Portage and Arcadia Creek Water Quality Monitoring

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INTRODUCTION

A Watershed Management Plan (WMP) was developed for Portage Creek and Arcadia Creek in the south central portion of the Kalamazoo River Watershed. The project was funded for a two-year period beginning July 1, 2001 by a Nonpoint Source Pollution Grant under Section 319 of the Clean Water Act (CWA). The Michigan Department of Environmental Quality (MDEQ) approved the WMP in July 2003. A critical element of the planning process involved monitoring in-stream water quality. The following report summarizes water quality monitoring data that was critical to the creation of the WMP. These data also serve as a baseline for tracking water quality improvements through plan implementation and for future monitoring. A previous data report was prepared by Kieser & Associates (K&A) for Portage Creek and is included as Attachment A for reference.

BACKGROUND

The watersheds of these two streams encompass 43,700 acres within the Cities of Kalamazoo and Portage, and Oshtemo, Texas, and Kalamazoo Townships in Kalamazoo County. These streams discharge to the Kalamazoo River within the City of Kalamazoo (Figure 1). Two major tributaries flow into Portage Creek (e.g., West Fork Portage Creek and Axtell Creek) before it joins with the Kalamazoo River. Thus, there were four individual drainage areas monitored (Arcadia Creek, Axtell Creek, Portage Creek, and the West Fork of Portage Creek) during dry and wet weather conditions during the course of this project.

Portage Creek

The Portage Creek Subwatershed lies within the Cities of Portage and Kalamazoo and in Texas Township, with the majority flowing through the City of Portage (Figure 2). This 12.5 mile creek begins west of US-131 in Texas Township at Hampton Lake. After exiting this lake the creek then flows in a northeast direction, through most of the City of Portage before turning north through the City of Kalamazoo, and into the Kalamazoo River. Several impoundments exist within this watercourse both in Portage and the City of Kalamazoo. Two significant urban drains, the Schuring and Consolidated Drains, contribute flow to Portage Creek in the City of Portage near South Westnedge Avenue. Both the West Branch of Portage Creek and Axtell Creek (each considered as separate subwatersheds in this project) flow into Portage Creek within the City of Kalamazoo. The portion of the creek from the Bryant Mill Pond to the Kalamazoo River is listed on the USEPA's Superfund National Priorities List for PCB contaminated sediments.

Only 678 acres out of the 16,067 acres in the Portage Creek Subwatershed do not contribute overland flow to the creek under any conditions but do contribute water to lakes and groundwater. These non-contributing areas are typically due to municipal and private stormwater retention basins in the subwatershed. The lands draining to the creek include land uses of approximately 21.3% urban, 52.4% open space and forest, 3.1% water/wetlands and 23.2% agriculture.

Arcadia Creek

The Arcadia Creek Subwatershed lies within portions of Oshtemo Township and the City of Kalamazoo (Figure 3). This subwatershed flows mostly in an easterly direction, with the headwaters of Arcadia Creek starting west of 11th Street, in the southeastern portion of Oshtemo Township. The watercourse then flows through the western portion of the City of Kalamazoo, roughly parallel with Stadium Drive and on through to the downtown area before finally discharging to the Kalamazoo River. For much of its length into the city, a railroad bed lies beside the creek

Over 6,300 of the approximately 10,971 acres in the Arcadia sub-watershed do not contribute overland flow to the creek. These non-contributing areas are found within the western-most portion of the subwatershed, in eastern Oshtemo Township and western Kalamazoo. During rainfall events approximately 4,600 acres contribute storm water to the creek from direct surface runoff and storm sewer connections.

The drainage area includes land uses of approximately 42% urban, 45% open space and forest, 4% water/wetlands and 9% agriculture. Within the City of Kalamazoo portion of the subwatershed, curb and gutter systems direct storm water to storm sewers that collect, transport and discharge storm water directly into the creek. Virtually all 5.5 miles of the creek receive storm water contributions from lightly to heavily urbanized areas within the City of Kalamazoo.

