

# **Tahoe TMDL Stormwater Monitoring Program WY03-04**

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# Objectives of TMDL SWM program

- ❖ Establish a basin-wide network of stormwater runoff monitoring sites.
- ❖ Develop uniform formats for reporting data and for data management.
- ❖ Determine event mean concentrations (EMCs) from different types of runoff events around the basin.
- ❖ Provide stormwater runoff data suitable for watershed model calibrations, project planning and BMP design.

**Prior to the TMDL  
stormwater  
monitoring  
program:**

**Tahoe urban  
runoff monitoring  
consisted of grab  
samples taken at a  
few locations,  
primarily on the  
north shore, and  
without continuous  
flow monitoring.**



# Objectives

- ❖ Establish a basin-wide network of stormwater runoff monitoring sites.



## Distribution of Land Uses in the Lake Tahoe Basin

Land Use Type	Area (ha)	Proportion
Single Family Residential	4,492	5.5%
Multi-family Residential	1,342	1.7%
Commercial / Institutional	687	0.8%
Transportation	1,296	1.6%
Recreational / Open Space	3,526	4.3%
Mixed Urban	1,404	1.7%
Vegetated	66,926	82.2%

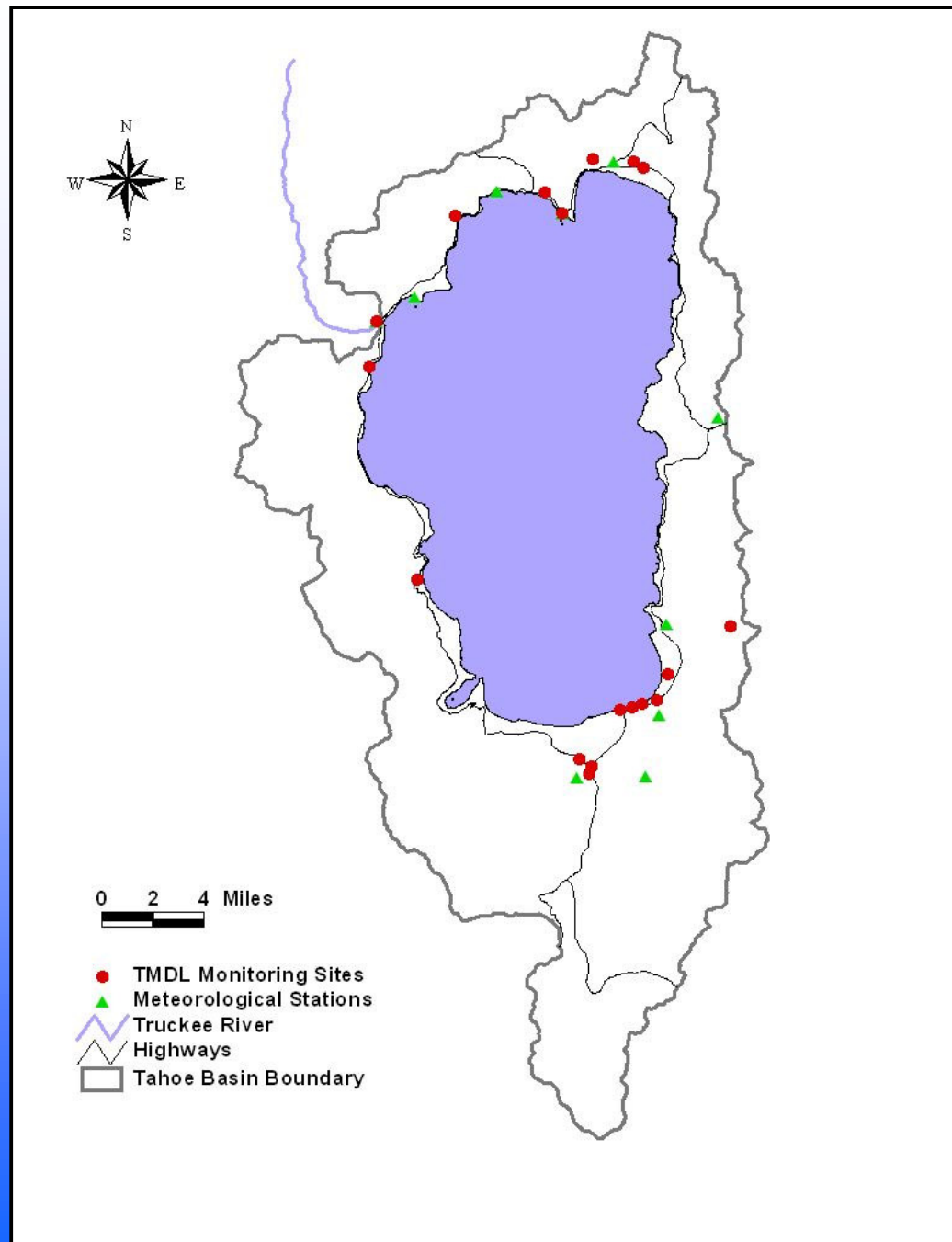
## TMDL Stormwater Monitoring Site LULC Matrix

TMDL Autosampler Sites		Land Use Proportion (%)							Erosion Hazard (%)			%	Drainage
Location	ID	Single Family Residential	Multi Family Residential	Commercial / Institutional	Primary Roads	Secondary Roads	Recreational Vegetated	Unimpaired Vegetated	Slight	Moderate	High	Impervious Cover	(m2)
Andria Dr.	AD	68				22		9		34	66	37	57,897
Bonanza Ave.	BB	41	14	2		14		29	98	1	1	34	370,499
Bijou Creek	BC	15	2	1		4	7	70	49	8	43	11	4,422,655
Don Cheapo's	DC			76	10	14			100			62	9,686
Dale Dr.	DD	67				20		13		99	1	34	119,755
Glorene and Eighth	GE	3		77		16		4	100			67	4,115
IV Raley's	IR		32	55	4	3		6	100			45	97,665
Mountain Dr.	MD	62				18		19			100	35	18,456
Northwood Blvd.	NW	67	2	6		13		12	71	26	2	26	286,695
Osgood Ave.	O3	23	38	2	4	19		13	100			48	96,786
Regan Beach	RB	41	22	3		21		13	100			45	196,641
Speedboat Ave.	SB	34	3	22	6	14		21	2	41	58	42	165,541
SLT Casinos	SC			77	2	2		18	77	23		81	346,268
Shivagiri	SG							100	80	20		0	994,580
Sequoia Ave.	SQ	53	11		5	11		20	100			29	66,887
SLT-Y	SY	14	9	44	3	10		19	100			53	147,492
Golf Course Creek	GC								X				
Lakeview Village	LV		X							X			
Coon Street	CI	40	24	1		19		16	100			33	94,654
TCWTS	S1	20	18	24	5	16	4	13	84	16		62	228,251
Roundhill 4.2	RC	74		1		9		14		8	92	28	310,411

# TMDL Stormwater Monitoring Site LULC Matrix

Status	TMDL Autosampler Sites			Percent Coverage by Landscape Classification								% Erosion Hazard			Drainage Area
	ID	Location	Org	Single Family Residential	Multi Family Residential	Commercial	Institutional	Transportation	Recreation / Open Space	Mixed Urban	Vegetated	Slight	Moderate	High	(m2)
Existing	AD	Andria Dr.	DRI	68				30			2		34	66	57,897
	BB	Bonanza Ave.	TRG	39	10	0				37	13	98	1	1	370,499
	BC	Bijou Creek	DRI	34	1	1	1		8	8	48	49	8	43	4,422,655
	DC	Don Cheapo's	DRI			7					91	2			9,686
	DD	Dale Dr.	DRI	70				18		5	7		99	1	119,755
	GE	Glorene and Eighth	TRG	7		71					22	100			4,115
	IR	IV Raley's	DRI		5	48		12			34	100			97,665
	MD	Mountain Dr.	TRG	59				24			17			100	18,456
	NW	Northwood Blvd.	DRI	62	1		5	24		2	6	71	26	2	286,695
	O3	Osgood Ave.	TRG	22	37	1	2				34	4			96,786
	RB	Regan Beach	DRI	37	27	1	0				35	0			196,641
	SB	Speedboat Ave.	TRG	35	8	10	3	22		9	13	2	41	58	165,541
	SC	SLT Casinos	DRI		0	94		5			1	77	23		346,268
	SG	Shivagiri	TRG	1							99	80	20		994,580
	SQ	Sequoia Ave.	TRG	57	9			24			10	100			66,887
	SY	SLT-Y	TRG	16	2	41				6	30	5	100		147,492
	Proposed	GC	Golf Course Creek	na								X	X		
LV		Lakeview Village	na		X								X		
Adopted	CI	Coon Street	TRG	14	52	0		21		8	6	100			94,654
	S1	TCWTS	TRG	22	13	22	30	8		1	1	84	16		228,251
	R4	Roundhill	DRI	55	3	2	2	15		4	19		16	84	325,399

**The TMDL stormwater monitoring program expanded to multiple sites around the Tahoe Basin, and included meteorological data, as well as continuous flow monitoring and frequent sample collection.**





# TMDL Stormwater Monitoring Installation



## Collecting TMDL Stormwater Runoff Samples





## **Another Stormwater Monitoring Installation**



# Objectives

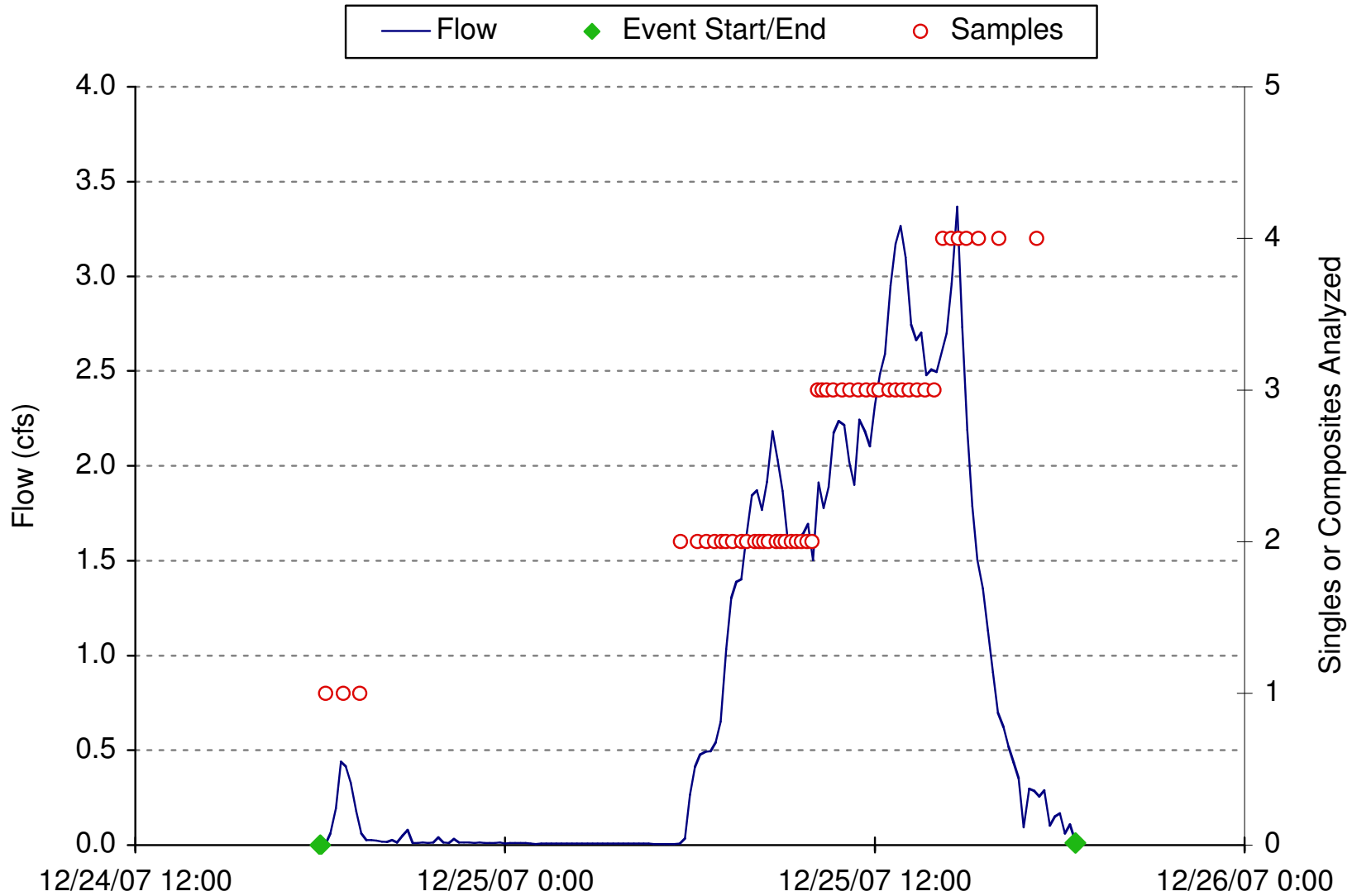


❖ Develop uniform formats for reporting data and for data management.

