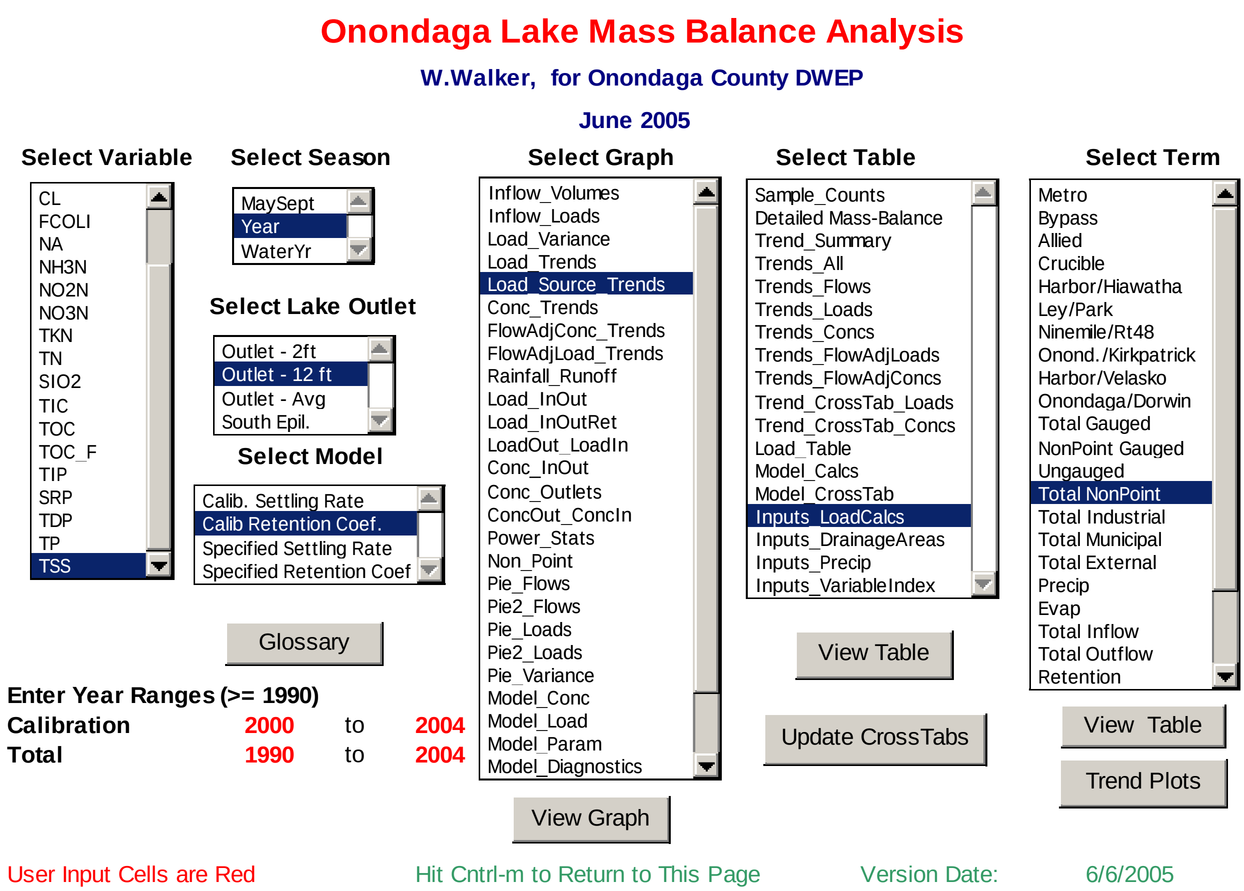
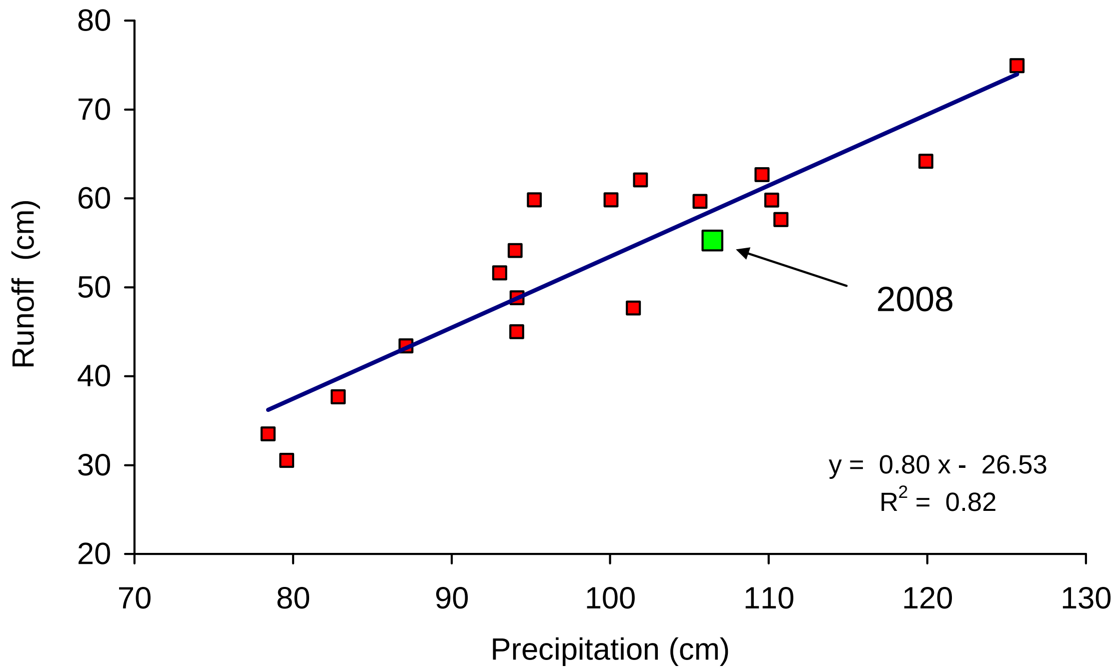
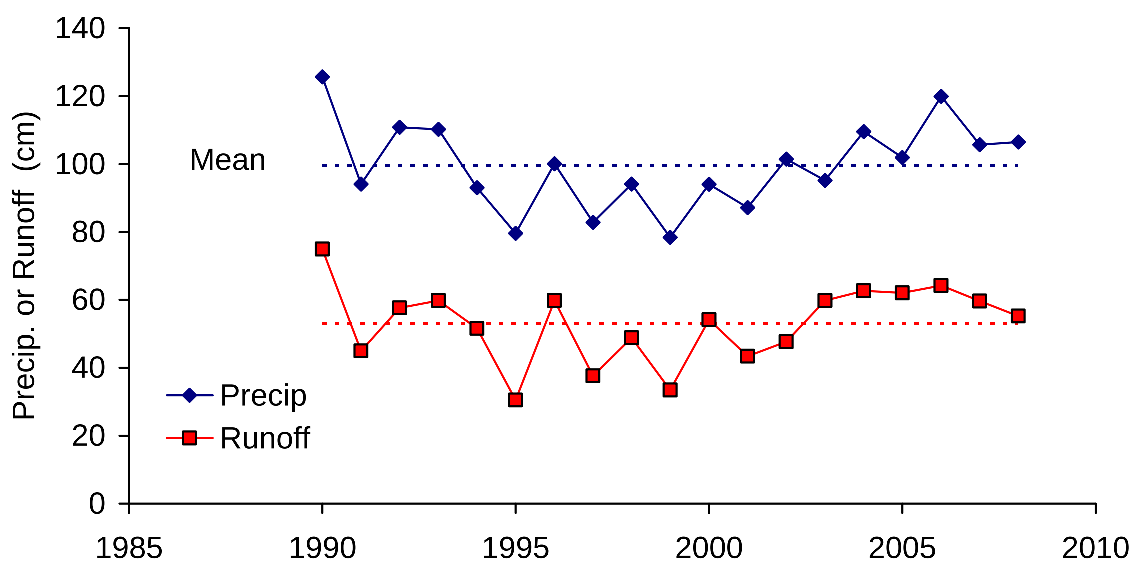