A closer look at the flow path of the creek reveals that it first flows through a vegetated ditch, then is piped underground to emerge east of Drake Road into a small pond prior to discharging into another small channel. From there, the water course continues in a narrow channel, parallel to railroad tracks, through scrub vegetation and behind a mobile home community. The creek then flows through a wetland, a City well field and into another ecologically disjunct area having uplands and wetlands with vegetation of a unique composition. The creek next passes under Stadium Drive, through the Kalamazoo Christian High School property then under Howard Street to Western Michigan University (WMU) property where it follows a series of shallow "S" curves passing back and forth under Stadium Drive (four times). Near WMU's Waldo Stadium additional storm water flow contributions from the WMU Goldsworth Valley pond and other WMU outlets enter the creek, where it is piped underground until emerging at Lovell Street and the Kalamazoo College campus. It is within this area that exists a “pinch point”, or flow restriction associated with the limiting size of this underground culvert, which periodically causes flooding. Except for being piped under several roads, the creek remains at the surface through this stretch, flowing within a constricted narrow, steep-sided channel with stone-lined banks. Piped under South Westnedge Avenue, the Creek emerges into a concrete-lined, open box channel to flow into a sediment detention pond at the Arcadia festival site. Overflow is then directed and conveyed underground to the discharge point at the Kalamazoo River approximately 0.2 miles away.

West Fork of Portage Creek

The drainage area for the West Fork of Portage Creek includes portions of Texas Township, Oshtemo Township, the City of Portage and the City of Kalamazoo (Figure 4). The creek flows for approximately 8.1 miles in a generally northeast to east direction from its headwaters at Scouters Pond in Texas Township to Portage Creek close to Milham Park in the City of Kalamazoo. Several impoundments and small lakes exist within the water course. The West Branch flows through the Rota-Kiwan Boy Scout Reservation, Kalamazoo Valley Community College, the Al Sabo Preserve (well field for the City of Kalamazoo), and suburban residential areas in the southern area of the Parkview Hills. Water stemming from the Asylum Lake area also connects to the West Branch through a series of small, linked ponds and wetlands within and near Parkview Hills. From here the stream flows through more ponds, residential neighborhoods, a City of Kalamazoo well field, commercial properties in the Cities of Portage and Kalamazoo, to the Blanch Hull Preserve and the confluence with Portage Creek.

Of the 15,170 acres in the West Branch of Portage Creek Subwatershed, slightly more than one-half (8,778 acres) were determined to contribute direct surface runoff and/or storm sewer flow to the creek. The non-contributing areas include municipal retention basins (primarily in the City of Portage), and private retention areas, Whites Lake in Kalamazoo, Crooked, Eagle, Duck and Pretty Lakes in Texas Township, and approximately 5,800 acres of rural, non-sewered land within the headwater areas of this subwatershed. The contributing drainage area includes land uses of approximately 18.3% urban, 50.7% open space and forest, 7.7% water/wetlands and 23.5% agriculture. Drinking water pumping stations are known to impact the surface water levels and lower them during drought periods. This is primarily observed in the tailwaters of the creek immediately upstream of South Westnedge Avenue.

Axtell Creek

The Axtell Creek Subwatershed lies entirely inside of the City of Kalamazoo (Figure 5). There are 1,519 acres in this subwatershed, located within the west-southwest portion of the city. Greater than one-half of this acreage, including the areas surrounding Pikes Pond, Kleinstuck Marsh, Whites Lake and Woods Lake, do not contribute surface water flow to the creek. The land uses of the contributing drainage area are approximately 48% urban, 45% open space and forest, 4% water/wetlands and 3% agriculture. The artesian headwaters of Axtell Creek are found within the City of Kalamazoo Well Field #4, at the intersection of Maple Street and Crosstown Parkway. Pressure relief overflow from active wells provides a significant contribution to the base flow of the creek in this area. Above the headwaters, there are storm sewers that collect and discharge storm water into the creek near the headwaters. The stream flows 1.24 miles from the well field through a channel along Crosstown Parkway to a series of large, shallow recharge ponds (known as the Crosstown Ponds) before discharging to Portage Creek. Over portions of its length, small sections of the creek are piped underground, primarily under roadways. Most of the watershed is residential and commercial. Mowed landscapes surround the ponds. Additional contributions to flow are from the fountain at the intersection of Howard Street and Crosstown Parkway, the ponds at Crosstown Apartments and storm sewers outlets. The confluence of Axtell Creek with Portage Creek is located within Upjohn Park. Portage Creek ultimately discharges to the Kalamazoo River, approximately 1.75 miles beyond its confluence with Axtell Creek.