❖ Determine event mean concentrations (EMCs) from different types of runoff events around the basin.



# TMDL event SY-04-06, constant volume sampling



## TMDL site SLT-Y event summary WY04

Event ID	Runoff Start (Date Time)	Runoff Duration (hh:mm)	Event Type	Runoff Volume (cf)	Peak Flow (cfs)	Sample Pacing Set	Samples Collected	Singles or Composites Analyzed
na	1/22/03 0:00	na	site activated	na	na	na	na	na
SY-04-01	11/1/03 10:40	5:10	snowmelt	1,112	0.29	750cf	2	2
SY-04-02	11/9/03 5:40	26:20	snowmelt	6,560	0.81	200cf	24	2
SY-04-03	12/1/03 20:10	6:00	rain	1,389	0.38	300cf	8	1
SY-04-04	12/5/03 7:30	8:50	rain	10,483	2.04	700cf	21	2
SY-04-05	12/6/03 2:00	30:30	rain	86,703	2.81	700cf, 1800cf	62	3
SY-04-06	12/23/03 18:00	24:30	rain/snowmelt	73,004	3.37	500cf to 2500cf	54	4
SY-04-07	1/7/04 3:10	16:50	snowmelt	4,233	0.47	200cf, 500cf	14	2
SY-04-08	1/8/04 10:20	15:30	snowmelt	1,394	0.14	400cf, 250cf	5	2
SY-04-09	1/9/04 10:30	14:50	snowmelt	802	0.07	250cf	4	1
SY-04-10	1/27/04 11:00	16:10	snowmelt	1,048	0.28	50cf, 100cf	16	3
SY-04-11	1/28/04 11:20	14:00	snowmelt	908	0.18	100cf	11	5
SY-04-12	2/2/04 20:30	35:20	snowmelt	1,101	0.11	100cf	11	6
SY-04-13	2/6/04 14:40	33:10	snowmelt	1,328	0.20	50cf	28	4
SY-04-14	2/16/04 7:50	15:50	rain on snow	66,272	2.39	800cf, 2000cf	34	3
SY-04-15	2/18/04 4:40	17:00	rain, grauple	11,902	0.91	150cf, 500cf	24	3
SY-04-16	2/19/04 10:50	14:00	snowmelt	601	0.14	300cf, 150cf	5	1
SY-04-17	2/22/04 11:50	15:50	snow, rain on snow	3,565	0.58	400cf	8	1
SY-04-18	2/25/04 14:40	13:30	snow, sleet	11,689	1.18	500cf, 750cf	20	1
SY-04-19	2/26/04 10:10	9:10	snow/sleet	6,195	0.55	400cf, 600cf	17	1
SY-04-20	2/27/04 11:00	9:40	snow, snowmelt	4,681	0.69	600cf	11	1
SY-04-21	3/1/04 11:30	9:10	snow	3,581	0.78	600cf	7	1
SY-04-22	3/2/04 8:20	8:50	snow, snowmelt	2,864	0.58	300cf	9	2
SY-04-23	5/11/04 3:00	16:20	snow, snowmelt	16,633	1.11	1200cf	24	6
SY-04-24	5/27/04 23:40	11:30	rain	20,148	3.38	1200cf	11	2
SY-04-25	6/29/04 13:10	17:20	rain, thunderstorm	14,848	3.48	1200cf	12	3
SY-04-26	6/30/04 14:10	5:40	thunderstorm	7,143	2.18	1200cf	6	2

## WY04 analytic summary for TMDL site SLT-Y

Event ID	Average or EMC	TKN (ug/L)	NO3-N (ug/L)	NH4-N (ug/L)	TP (ug/L)	TDP (ug/L)	SRP (ug/L)	TSS (mg/L)	Turbidity (NTU)
na		na	na	na	na	na	na	na	na
SY-04-01	EMC	5,826	507	1,653	2,161	112	77	206	748
SY-04-02	EMC	3,884	253	412	1,692	46	44	504	605
SY-04-03	EMC	1,806	135	39	614	51	14	125	na
SY-04-04	EMC	4,849	130	52	1,172	31	21	198	251
SY-04-05	EMC	1,717	113	89	398	60	51	71	81
SY-04-06	EMC	3,719	72	43	988	40	38	280	298
SY-04-07	EMC	4,499	204	82	5,417	22	4	1,160	2,212
SY-04-08	EMC	1,815	46	11	1,886	112	95	341	530
SY-04-09	EMC	1,911	163	20	1,171	90	6	192	278
SY-04-10	EMC	2,807	180	50	2,623	77	55	559	1,067
SY-04-11	EMC	2,673	147	196	1,325	26	11	250	403
SY-04-12	EMC	1,588	159	59	922	17	4	173	327
SY-04-13	EMC	2,684	220	141	1,127	19	7	259	541
SY-04-14	EMC	2,358	154	135	1,192	61	47	369	315
SY-04-15	EMC	2,855	171	140	1,278	42	30	314	369
SY-04-16	EMC	1,212	127	49	393	36	15	89	186
SY-04-17	EMC	3,901	228	177	2,474	48	23	281	1,037
SY-04-18	EMC	2,242	144	116	1,145	49	20	326	404
SY-04-19	EMC	1,497	99	77	1,236	24	16	354	427
SY-04-20	EMC	2,440	122	116	1,254	27	4	406	478
SY-04-21	EMC	2,821	132	193	2,333	41	14	630	970
SY-04-22	EMC	457	164	151	2,604	37	12	574	1,034
SY-04-23	EMC	1,789	290	359	450	134	117	90	109
SY-04-24	EMC	1,273	254	40	406	19	4	134	81

SY-04-25 and SY-04-26 pending

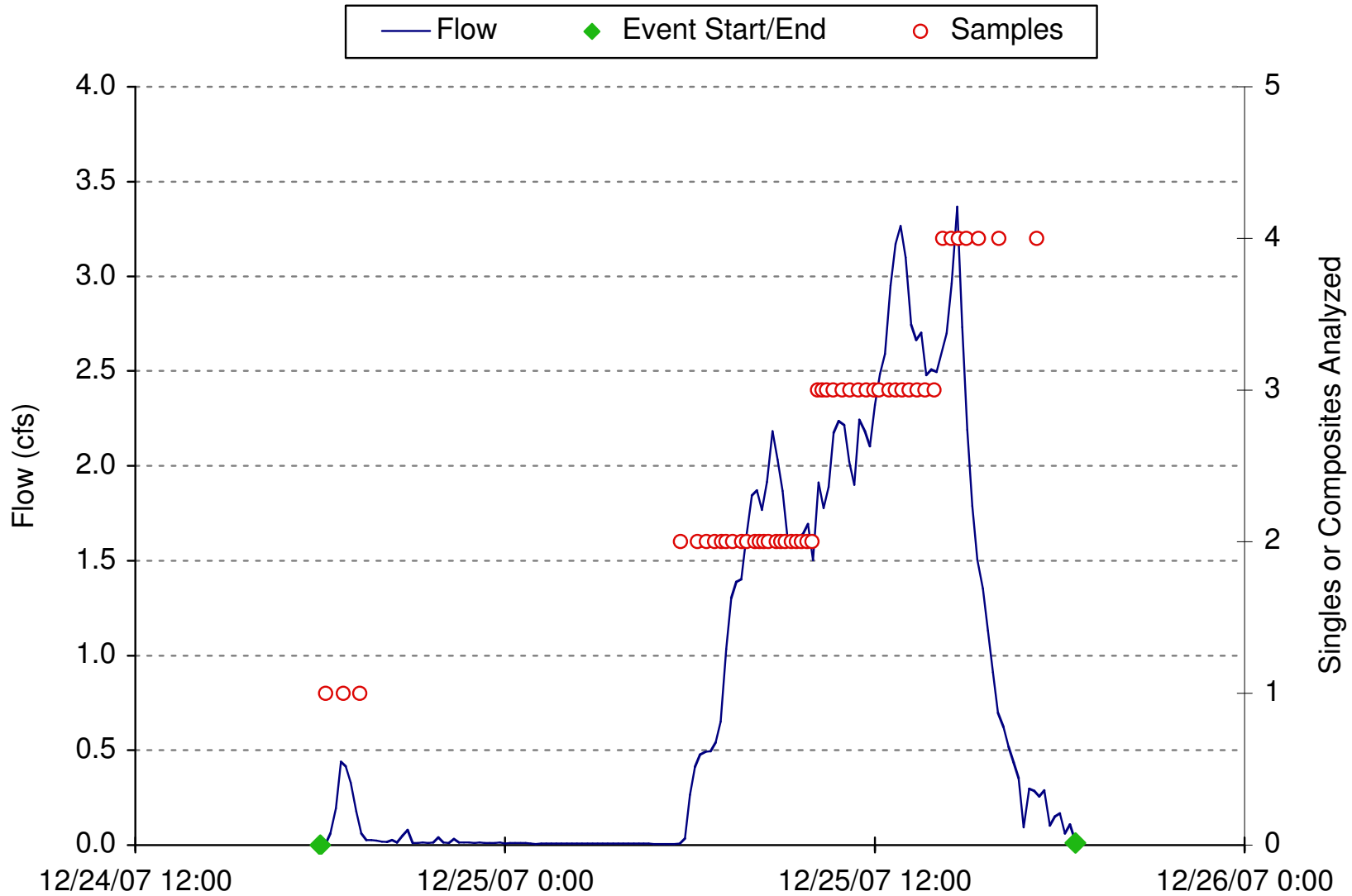
# Objectives



- ❖ Provide stormwater runoff data suitable for watershed model calibrations, project planning and BMP design.