Figure 2
Precipitation and Runoff, 1990-2008





Summary Statistics	1990-2008 Mean	1990-2008 Min	1990-2008 Max	2008 Mean	2008 Percentile
Precipitation (cm)	99	78	126	106	70%
Runoff (cm)	53	31	75	55	50%

Figure 3

Long-Term Variations in Total Inflow & Outflow Concentrations

Squares = Inflow, Circles = Outflow   Error Bars = +/- 1 Standard Error   X-Axis = Calendar Year

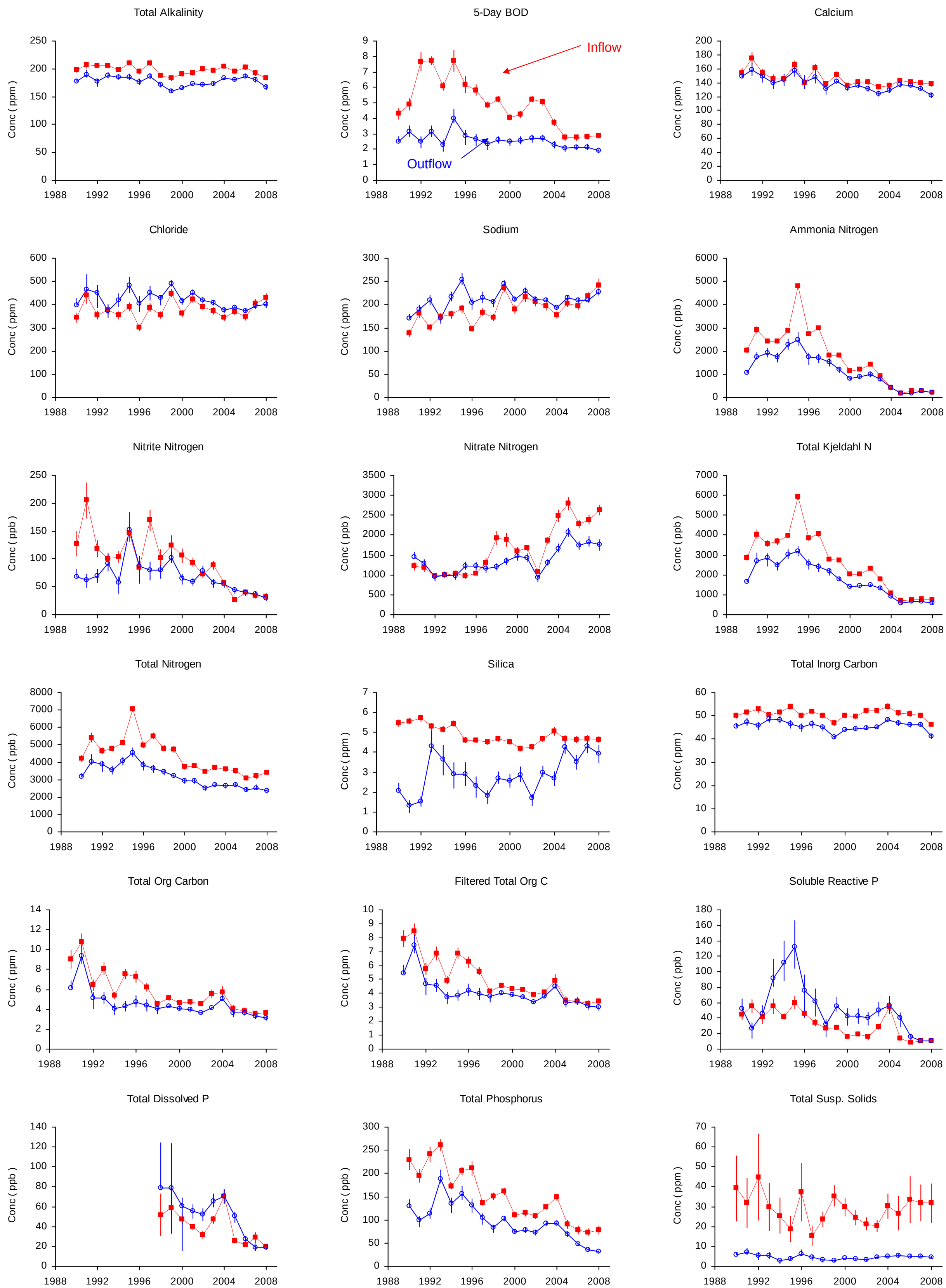


Figure 4
Long-Term Variations in Total Inflow & Outflow Loads

Squares = Inflow, Circles = Outflow   Error Bars = +/- 1 Standard Error   X-Axis = Calendar Year

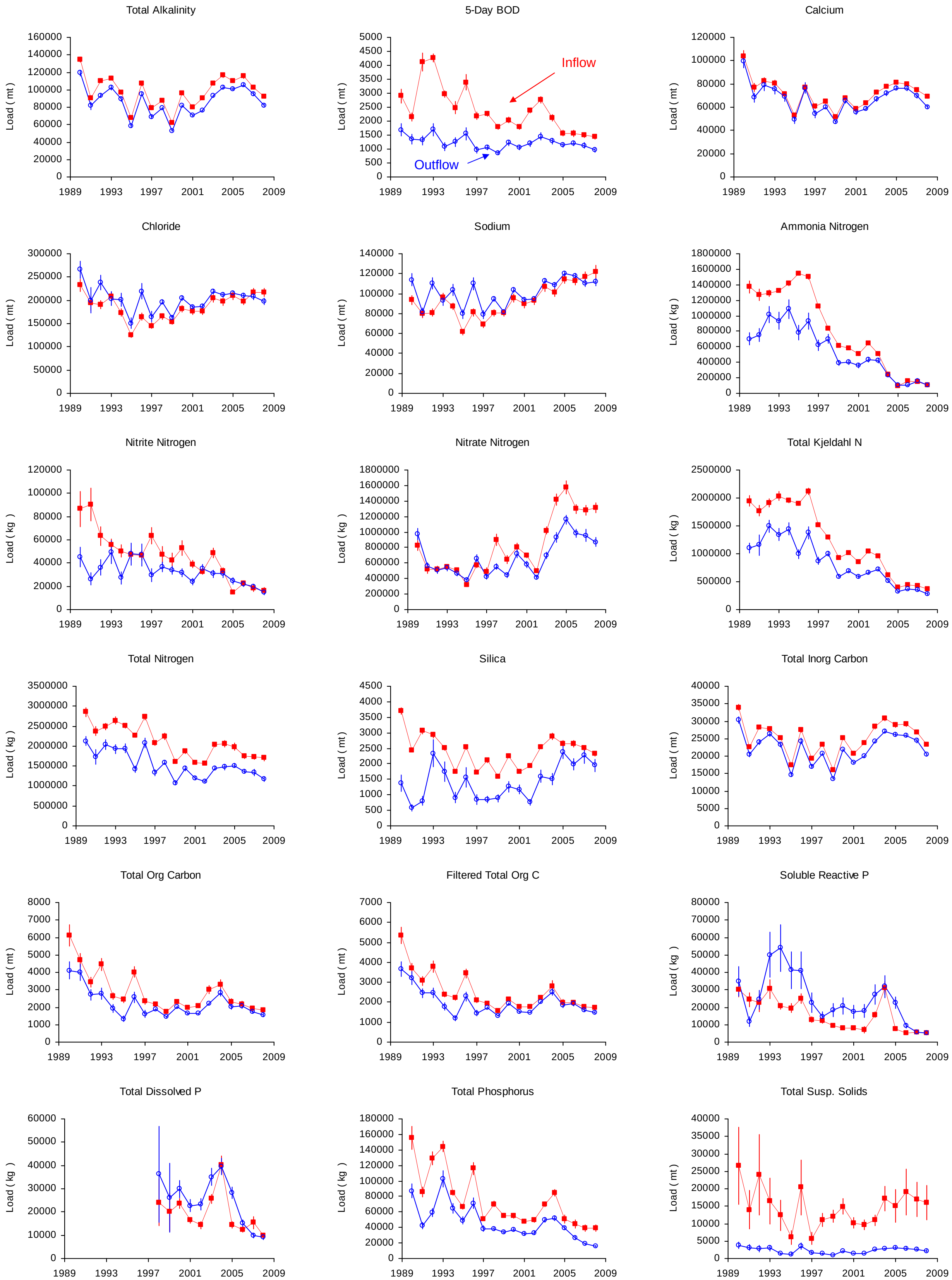


Figure 5

Long-Term Variations in NonPoint & Metro Loads

Squares = NonPoint Sources, Circles = Metro + Bypass   Error Bars = +/- 1 Standard Error   X-Axis = Calendar Year