METHODS

A QAPP plan was submitted to and approved by the MDEQ prior to commencement of monitoring on this project. This section describes various monitoring efforts originally outlined this QAPP.

Grab Sampling

Twenty-six grab sample stations were established throughout these subwatersheds The City of Portage contributed to add an additional 5 stations to the upstream sections of Portage Creek within their City boundaries (Attachment A). Sampling stations were numbered in sequential order from the confluence of each subwatershed to its headwaters due to a sequential upstream sampling order. Stations were distributed as follows:

- 13 stations in Portage Creek (PC) (Figure 2)
- 7 stations in Arcadia Creek (AC) (Figure 3)
- 5 stations in West Fork Portage Creek (WF) (Figure 4)
- 3 stations in Axtell Creek (AX) (Figure 5)

Water quality measurements and samples were obtained at these stations from flowing water by wading or reaching into the stream from the banks or bridges.

Flow was calculated at select grab stations by measuring the geometry of the creek and the cross-sectional velocity across the creek. These data were incorporated with available USGS flow station data to track flow accrual through the subwatersheds.

Field personnel also divided each of the 4 watercourses into “stretches” based on similar land use and habitat quality as defined by a WMP survey and numbered from the headwaters to the confluence of each watercourse. They are represented by numbers in Tables 1 and can generally be approximated on the maps provided (Figure 2-5). The “stretch” concept was independent of the sampling station layout, but was used as an organizational tool to discuss watershed management priorities and target areas of concern. These stretch numbers were relied upon heavily by the WMP steering and technical committees and can be cross-referenced within the final WMP.

Automated Sampling

Sampling stations were established at the mouths of Arcadia Creek (AC 0) and Portage Creek (PC 0) in order to assess subwatershed wide loading to the Kalamazoo River. Axtell Creek and the West Fork of Portage Creek both flow into Portage Creek.

Therefore, the station at the mouth of Portage Creek was representative of loading from these three subwatersheds. Automated-Samplers (ISCOs) were installed at these two creek mouth stations. They recorded water level readings on ten-minute intervals and recorded precipitation information from tipping-bucket rain gauges. Additional rain gauge information was collected from a network of rain gauges located throughout the watershed associated with monitoring of the Consolidated Drain, Portage, Michigan (K&A; 2003). The ISCOs also were programmed to collect water samples during selected wet and dry weather periods.

Sampling Schedule

Samples were collected from these stations during seasonal events. One dry weather and one wet weather event were monitored for each season of the project. Dry weather baseline samples were collected on December 10, 2001, February 25, 2002, June 17, 2002 and September 4, 2002. Wet weather events were monitored on November 27, 2001, March 8, 2002, May 8, 2002 and September 20, 2002. Grab sample stations and ISCOs were monitored on the same days. In addition, five dry weather and six wet weather events were monitored at the ISCOs only.

Sampling Protocols

The QAPP was approved by the MDEQ in 2001. Sampling activities associated with Section 319 funding followed the procedures laid out in that plan. Monthly internal audits were completed to assure that field equipment was properly maintained. Performance audits were also completed upon receipt of analytical data, to check the results returned by the analytical laboratory.

All collected samples were analyzed for TSS and TP unless sample volume was limited. In addition, 25% of the collected samples were analyzed for Soluble Reactive Phosphorus (SRP). SRP and TP were analyzed by the Upstate Freshwater Institute of Syracuse, NY. TSS samples were analyzed by KAR Laboratories of Kalamazoo, MI. Field parameters including pH, dissolved oxygen, conductivity and temperature, were measured at the grab samples stations.