# TMDL event SY-04-06, constant volume sampling

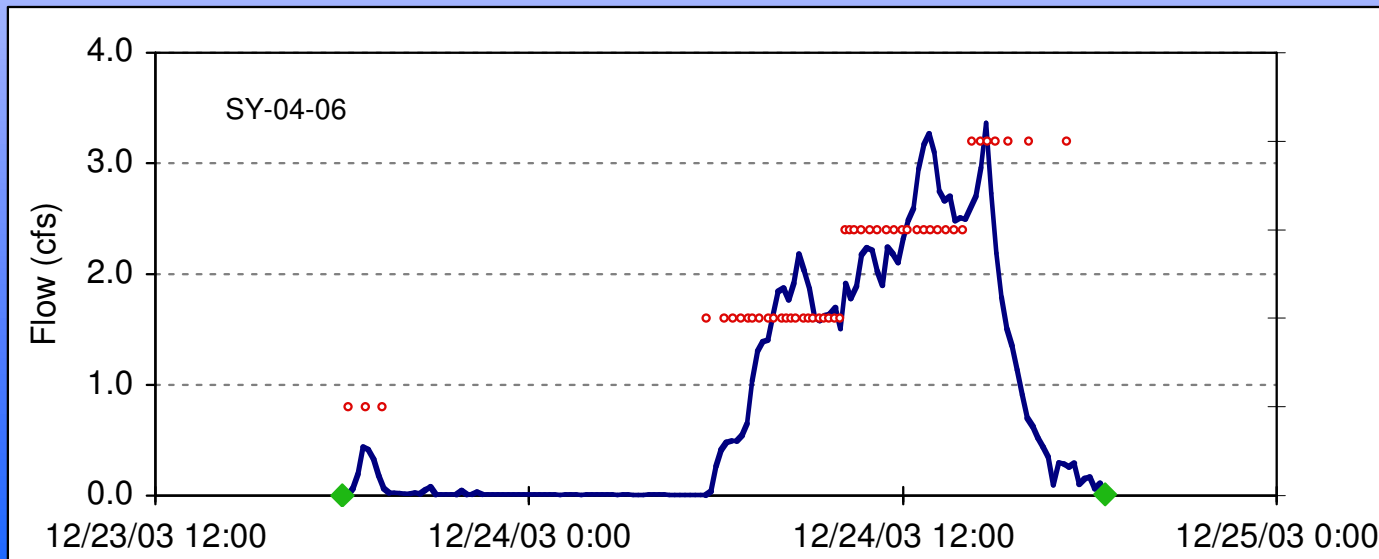
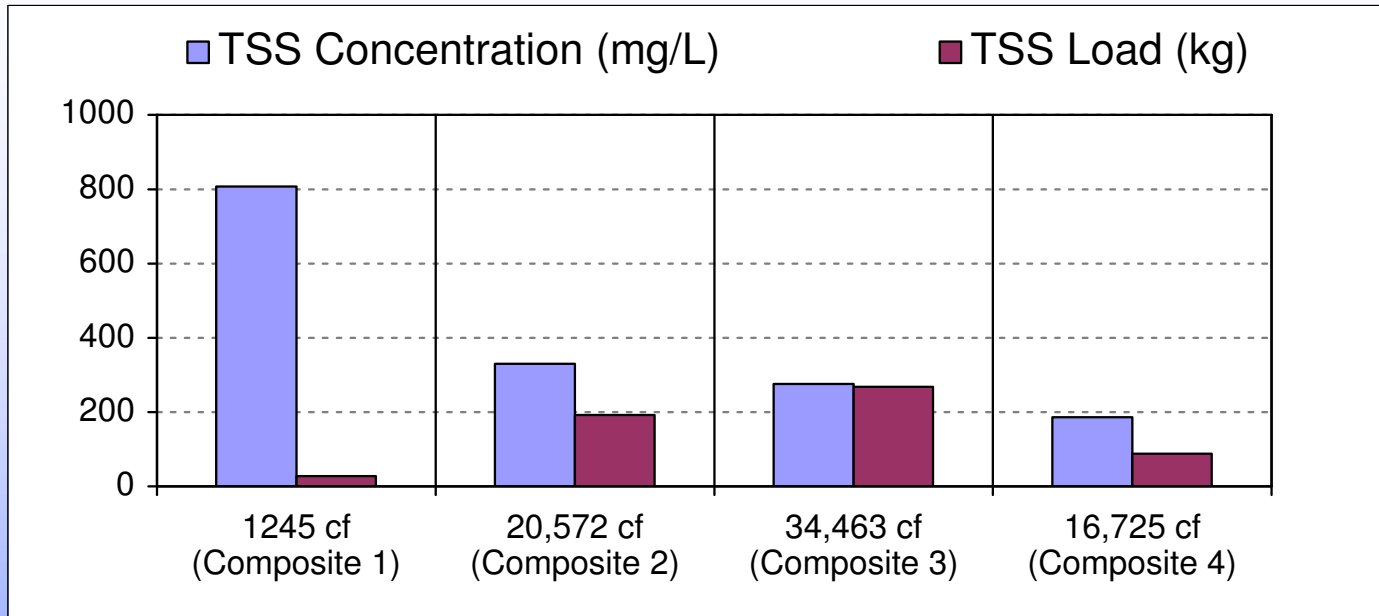


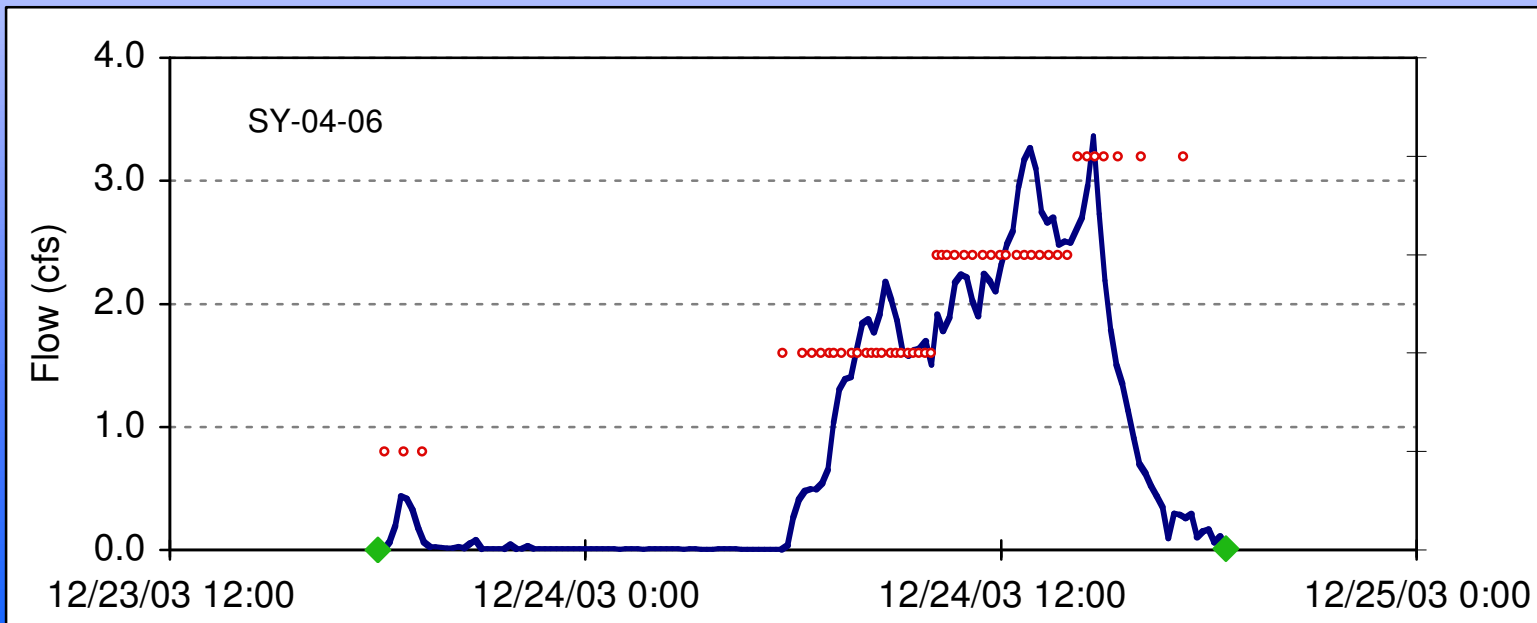
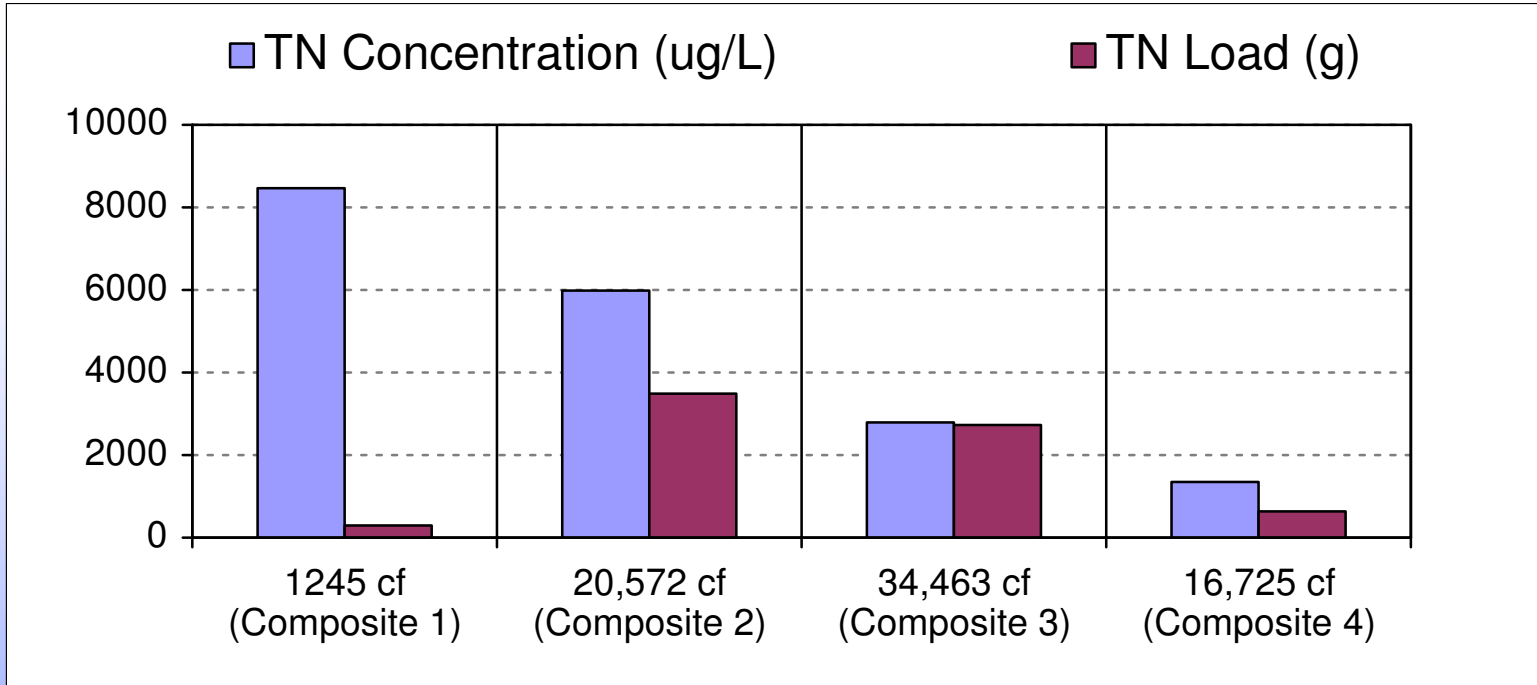
**Analytic results,  
four composite samples  
TMDL event SY-04-06  
(constant volume sampling)**