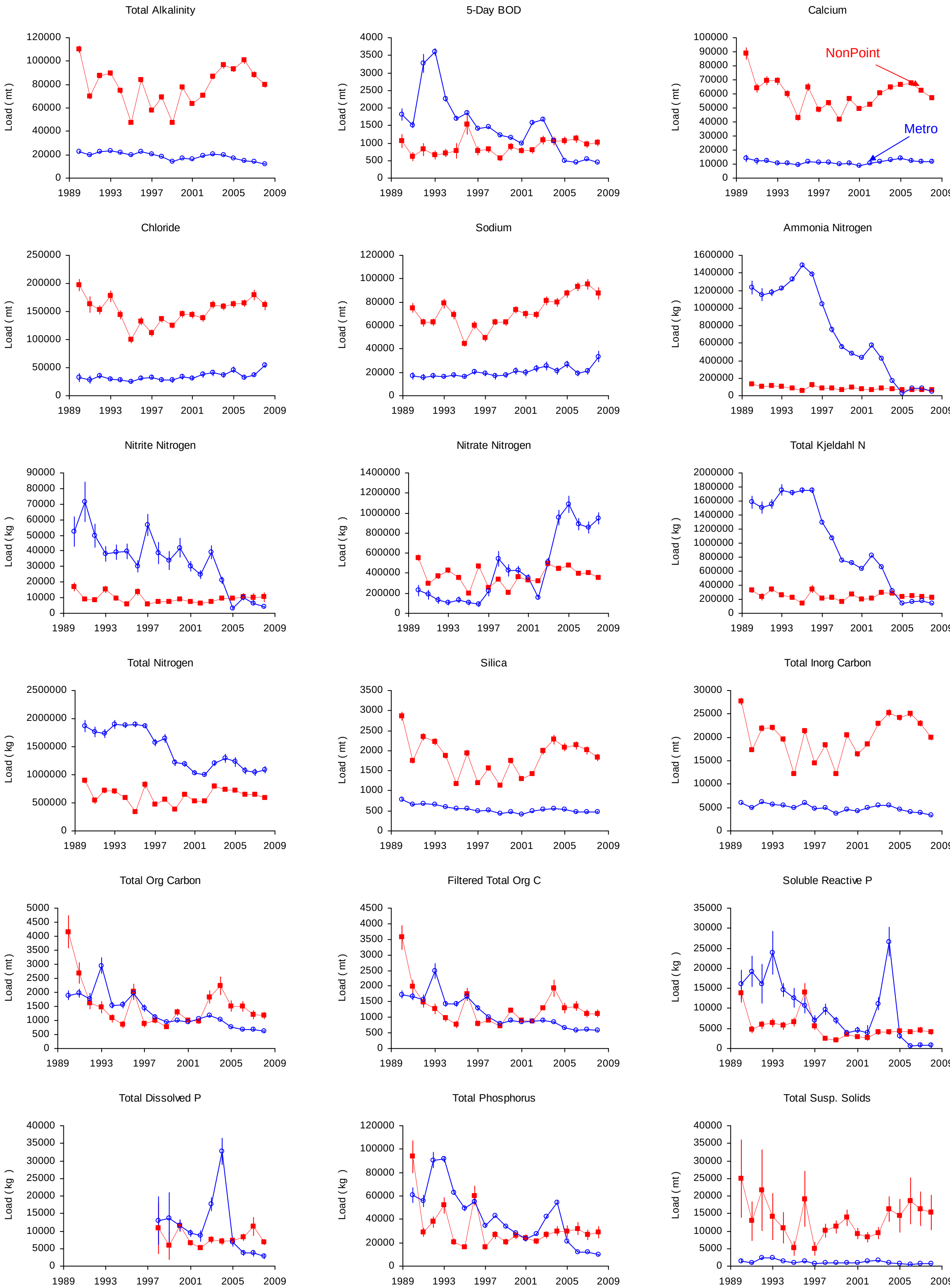


Figure 6 Trends in Rainfall-Adjusted NonPoint Loads by Variable, 1990-2008

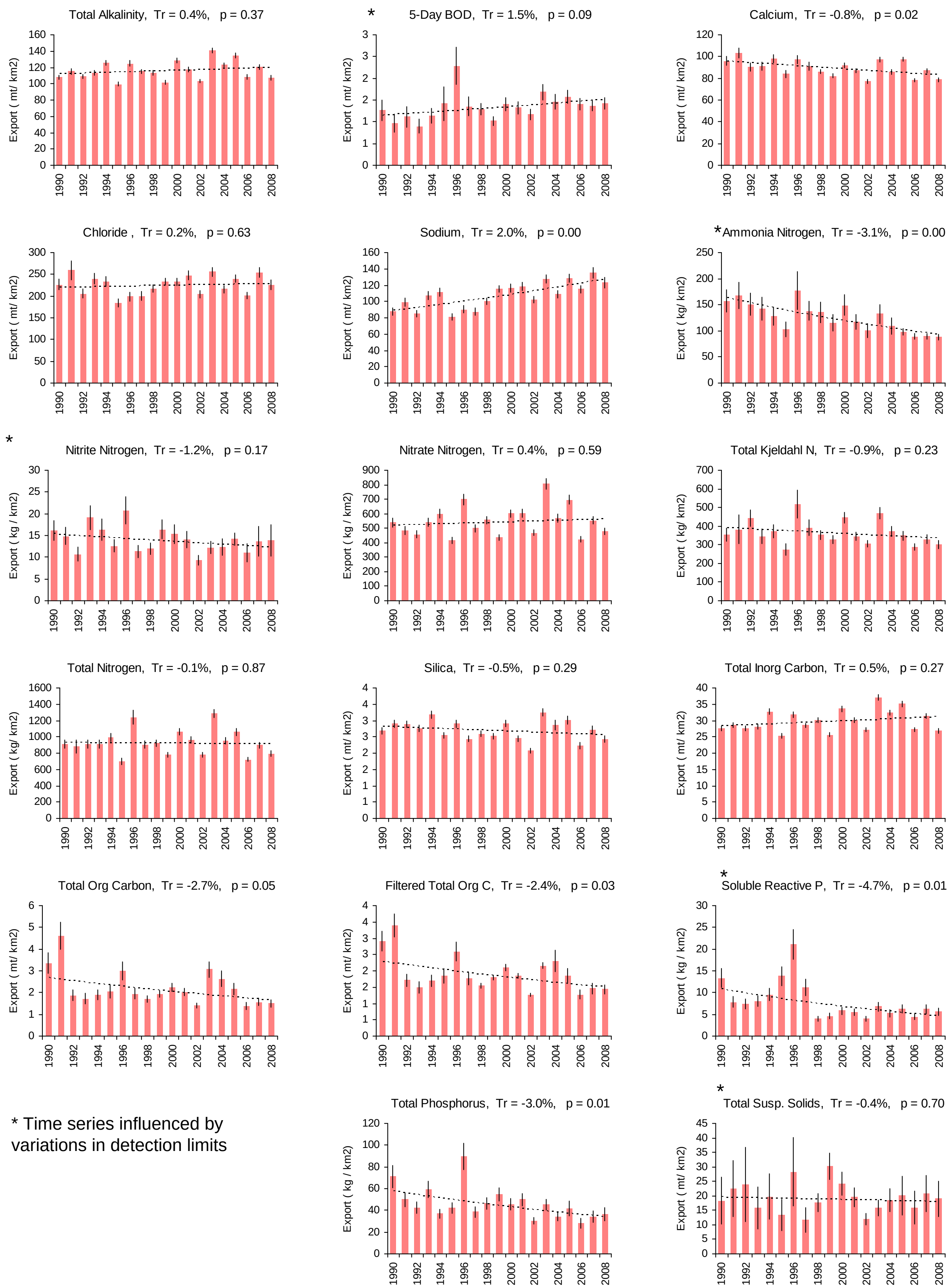


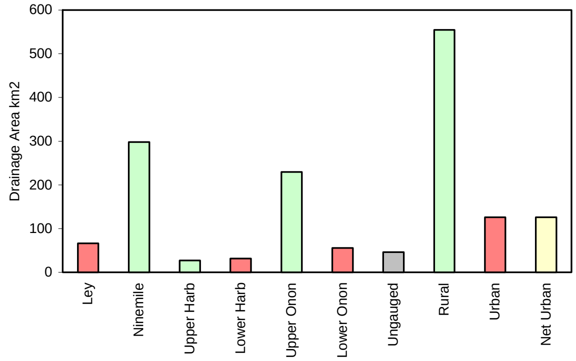
Figure 7 Spatial Variations in NonPoint Phosphorus Loads

Variable: Total Phosphorus

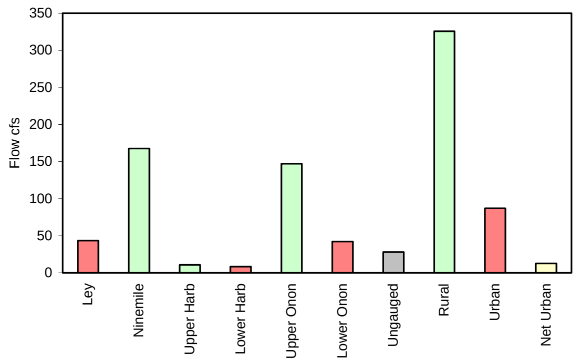
Period: 1999 - 2008

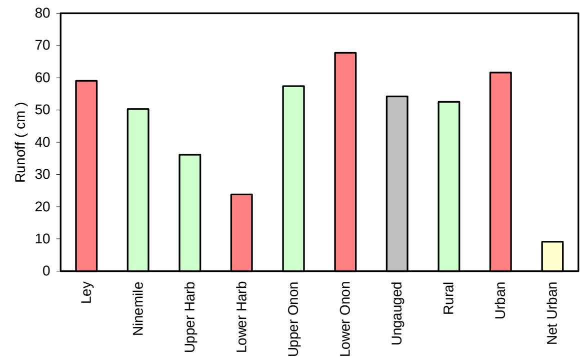
Total Values