RESULTS

Water Quality Sampling

It was expected that TP and TSS concentrations and conductivity would generally increase from headwater areas downstream due to increasing contributions from stormwater runoff in developed areas of the watersheds. Deviations from this expected trend were identified as areas of potential loading. Additionally, concentration spikes observed during dry weather events could signal illicit connections to the storm sewer system. Analyte concentration vs. stream mile were plotted for all subwatersheds for wet and dry events (Attachment B). Flow and concentration vs. time at the mouths of Portage and Arcadia Creek were also plotted (Attachment C). Both plots were periodically published on the project website as they became available.

Basic assessments of "good" and "poor" water quality were determined during wet and dry weather organized by WMP "stretch" number for a quick reference and overview. Table 1 provides K&A synopsis of these observations. Good refers to the stations where effects of stormwater loading were minimal under wet weather conditions whereas poor water quality suggests noticeable and/or significant water quality impacts related to wet weather data. Similar comparisons are accurate for dry weather conditions. A "Selected Upstream Features" column in Table 1 identifies the most likely sources contributing to water quality characteristics.

Summary details of each watercourse are listed as follows.

Portage Creek (Table 1a)

- Temperature increases associated with Pharmacia cooling water discharge have generally been mitigated with recent partial diversion of the discharge away from the creek in Stretch #9.
- Low dissolved oxygen levels are periodically noted in the Oakland Drive area (Stretch #2) associated with stagnant conditions and warmer temperatures.
- Residential, commercial and/or transportation activities at and above Centre Ave. (Stretch #5) are contributing higher levels of wet and dry weather TP.
- Schuring Drain, adjacent to the Consolidated Drain, (Stretch #8) is still a large contributor of total phosphorus and suspended solids during wet weather.
- Milham Park (Stretch #10) shows wet weather increases of total phosphorus and total suspended solids associated with storm water outfalls, sheet flow runoff and severe bank erosion.
- Storm sewered sections of Portage Creek through the City of Kalamazoo are substantially impacted by storm water contributions (Stretches 16-18) as evidenced by flashy flow and pollutant load at the mouth of Portage Creek (Attachment C).
- Summary: The headwaters of Portage Creek are affected by isolated local inputs. The middle sections of Portage Creek are increasingly affected by stormwater inputs during wet weather due to increased urbanization, particularly at road crossings and the heavily managed Milham park. The downstream sections of Portage Creek (primarily in the ultra-urban city of Kalamazoo) are highly vulnerable to stormwater runoff.

Arcadia Creek (Table 1b)

- Dry weather total phosphorus loading through downtown City of Kalamazoo areas is notable; especially downstream of the Arcadia Creek Festival Site Pond (Stretch 16). In addition, highly variable upstream sampling on June 17, 2002 suggests the possibility of illicit connection effects during this time of low flow in the creek (Stretches 6 and 14).

- Dry weather dissolved oxygen generally drops slightly in areas downstream of the Arcadia Creek Festival Site Pond during wet and dry weather (Stretch 16).
- The Arcadia Festival Site Pond functions as a nutrient sink during wet weather low flow and as a source during both dry weather low flow and wet weather high flow.
- Wet weather total phosphorus concentrations are elevated in middle stretches (10-15). Wet weather flow increases in a similar manner. Variation likely reflects local intensity of stormwater input from the various sources in this drainage at the time of sampling. Dense urban areas load higher concentrations of phosphorus and sediment.
- Extremely flashy flows and pollutant loads, due to the ultra-urban downtown Kalamazoo area, are evident at the mouth of Arcadia Creek (Attachment C).
- Summary: Upstream areas (above the downtown channel) receive significant urban stormwater inputs which exacerbate pollutant loads, high flashy flows and flooding conditions. Corridor areas are subject to severe streambank erosion and poor riparian management. Ultra-urban storm water contributions are evident through downtown areas. Evidence also suggests that illicit connections may be impacting water quality.

West Fork of Portage Creek (Table 1c)

- Some wet weather increase in total phosphorus noted near Oakland Drive (Stretch 4).
- Concern exists from recent persistent lack of dry weather flow downstream of S. Westnedge Avenue which could possibly be attributed to groundwater pumping from the Kalamazoo well field and drought conditions.
- Summary: Good water quality was observed through most of the stream reaches until downstream reaches in commercial areas near S. Westnedge Avenue and Kilgore Avenue where notable wet weather increases in total phosphorus and total suspended solids are observed (Stretch 8-10).