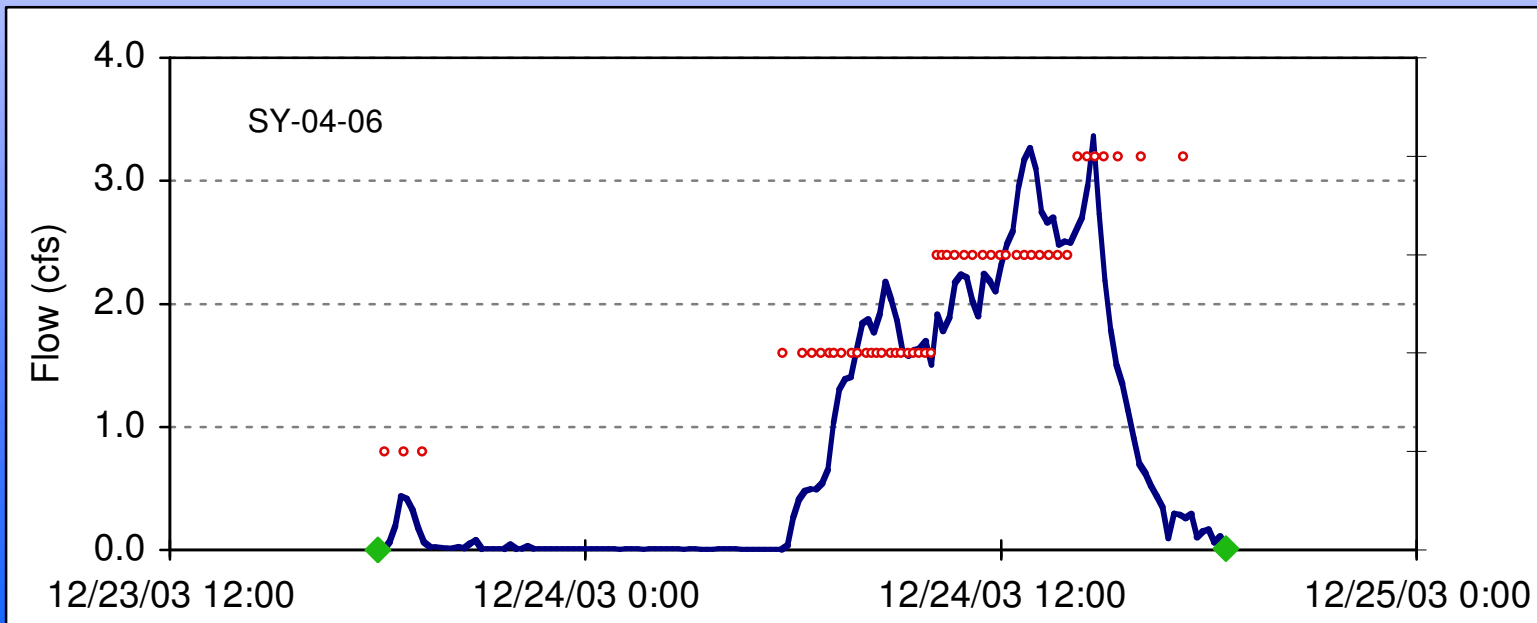
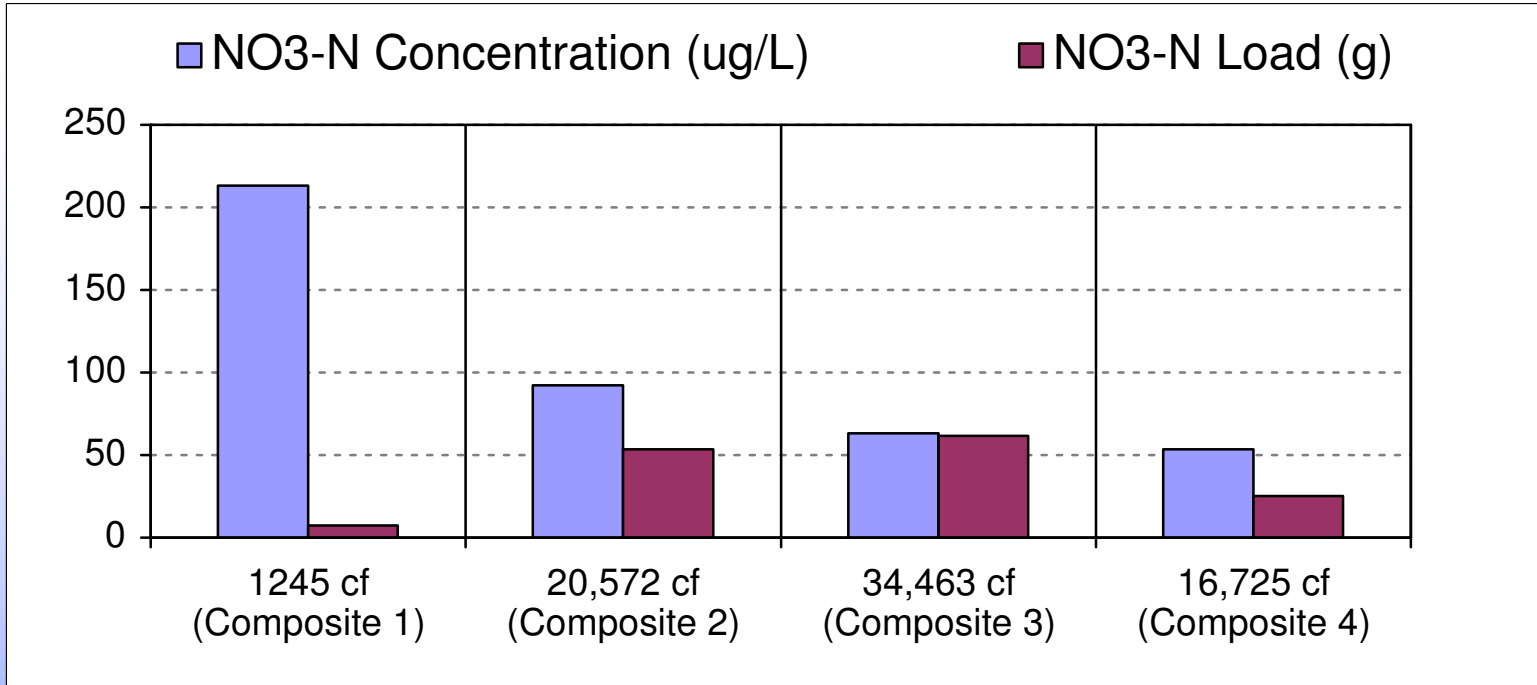
Site	Sample Start DateTime	Sample ID	TKN (ug/L)	NO3-N (ug/L)	NH4-N (ug/L)	TP (ug/L)	TDP (ug/L)	SRP (ug/L)	TSS (mg/L)	Turbidity (NTU)	Interval Volume (cf)
SY	12/23/03 18:11	0103	8,251	213	112	4,161	13	8	808	2,142	1,245
SY	12/24/03 5:41	0424	5,892	92	19	1,381	11	5	330	391	20,572
SY	12/24/03 10:08	2541	2,735	63	47	831	55	55	276	244	34,463
SY	12/24/03 14:12	4248	1,288	53	57	594	45	45	186	156	16,725
SY	12/23/03 18:11	average	4,542	106	59	1,742	31	28	400	733	18,251
SY	12/23/03 18:11	EMC	3,387	72	43	988	40	38	280	298	73,004

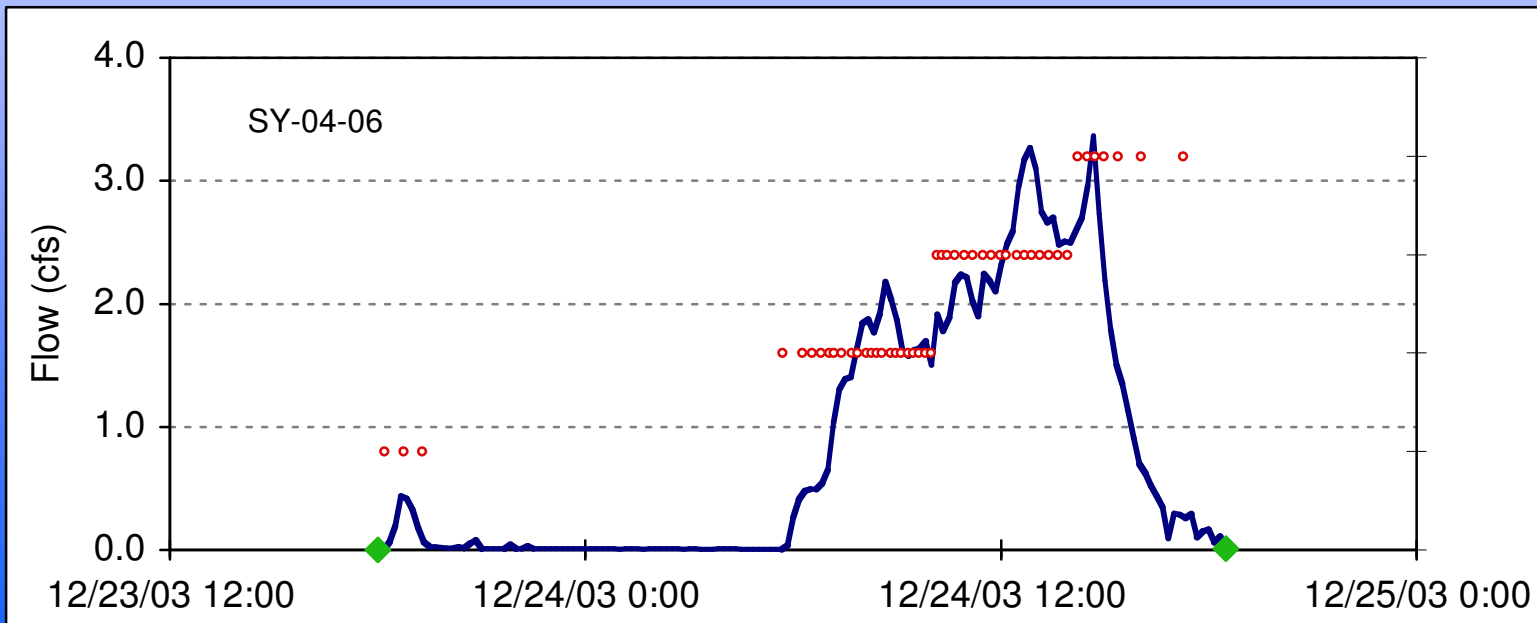
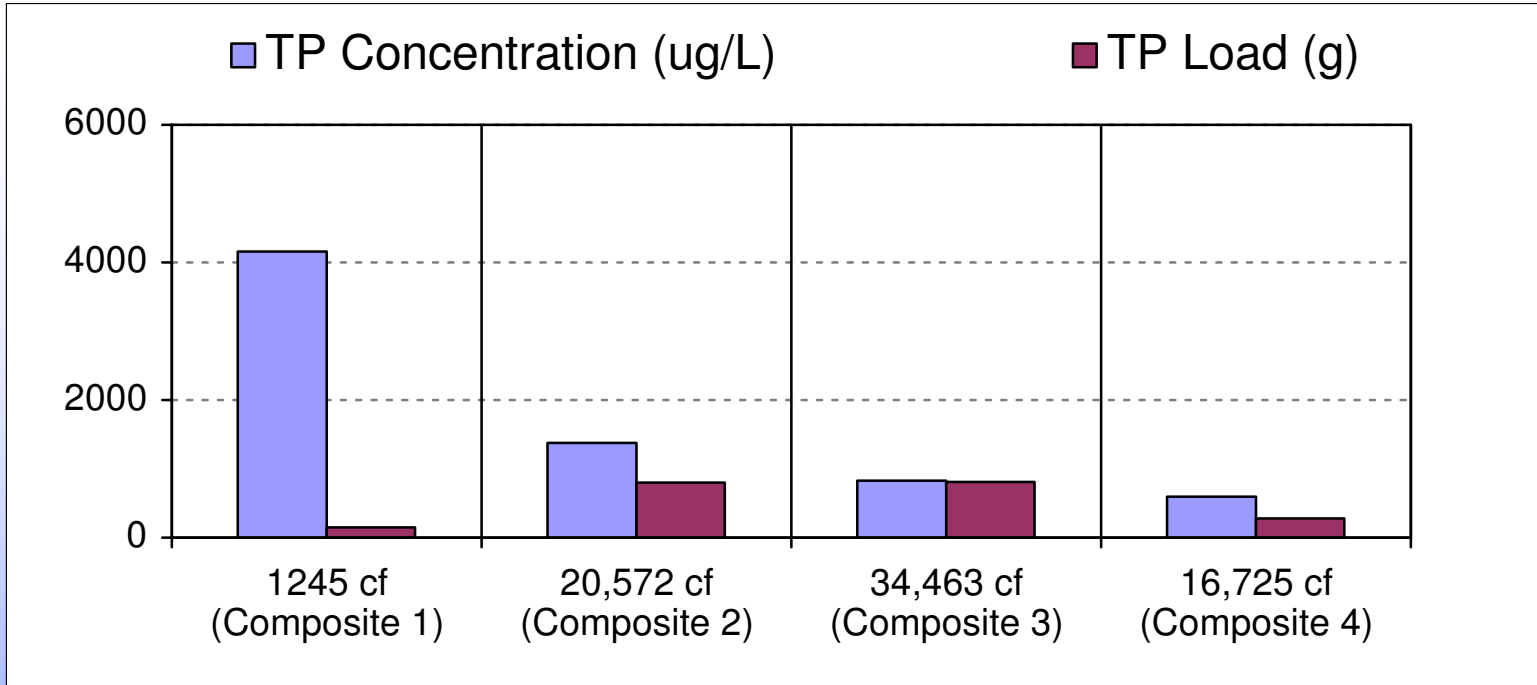
Previous event at this site:  
December 6, 2003