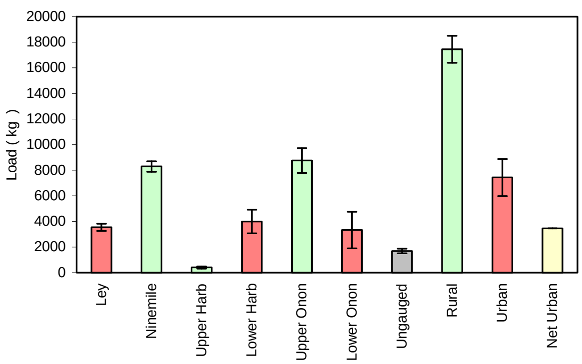
Unit Area Values

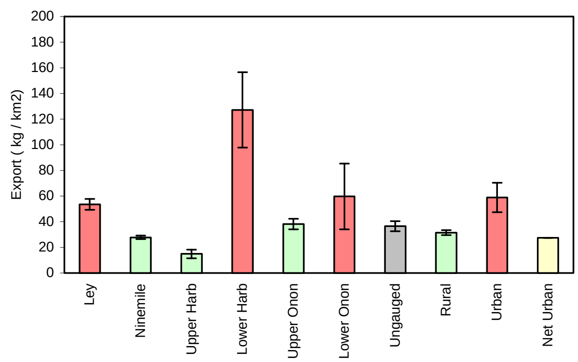


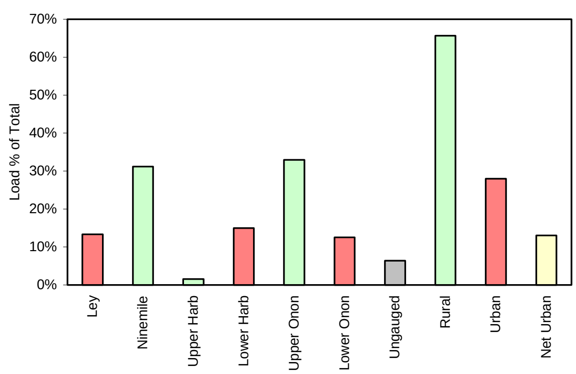
Label	Description
Ley	Above Park
Ninemile	Above Lakeland
Upper Harb	Above Velasko
Lower Harb	Between Velasko & Hiawatha
Upper Onon	Above Dorwin
Lower Onon	Between Dorwin & Kirkpatrick
Ungauged	Ungauged Watershed (Estimated)
Red	Lower Watersheds (~ Urban)
Green	Upper Watersheds (~ Rural)