Axtell Creek (Table 1d)

- Baseline dry weather upstream concentrations of total phosphorus are elevated compared to other creeks (Stretches 1-3).
- High dry weather total phosphorus concentrations are noted immediately above Crosstown Ponds and may indicate a potential illicit discharge or a resident waterfowl population (Stretch 4).
- Substantial total phosphorus and total suspended solid wet weather loads enter the creeks above the Crosstown Ponds from urban storm sewers (Stretch 4).
- Ponds appear to generally serve as 'sinks' of phosphorus and solids (Stretch 5).
- During summer months, Crosstown Ponds warm the stream substantially (Stretch 5).
- Summary: Evidence suggests that Axtell Creek water quality is vulnerable to human and resident waterfowl activity in its highly urbanized, steep-sided valley during both dry and wet weather.

Flow at Portage Creek 0 and Arcadia Creek 0

Stream flow at the ISCO sample stations Portage Creek (PC 0) and Arcadia Creek (AC 0) was calculated based on relationships between water elevation and streamflow. Stage-discharge cross-sectional measurements were conducted at the Portage ISCO in order to establish a relationship between measured 10-minute water elevation and flow (Figure 6). A 2-stage weir was installed at the Arcadia ISCO sample location in order to accurately measure water elevation. The stage-discharge relationship was calculated based on the dimensions of the weir and Arcadia flow characteristics at the outfall (Figure 7). The resulting flows converted from measured levels for Portage and Arcadia Creek during the entire study period can be seen in Figure 8 and Figure 9 respectively.

Graphs of individual events illustrate the responses of TP and TSS concentrations to creek flow (Attachment C). During wet weather, rapid changes in streamflow coincide with dramatic differences in concentration. During dry weather, relatively consistent concentrations reveal dry weather stability.

Portage Creek baseflow had two characteristic periods (Figure 8). The first occurred during the first half of the study between November 2001 and June 2001. During this time, baseflow was elevated (> 40 cubic feet per second cfs) due to wet Spring weather conditions. Winter 2002 and early Spring 2002 rainfall and snowmelt events produced relatively small peak flows compared to the much larger peak and baseflows seen in late Spring 2002 and early Summer 2002. The second distinctive time period began around July 1, 2002 when baseflows dropped to 30-40 cfs but storm events continued to cause dramatic increases in flow by as much as 10-fold. By the end of the study period, baseflow was again increasing in early Spring 2003.

Arcadia Creek flow (Figure 9) was more consistent than Portage creek and was steady at 2-4 cfs. However, storm events regularly caused rapid increases in flow (i.e., 200-300 fold). Arcadia Creek's highly impervious urban watershed drives its very flashy flow characteristics.

Flow and pollutant concentration regressions were calculated for Portage and Arcadia Creek for TSS and TP. Two regressions were developed for Portage Creek to apply to the two distinct flow periods for TP (Figure 10) and TSS (Figure 11). Eight wet weather events measured at the Portage ISCO were used. Of the ten measured events, two were grouped as one event because they occurred within a close time span of one another; and one event was based on snow melt runoff.

A single regression defines the relationships for Arcadia Creek flow to TP (Figure 11) and TSS (Figure 12). Events were consistent with these exceptions: one event was based on snowmelt; one event was based on pond dredging and not considered "natural" wet or dry; and one event was not completely monitored. During the latter event, the weir constructed at the Arcadia Creek outfall broke. Very high creek flows (over 200 cfs) were measured before the weir collapsed, illustrating the hydraulic behavior of an urbanized watershed. The graph of this event illustrates a sharp rise in flow measured before the weir broke.

Loading

Each 10-minute flow value was multiplied by the corresponding pollutant concentration value (from the appropriate regression) to calculate instantaneous load. The instantaneous loads were converted to 10-minute loads then summed by period of interest.