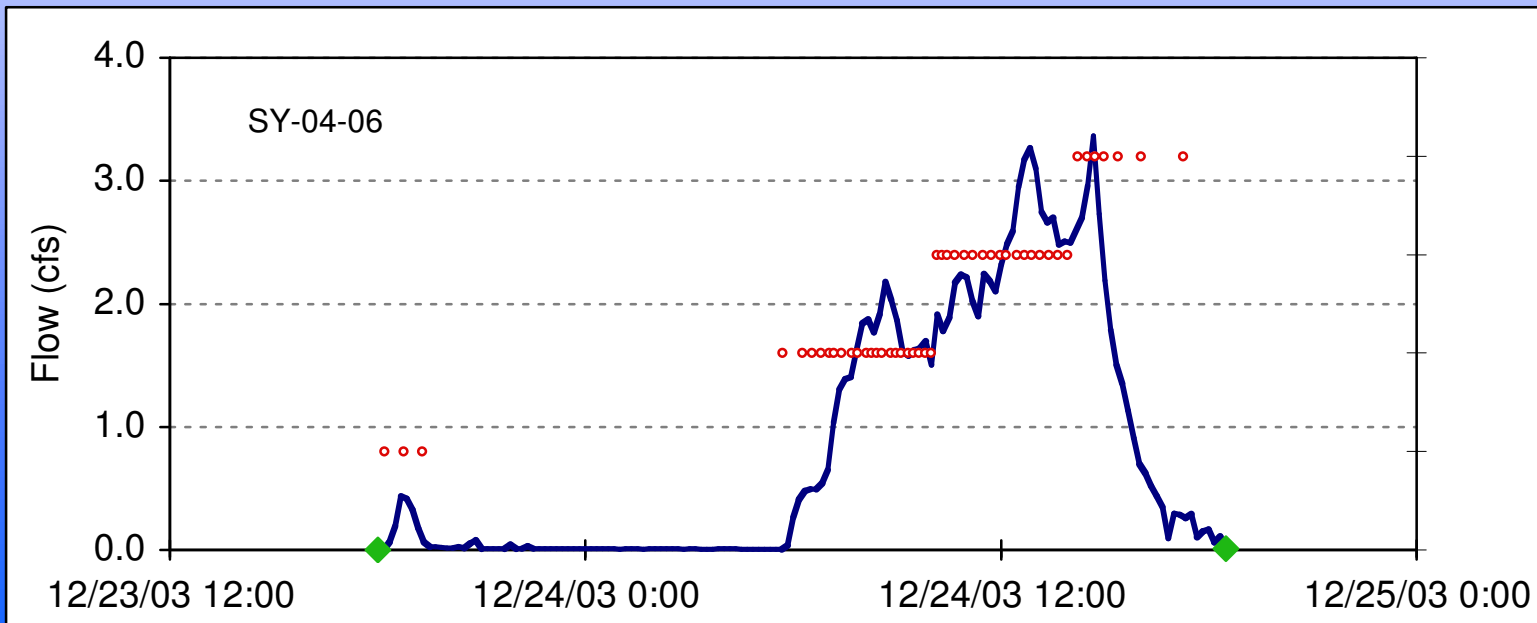
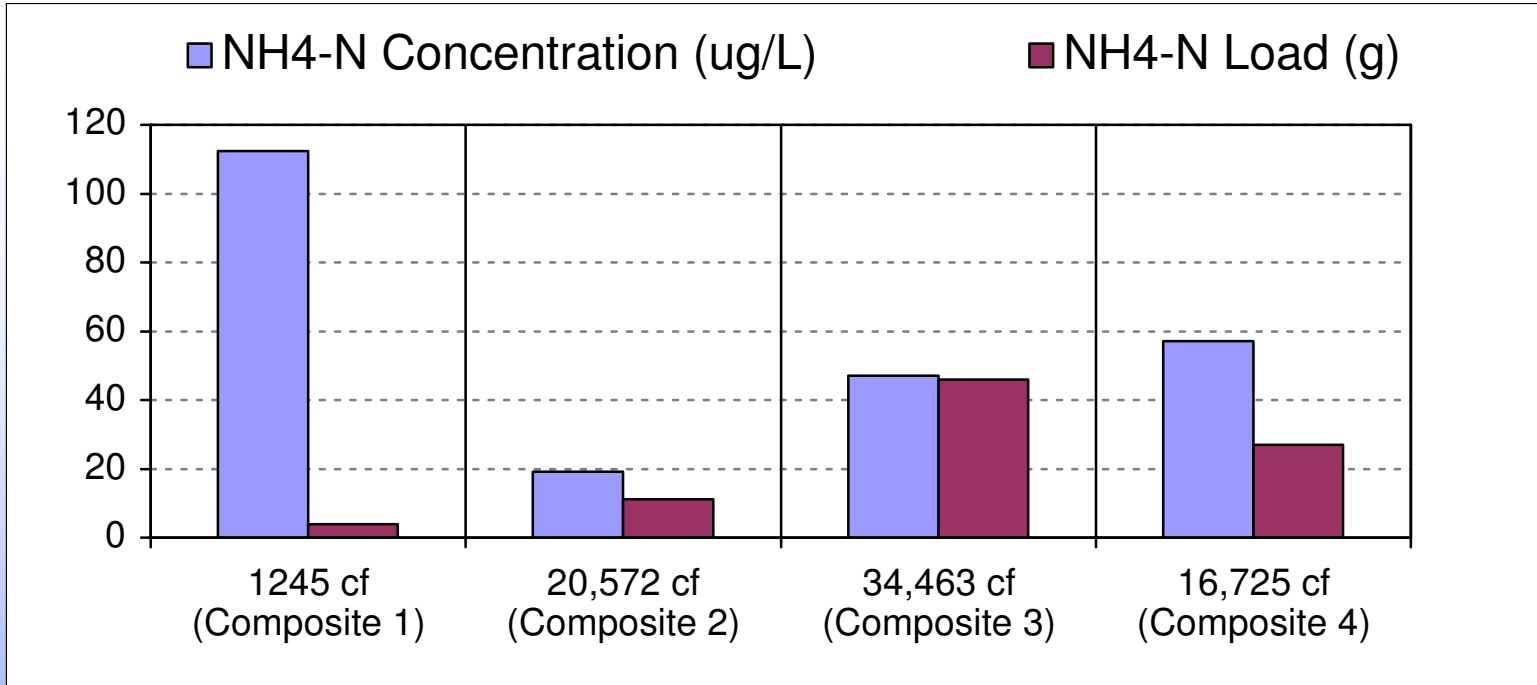
# TMDL event SY-04-06, constant volume sampling

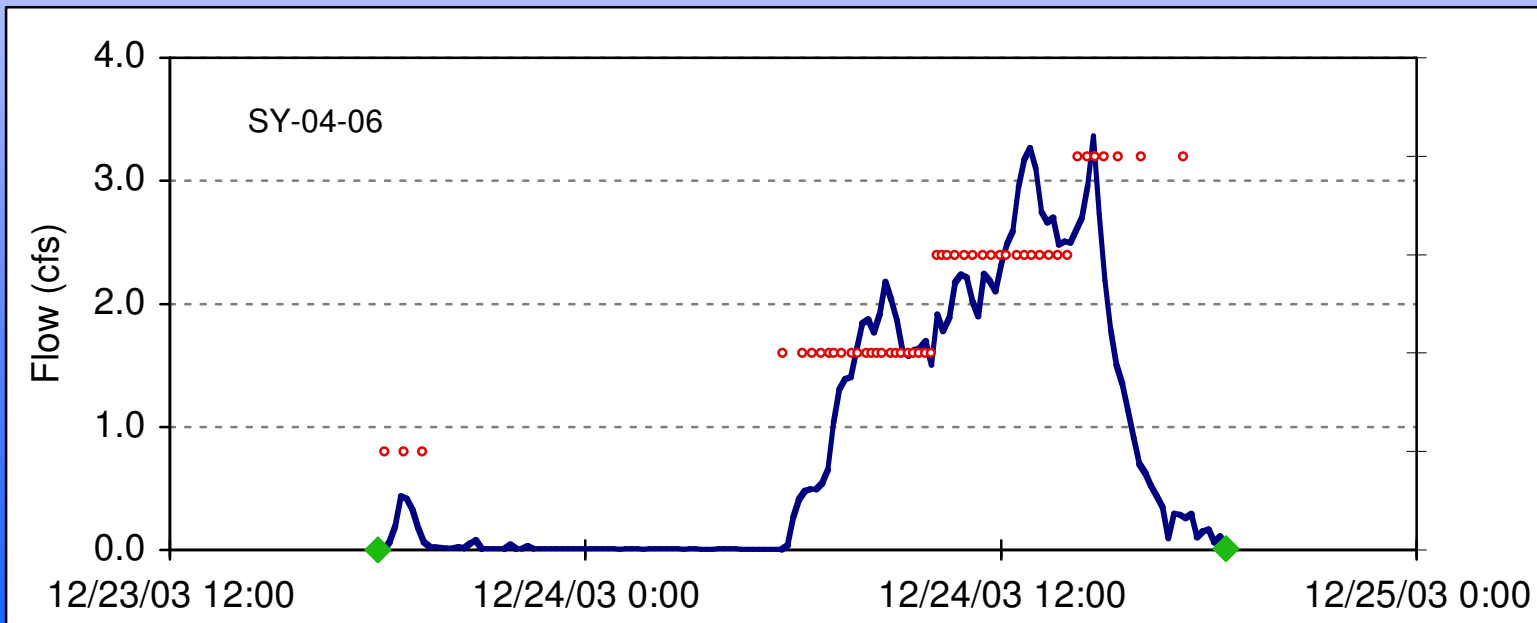
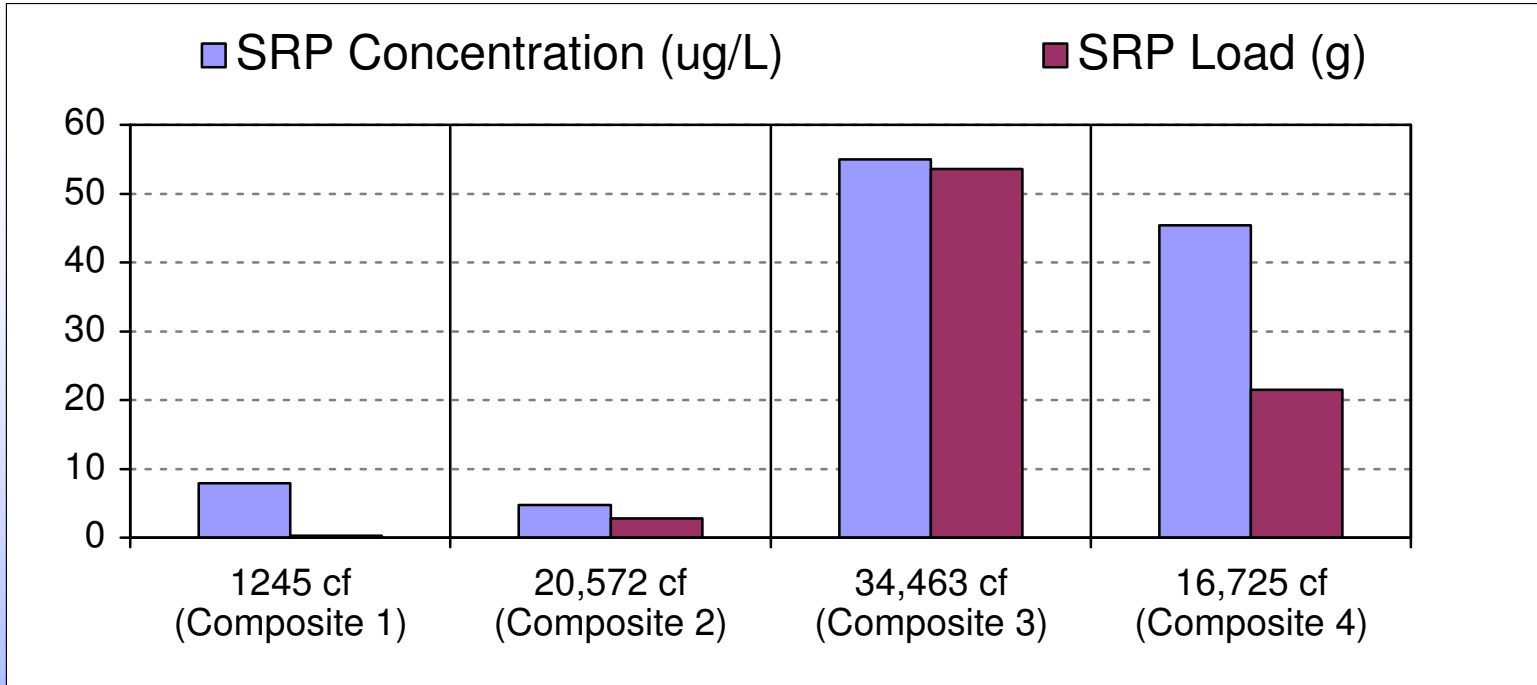