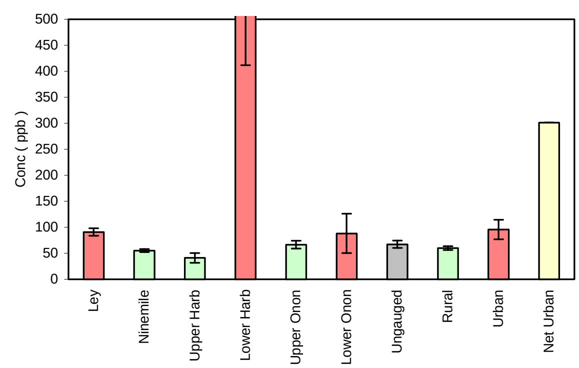
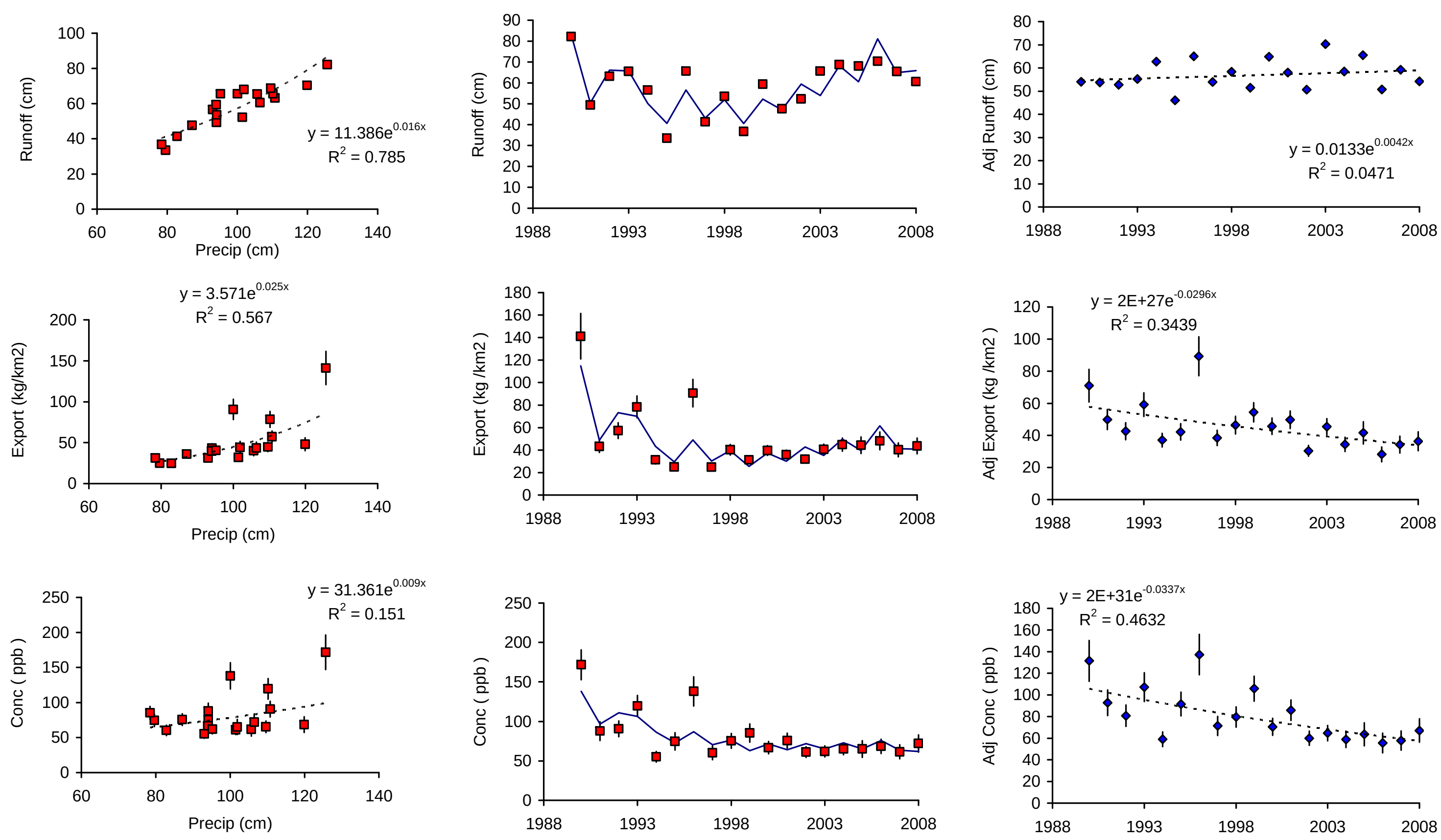


Figure 8 Trends in Nonpoint Runoff and Total P Load Adjusted for Rainfall Variations, 1990-2008

Site: T NonPoint Dr Area : 662.8 km^2 Variable : Total Phosphorus Period: 1990 - 2008

Correlations with Precipitation | Observed & Predicted Time Series | Adjusted for Variations in Precipitation



Dashed Line = Regression vs. Precip
Vertical Bars = +/- 1 Standard Error of Measured Yearly Value

Solid Line = Regression vs. Year and Precip

Dashed Line = Regressionof Adjusted Value vs. Year

Regression Model: Ln (Y) = A0 + A1 Year + A2 Precip Years: 19

Adjustment to Mean Precip: Ln (Yadjusted) = Ln (Y) + A2 (Mean_Precip - Precip) Mean_Precip = 99 cm/yr

	Ln Runoff vs. Precip & Year			Ln Export vs. Precip & Year			Ln Conc vs. Precip & Year		
	Coef	SE	p	Coef	SE	p	Coef	SE	p
A0	-5.91055			60.26478			70.78049		
A1 (Yr)	0.00418	0.00471	0.39	-0.02956	0.01023	0.01	-0.03374	0.00910	0.00
A2 (Precip)	0.01603	0.00207	0.00	0.02623	0.00449	0.00	0.01021	0.00400	0.02
R^2	0.79517			0.71561			0.54311		
Std Error	0.11219			0.24368			0.21675		

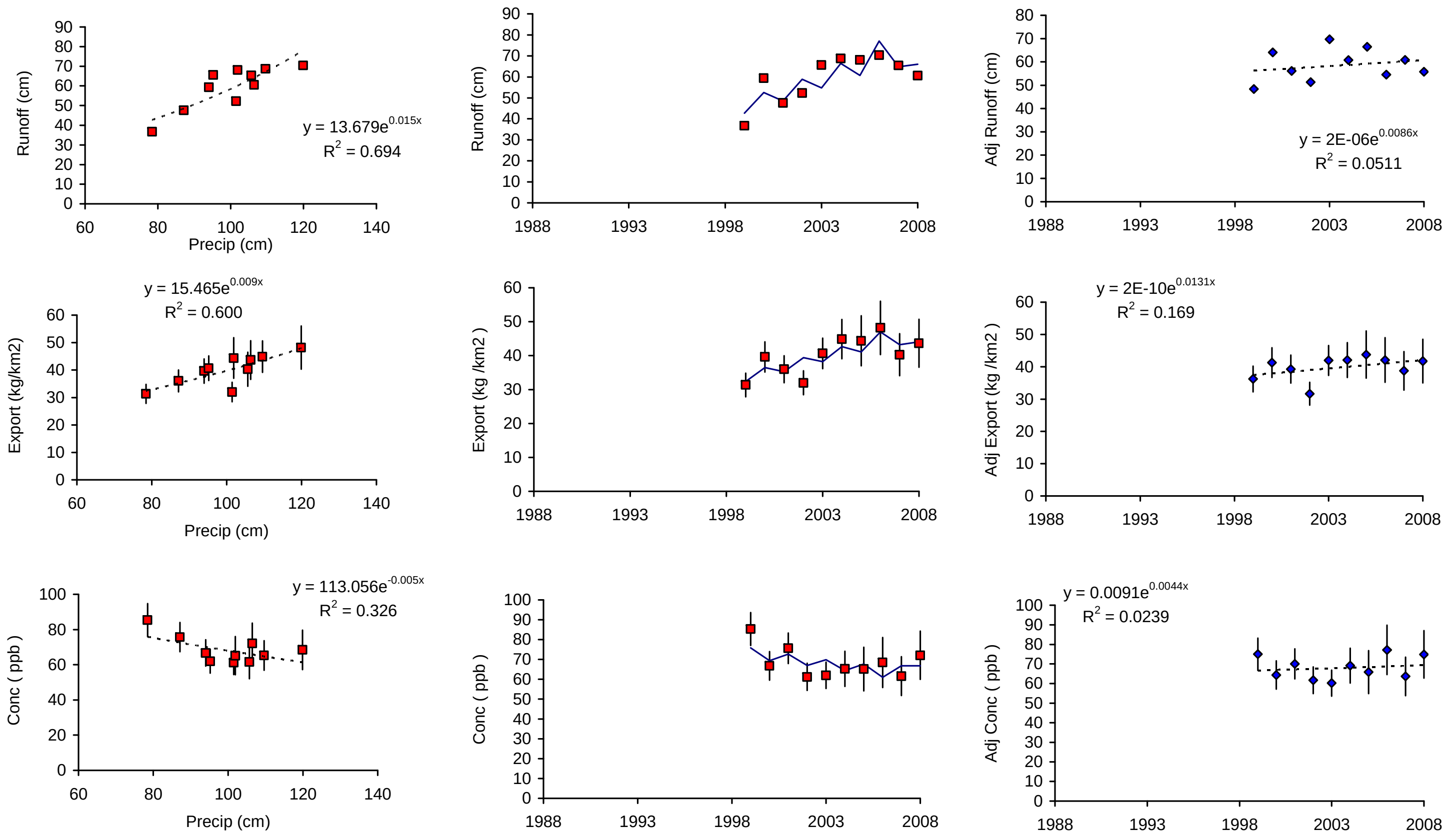
Summary of Trends (Percent / Year)