Entire Study Period (November 2001 to April 2003)

Portage Creek loading for the entire study period totaled 2,075 tons TSS and 13,603 lbs. TP. Arcadia Creek loading for the same period totaled 449 tons TSS and 2,385 lbs. TP (Table 2).

Monthly loads for Portage Creek TSS and TP are plotted in Figure 14 and Figure 15, respectively. Arcadia Creek monthly loads are plotted in Figure 16 and Figure 17. From the monthly plots, loading for the year 2002 and also for time periods of interest for a Kalamazoo River/Lake Allegan phosphorus TMDL have been established.

Year 2002 Period (Calendar Year)

Portage Creek loading for the year 2002 totaled 1,460 tons TSS and 9,521 lbs. TP. Arcadia Creek loading for the same period totaled 403 tons TSS and 2,023 lbs. TP (Table 2).

Loading calculated by Kieser & Associates for Portage Creek based on drainage area, shape, and soil type results in estimates for Portage Creek TSS of 1673 tons and TP of 8,771 lbs. A loading estimate for Arcadia Creek results in estimates of TSS of 660 tons and TP of 4,100 lbs.

TMDL Periods of Interest

Sampling conducted by the MDEQ using automated sampling equipment in association with the Kalamazoo River/Lake Allegan TMDL effort estimated 1998 TP loads to the Kalamazoo River from Portage Creek at 1,078 lbs. during April-June and 606 lbs. during July-September (Table 3). K&A estimates during the same time periods for 2002 were 832 lbs. and 1,316 lbs respectively.

Very limited sampling conducted by the MDEQ estimated 1998 TP load to the Kalamazoo River from Arcadia Creek at 218 lbs. during April-June and 220 lbs. during July-September (Table 3). K&A estimates from extensive monitoring during the same time periods for 2002 were 152 lbs. and 338 lbs., respectively.

Although it is not possible to discern differences as related to land cover or weather changes, the project database suggests similarities with MDEQ estimates for 1998 and K&A model estimates for 2002.

REFERENCES

Kieser & Associates, 2003. *Monitoring of the Consolidated Drain and the City of Portage Stormwater Quality and Trailways Facility*. Final Report of Clean Michigan Initiative Project 1999-0025.

Table 1a. Portage Creek general water quality evaluation at stream sample stations distributed across the length of the stream. Stretchs were identified in a riparian corridor survey conducted during the watershed management planning process. Selected upstream features indicate watershed characteristics that likely influence water quality at each sampling station.

Stretch #	Representative Sample Station	Stretch Description	Selected Upstream Features	Good Wet	Good Dry	Poor Wet	Poor Dry
1	PC 13	Headwaters to Oakland Drive		x	x		
			Gourdneck State Game Area				
			Wetlands				
2	PC 12	Downstream of Oakland Drive			x	x	
			Golf course				
			Wetlands				
3	PC11	West end of Dogwood Trail					
			Wooded residential				
4	PC11	East end of Dogwood Trail and Creekside Commons					
			Encroaching residential				
5	PC11	Creekside Commons to Centre Avenue				x	x
			Light commercial				
6	PC10	City of Portage Bandshell			x	x	
			Commercial runoff				
			Centre Ave. crossing				
			Habitat rehabilitaton project				
7	PC9	Westnedge Avenue to Derk's Restaurant					
			Westnedge Ave. crossing				
			Commercial runoff				
			Channelized				
8	PC9	Derk's Restaurant to Garden Lane			x	x	
			Moderate riparian buffer				
9	PC8	Downstream of Garden Lane				x	x
			Garden Lane Crossing				
			Schuring/Consolidated Drain				
			Narrow riparian				
9	PC7	Romence Road		x	x		
			Recreational preserve				
			Naturalized park				
			Moderate riparian				
9	PC6	Gernatt Road				x	x
			Naturalized park				
			Pharmacia outfall				
9	PC5	Milham Road		x	x		
			Wide stream and riparian				
			Naturalized park				
10	PC4	Milham Park upstream		x	x		
			Naturalized park				
			Railroad encroachment				
	PC3	Milham Park downstream				x	x
			Waterfowl				
			Road crossing runoff				
			Bank erosion				
			Urban Park				