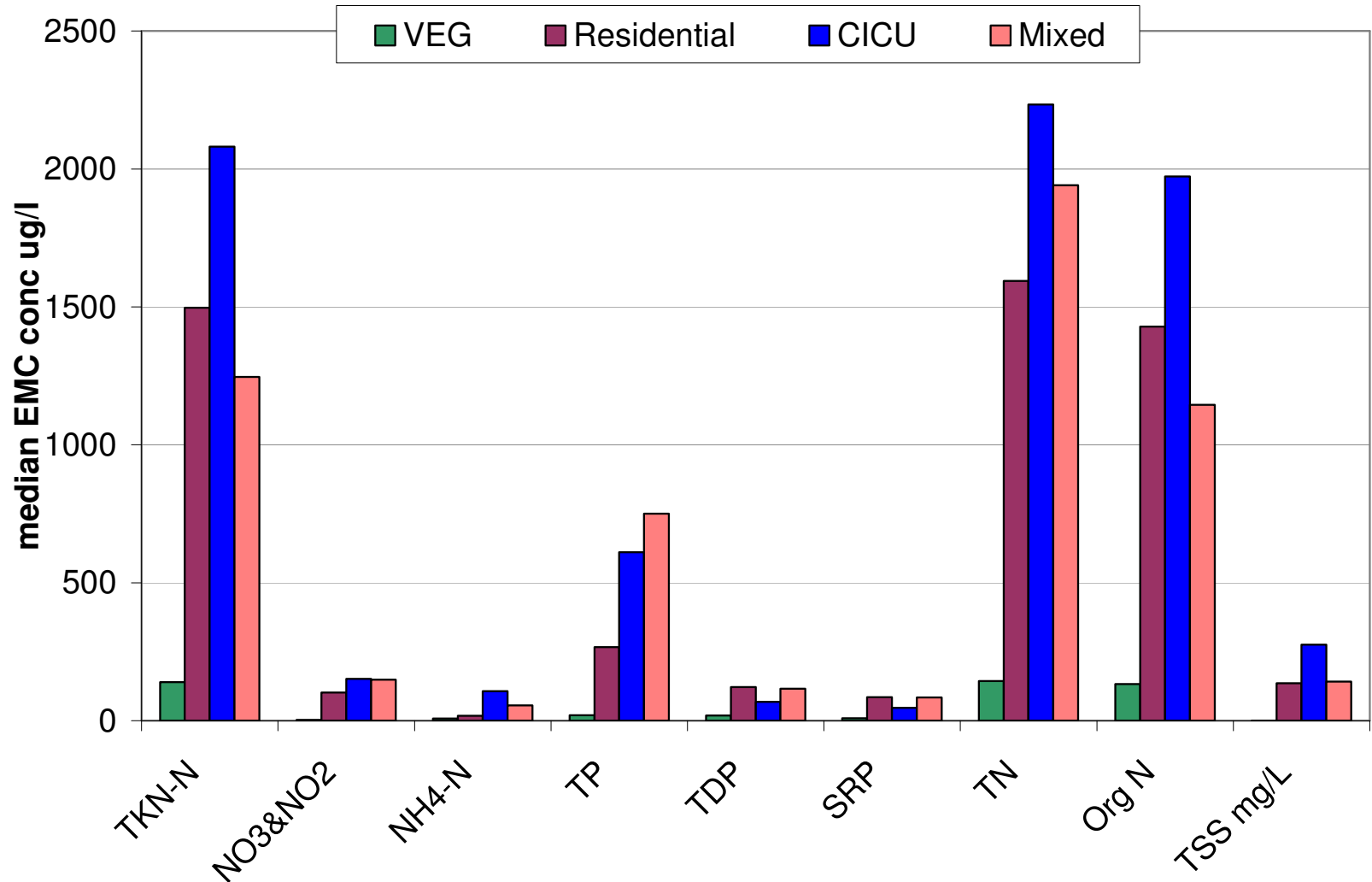
**Example:**  
**Results from the same runoff event in North Lake Tahoe (at SB) and in South Lake Tahoe (at SY)**

Event ID	Runoff Start (Date Time)	Runoff Duration (hh:mm)	Event Type	Runoff Volume (cf)	Peak Flow (cfs)	Sample Pacing Set	Samples Collected	Singles or Composites Analyzed
SB-04-04	12/23/03 20:35	23:30	rain/snowmelt	42,459	1.81	2000cf	24	3
SY-04-06	12/23/03 18:00	24:30	rain/snowmelt	73,004	3.37	500cf to 2500cf	54	4

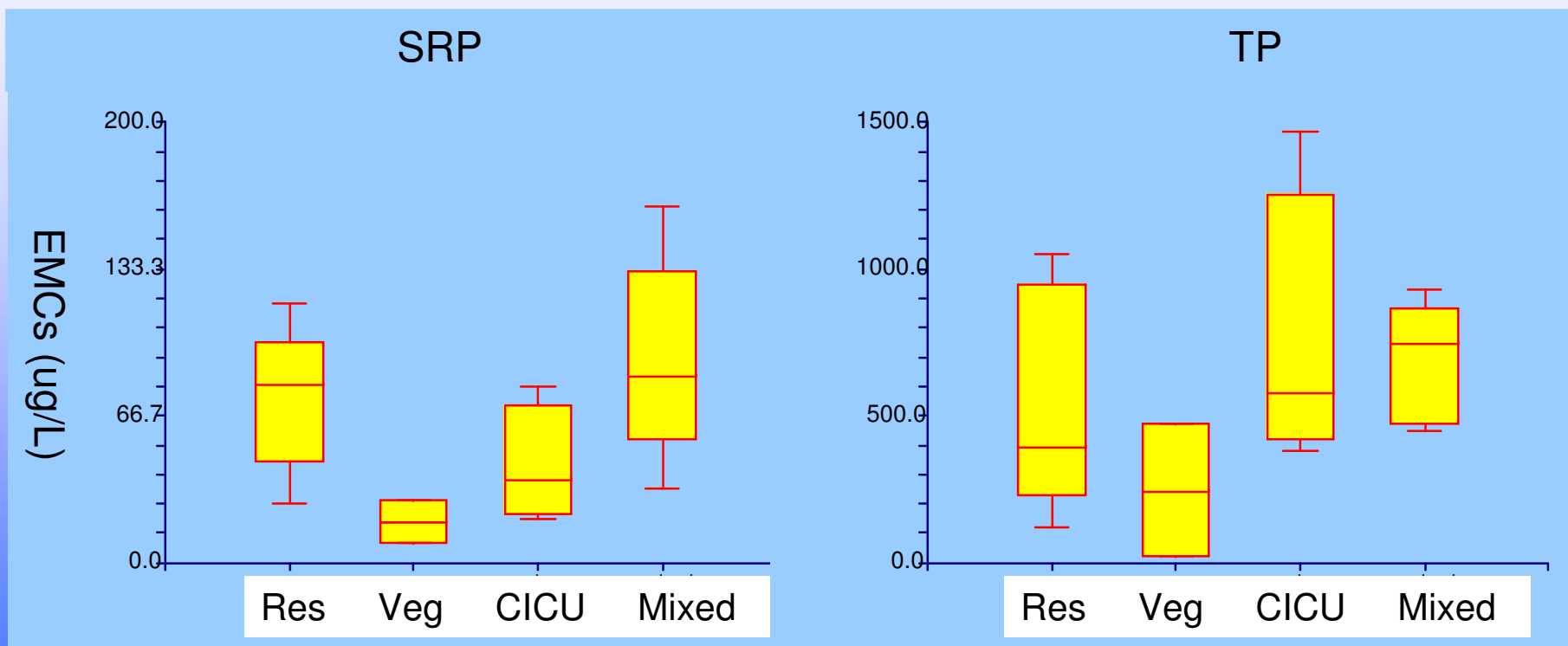
Event ID	Sampling Start (Date Time)	Average or EMC	Sampling End (Date Time)	TKN (ug/L)	NO3-N (ug/L)	NH4-N (ug/L)	TP (ug/L)	TDP (ug/L)	SRP (ug/L)	TSS (mg/L)	Turbidity (NTU)
SB-04-04	12/23/03 20:48	EMC	12/24/03 14:16	3,439	33	11	1,265	85	80	324	316
SY-04-06	12/23/03 18:11	EMC	12/24/03 17:15	3,719	72	43	988	40	38	280	298