	Trend	p
Runoff	0.4%	0.39
Export	-3.0%	0.01
Conc	-3.4%	0.00

Figure 9 Trends in Nonpoint Runoff and Total P Load Adjusted for Rainfall Variations,1999-2008

Site: T NonPoint   Dr Area : 662.8 km^2 Variable : Total Phosphorus   Period: 1999 - 2008

Correlations with Precipitation   Observed & Predicted Time Series   Adjusted for Variations in Precipitation



Dashed Line = Regression vs. Precip
Vertical Bars = +/- 1 Standard Error of Measured Yearly Value

Solid Line = Regression vs. Year and Precip

Dashed Line = Regressionof Adjusted Value vs. Year

Regression Model: Ln (Y) = A0 + A1 Year + A2 Precip   Years: 10

Adjustment to Mean Precip: Ln (Yadjusted) = Ln (Y) + A2 (Mean_Precip - Precip)   Mean_Precip = 100 cm/yr

	Ln Runoff vs. Precip & Year			Ln Export vs. Precip & Year			Ln Conc vs. Precip & Year		
	Coef	SE	p	Coef	SE	p	Coef	SE	p
A0	-14.52930			-23.23012			-4.09566		
A1 (Yr)	0.00865	0.02333	0.72	0.01310	0.01817	0.49	0.00445	0.01780	0.81
A2 (Precip)	0.01276	0.00597	0.07	0.00676	0.00465	0.19	-0.00600	0.00456	0.23
R^2	0.70007			0.62739			0.33183		
Std Error	0.12796			0.09969			0.09766		

Summary of Trends (Percent / Year)	Trend	p
Runoff	0.9%	0.72
Export	1.3%	0.49
Conc	0.4%	0.81

Figure 10 Trends in Rainfall-Adjusted Phosphorus Loads from Individual Sources, 1990-2008

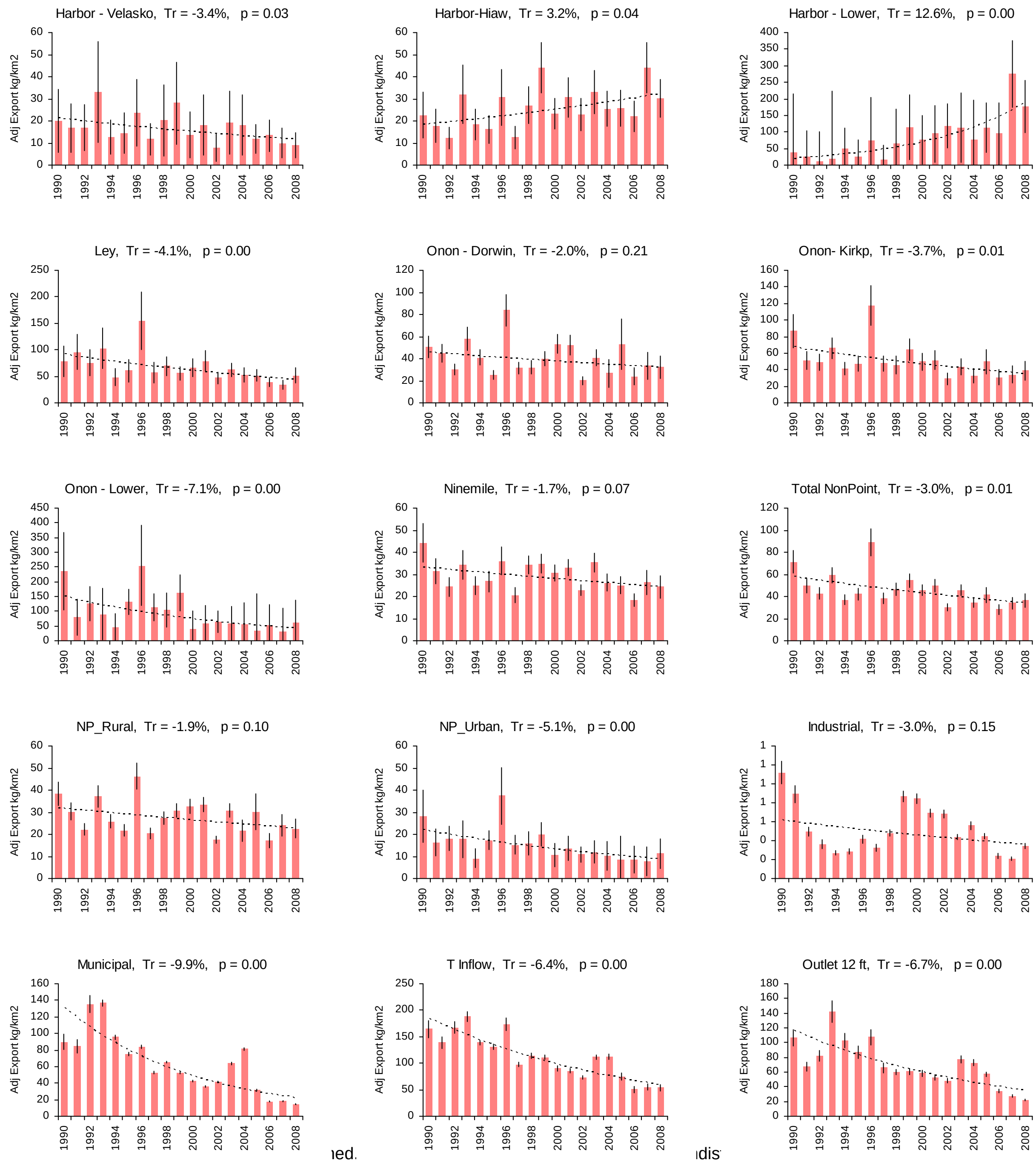
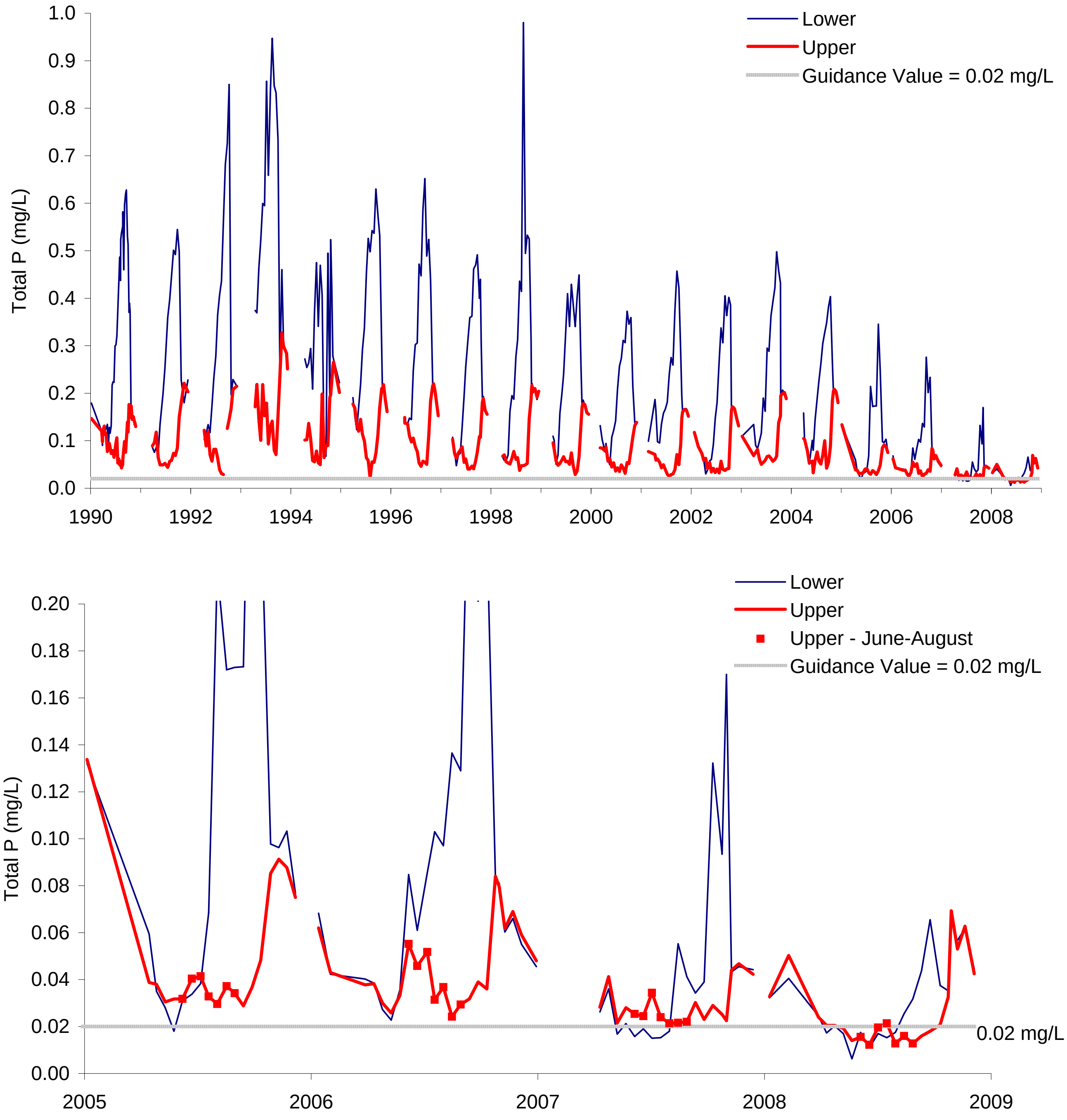


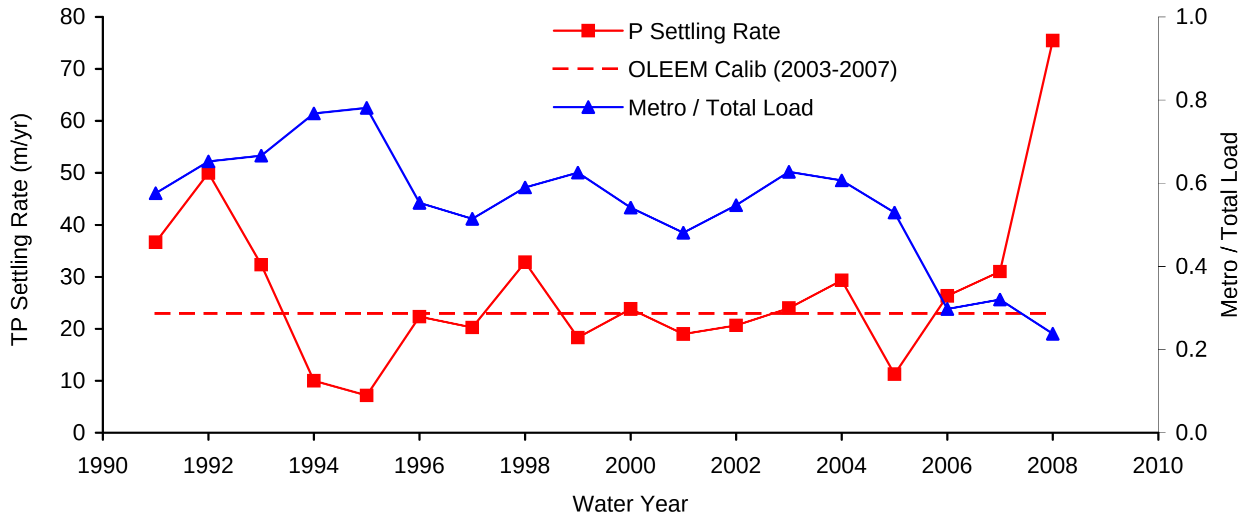
Figure 11 Trends in Lake Phosphorus Concentration, 1990-2008

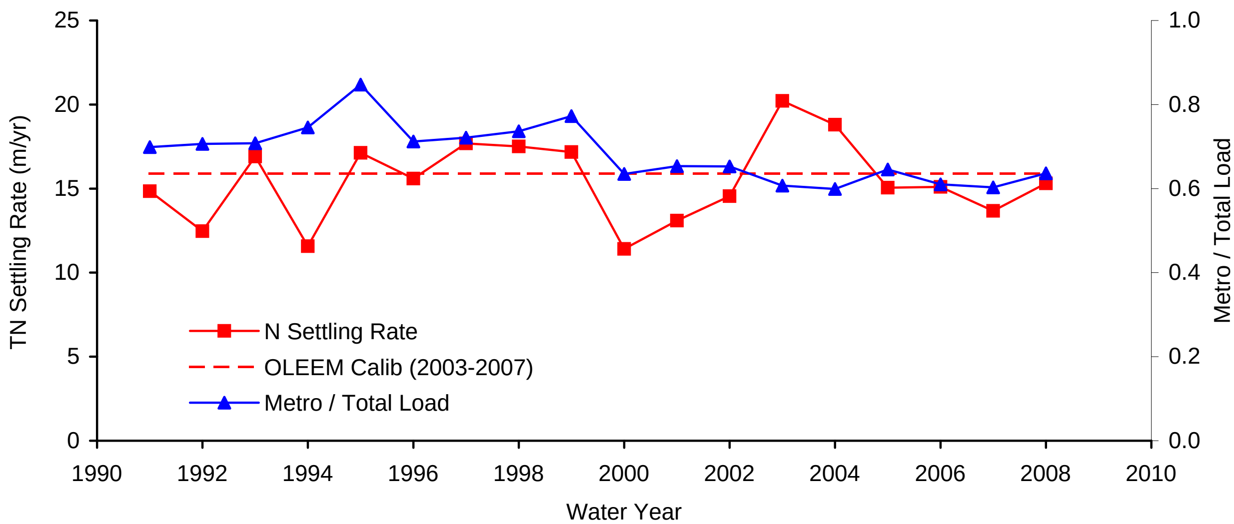


Lower 9 - 18 meters, South Deep station

Upper 0 - 3 meters

Figure 12 Phosphorus and Nitrogen Settling Rates, 1990-2008





Settling Rate (m/yr) = Nutrient Retention Per Unit Area (g/m^2-yr) / Average Outflow Concentration (g/m^3)
Metro / Total Load = fraction of P or N load attributed to Metro Sources (Treated + Bypass)
OLEEM = Onondaga Lake Empirical Eutrophication Model, calibrated to 2003-2007 data (Ecologic et al, 2009).
P settling rate in 2008 significantly higher than those measured in previous years.