Note: dataset continues thru event SB-04-32

# Median of EMCs for sites with dominant land use

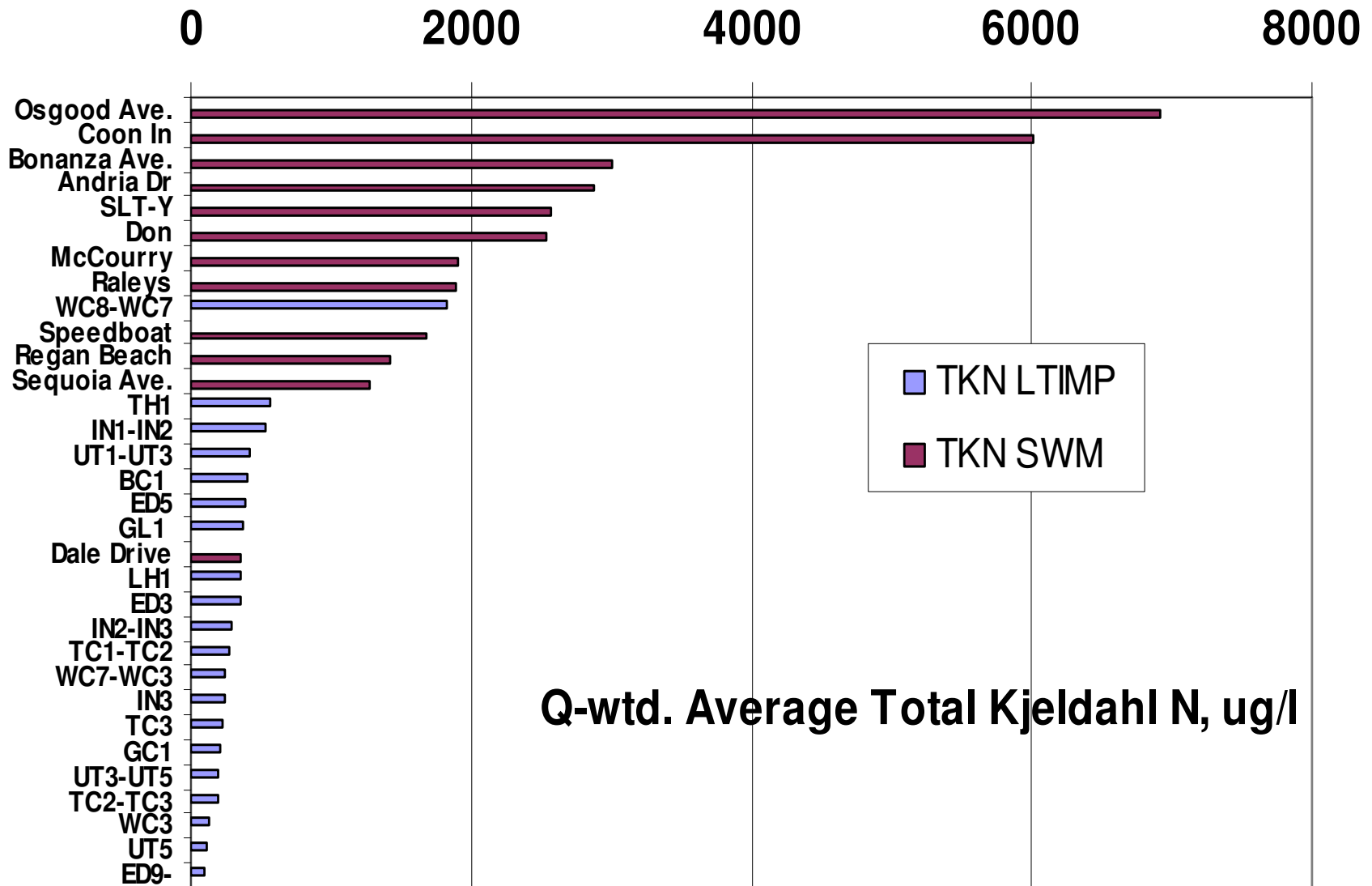


# Distribution of EMCs for orthophosphate and total phosphorus at sites grouped by dominant land use

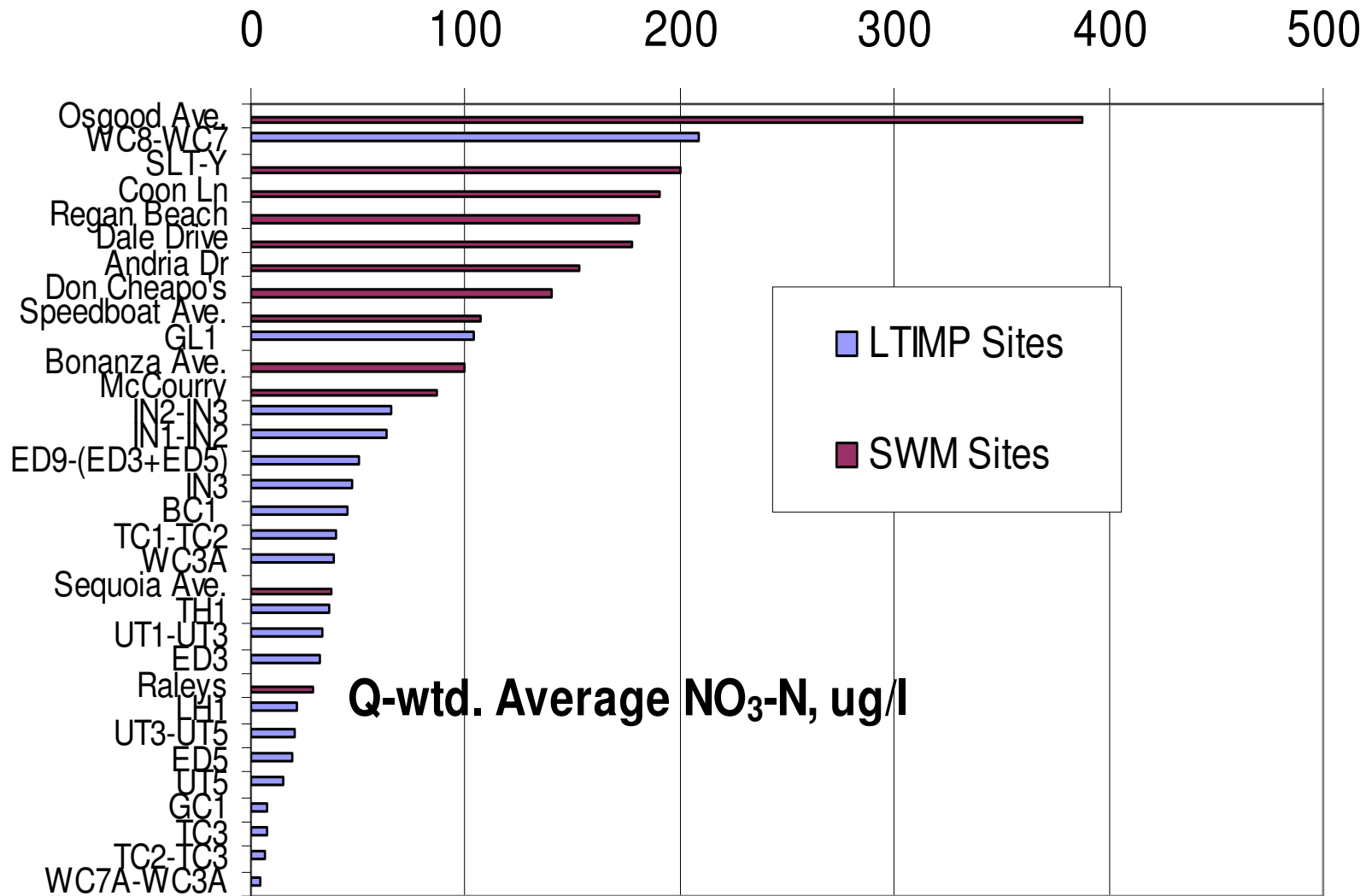


TMDL data WY03-04

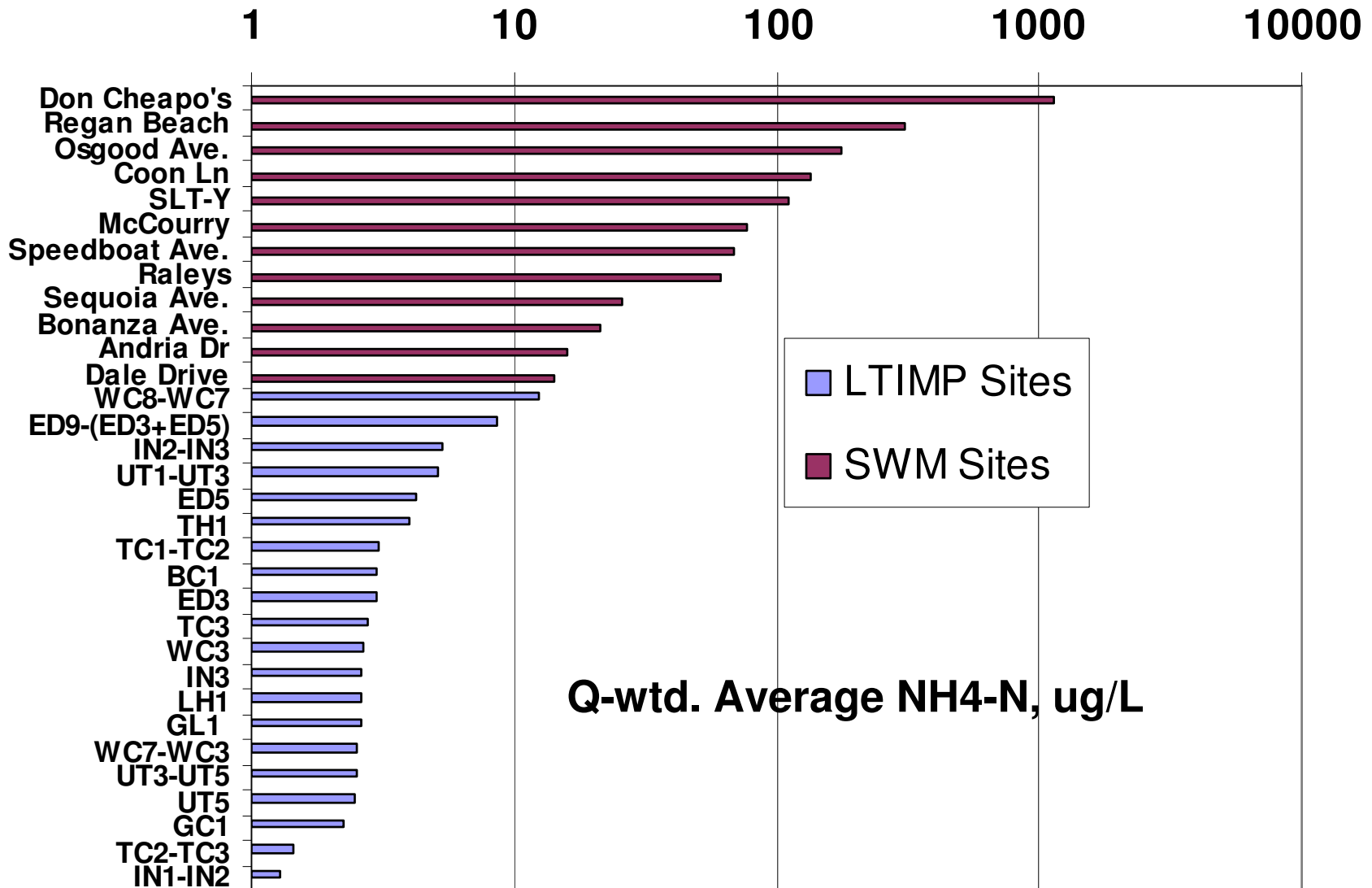
# Total Kjeldahl Nitrogen (ug/L)