Figure 13 Trends in Speciation of Phosphorus Loads, 1999-2008

Total P Load

Percent of Total P Load

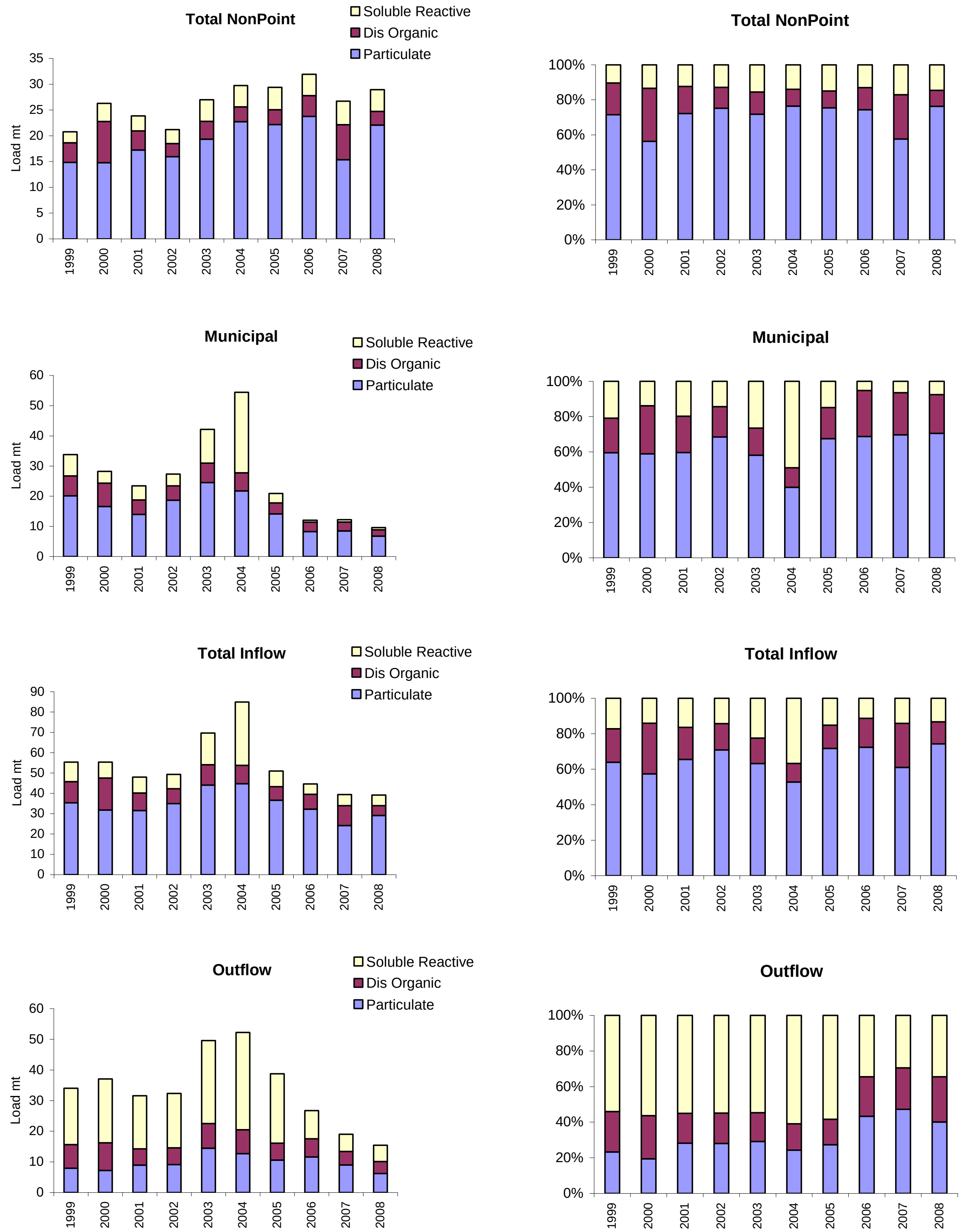
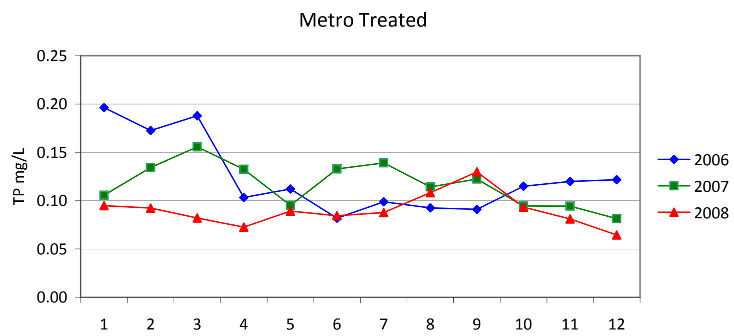
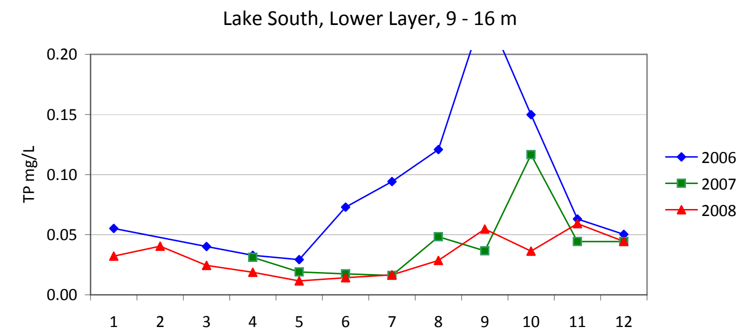
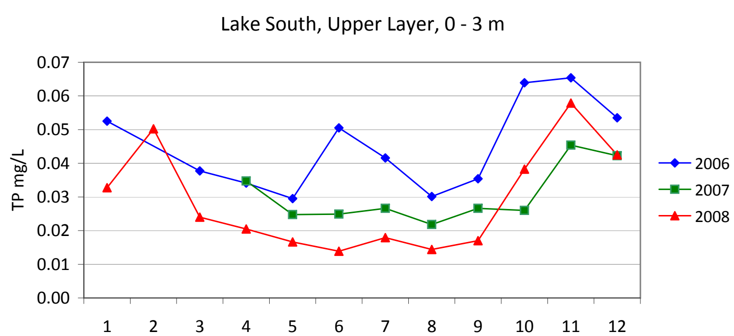
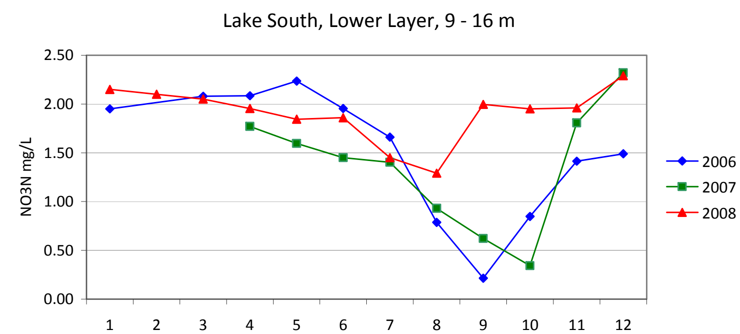


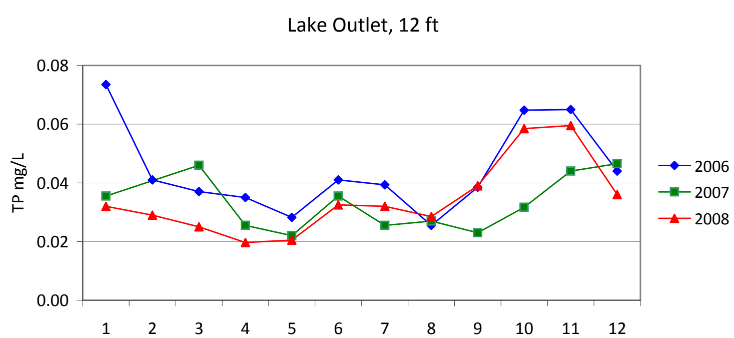
Figure 14 Monthly Mean Concentrations by Site & Depth, 2006-2008











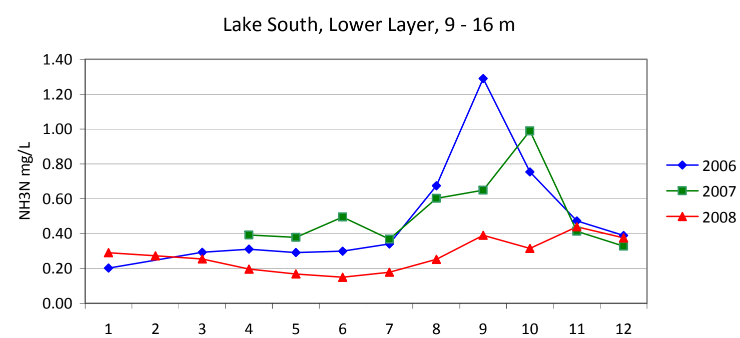


Figure 15 Metro Chloride Time Series and Lake South Conductivity Profiles, July-August, 2007 vs. 2008