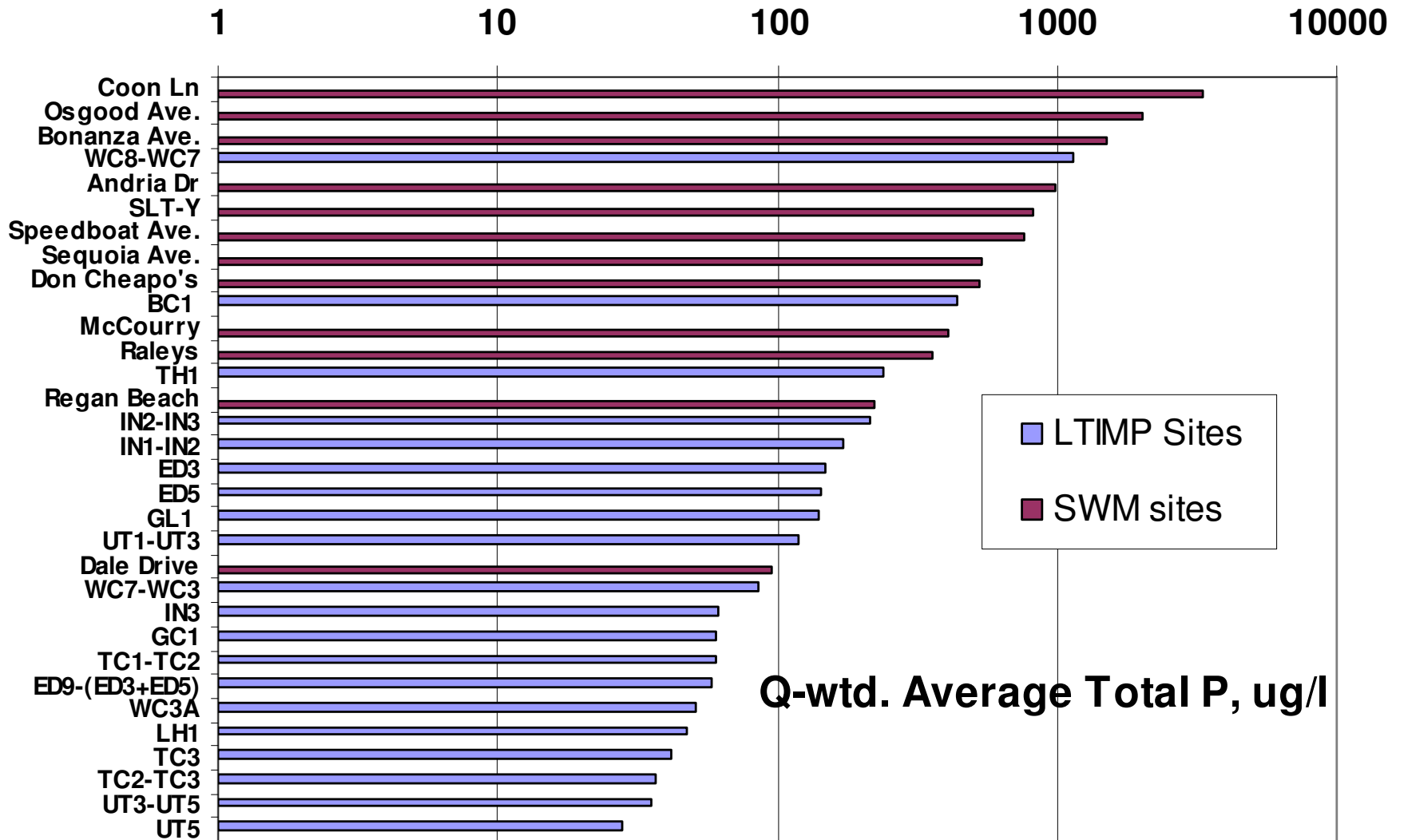
# Nitrate (ug/L)



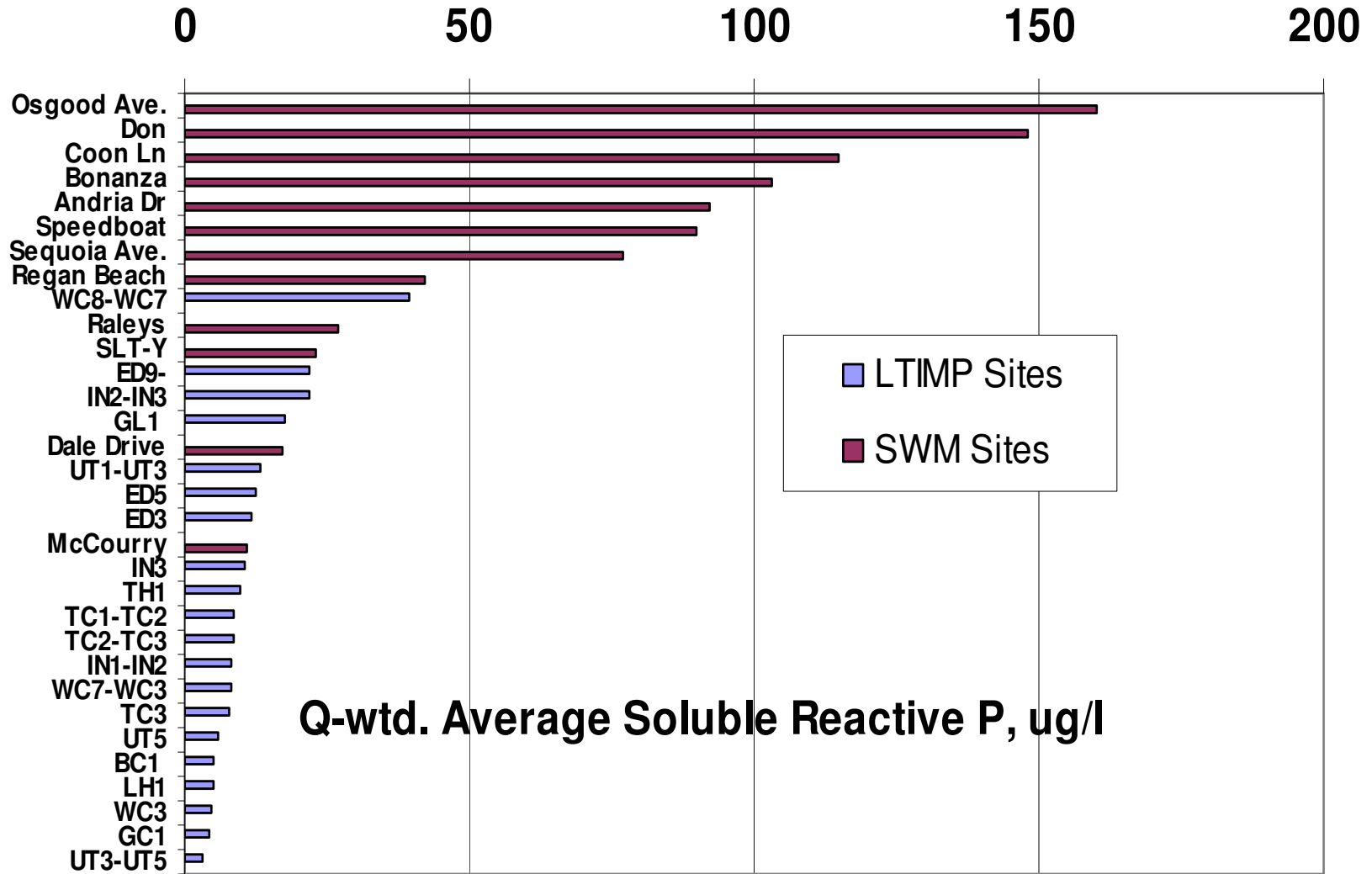
# Ammonium (ug/L)



# Total Phosphorus (ug/L)

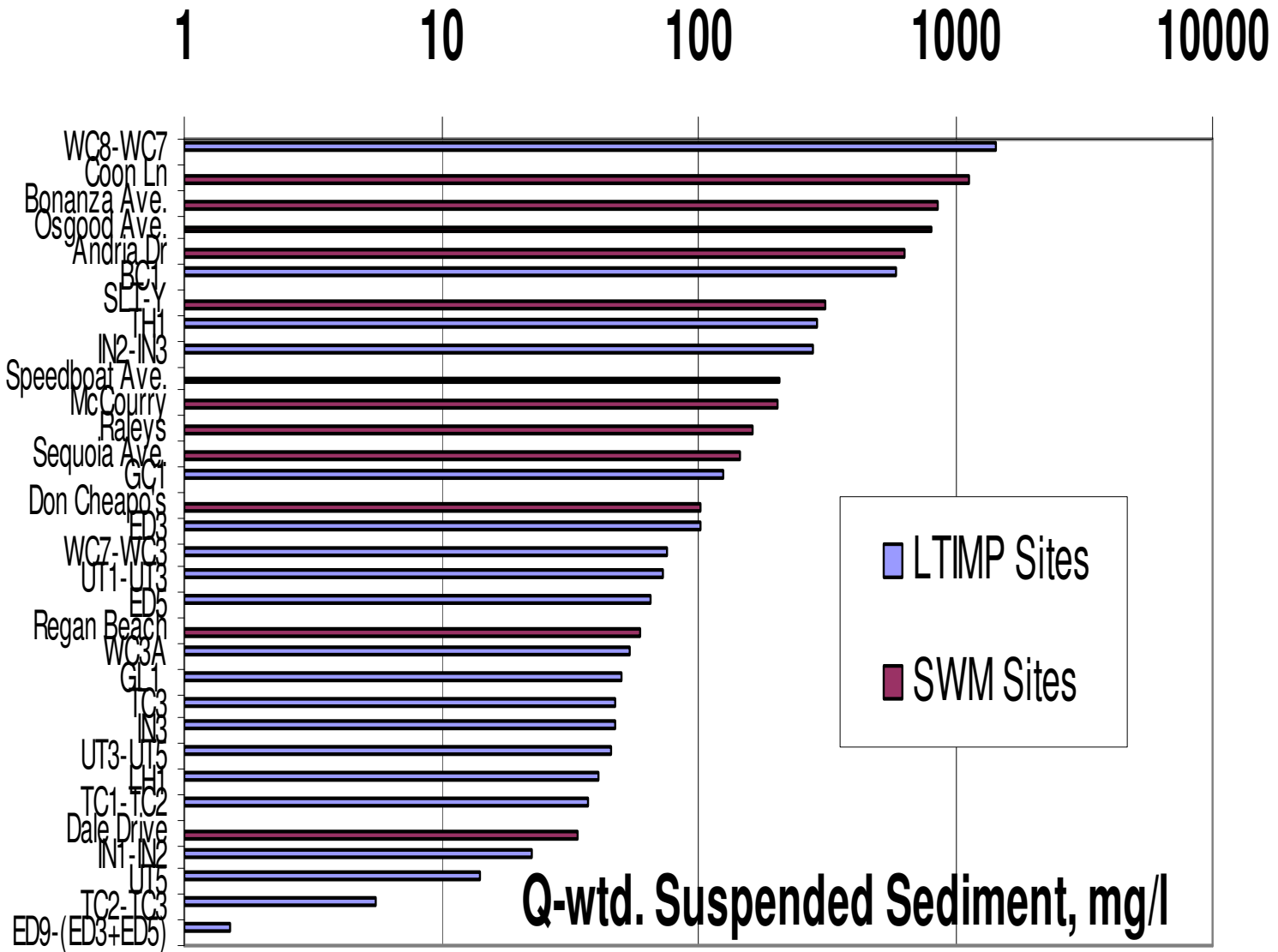


# Orthophosphate (ug/L)





# Suspended Sediment (mg/L)



# Multiple Regressions

- ❖ Use correlations to select variables.
- ❖ Multiple regression models for each constituent.
- ❖ Cross-validate models.

# Multiple Regression

Dependent Variable	Independent Variables
Total Nitrogen	% Coverage by Land Use
TKN-N	Average Percent Slope
NO3-N	Catchment Area
NH4-N	Avg Precipitation per Year
Organic Nitrogen	Percent Impervious Cover
Total Phosphorus	Erosion Hazard
Total Soluble Phosphorus	Residential Lot Density
OPO4 (SRP)	
TSS	

# Correlations between variables

	Land Use Proportions					Erosion Hazard			Density			Catchment Characteristics			
	SFR	MFR	CICU	Roads	VEG	Slight	Mod	High	D-SFR	D-MFR	D-RES	IMP C	Slope	Precip	Area
TN			X		X							X			
Org N			X		X										
TKN			X		X							X			
NO3+NO2			X					X		X	X	X	X		
NH4	X		X			X	X	X		X	X	X	X	X	
TP					X				X		X				
TDP	X			X	X										
SRP	X			X	X			X							X
TSS															

alpha = 0.1

# TMDL Stormwater Monitoring Program

- ❖ Established a network of urban stormwater runoff monitoring stations around Lake Tahoe.
- ❖ Provided WY03 and WY04 stormwater monitoring data in a consistent format for reporting and analysis.
- ❖ Have begun a statistical analysis of the stormwater data for characterization of independent variables that strongly influence runoff water quality.
- ❖ Plan to refine monitoring program to include randomized sampling of runoff from areas with targeted variables, and to continue long-term monitoring at selected calibration sites.