Table 1a continued

11	PC2	Blanch Hull Preserve and Monarch Mill Pond					
			Naturalized park				
			On-stream reservoir				
12	PC2	Cork Street to Alcott Street					
			Allied Paper Superfund site				
13	PC2	Alcott Street to Stockbridge Street				x	x
			Dilapidated industrial				
			Former Portage Paper Company				
14	PC1	Stockbridge Street to Lake Street					
			High density residential				
			Urban channelized				
15	PC1	Lake Street to Crosstown Parkway				x	x
			Urban channelized				
			Upjohn Park				
			Axtell Creek confluence				
16	PC0	Crosstown Parkway to Vine Street					
			Ultra-urban channelized				
17	PC0	Vine Street to Walnut Street					
			Ultra-urban channelized				
18	PC0	Walnut Street to confluence with Kalamazoo River				x	x
			Ultra-urban channelized				
			Fill material				

Table 1b. Arcadia Creek general water quality evaluation at stream sample stations distributed across the length of the stream. Stretchs were identified in a riparian corridor survey conducted during the watershed management planning process. Selected upstream features indicate watershed characteristics that likely influence water quality at each sampling station.

Stretch	Representative	Stretch	Selected	Good		Poor	
#	Sample Station	Description	Upstream Features	Wet	Dry	Wet	Dry
1	AC 7	West of Drake Road		na	na	na	na
			Non-contributing				
2	AC6	Pond east of Drake Road, north of Stadium Drive					
			On-stream stormwater pond				
3	AC6	Pond east end to Meadow View Mobile Home Park					
			Channelized, rail corridor				
			Urban debris, stormwater				
4	AC6	Meadow View to City of Kalamazoo Well Field #12					
			Channelized, rail corridor				
			Urban debris, stormwater				
5	AC6	City of Kalamazoo Well Field #12					
			Adjacent disconnected wetland				
			Wooded riparian				
6	AC6	Adams Outdoor Advertising property					
			Natural wetland area				
7	AC6	Second Reformed Church				x	x
			Preserved wetland area				
8	AC4	Kalamazoo Christian High School					
			Mowed riparian, on-stream pond				
			Waterfowl				
9	AC4	Howard Street to Stadium Drive					
			Wooded valley				
10	AC4	Amtrack rail, south of WMU					
11	AC4	West end WMU Power Plant Property					
			Mowed riparian				
12	AC4	East end WMU Power Plant Property					
			Bank erosion				
13	AC4	Near WMU Kanley Track			x	x	
			AC 5 WMU pond discharge				
14	AC3	Lovell Street to Academy				x	x
			Urban, channelized, downcut				
15	AC2	Academy to Elm					
			Urban, channelized, armored				
16	AC2	Arcadia pond inlet			x	x	
			Ultra urban, culvert				
16	AC1	Arcadia pond outlet				x	x
			Ultra urban, culvert				
16	AC0	Mouth				x	x
			Ultra urban, culvert				

na = not applicable, ponded water in this area does not flow downstream

Table 1c. West Fork Portage Creek general water quality evaluation at stream sample stations distributed across the length of the stream. Stretchs were identified in a riparian corridor survey conducted during the watershed management planning process. Selected upstream features indicate watershed characteristics that likely influence water quality at each sampling station.

Stretch	Representative	Stretch	Selected	Good		Poor	
#	Sample Station	Description	Upstream Features	Wet	Dry	Wet	Dry
1	WF5	Rota-Kiwan Camp and Al Sabo Preserve					
			Atwater Mill Pond				
2	WF5	12th Street to highway		x	x		
			Wooded valley				
3	WF4	Parkview Hills		x	x		
			Managed green space				
4	WF3	Parkview Hills to Oakland Drive		x	x		
			Ponds				
5	WF2	Along Timberlane Avenue					
			Light residential				
6	WF2	End of Timberlane					
			Wooded Valley				
7	WF2	City Well Fields to DeHaan Road					
8	WF2	Westnedge Avenue				x	x
			Lowes buried culvert				
			Ultra-urban stormwater				
9	WF1	Pratt Road and Candelwyk Apartments					
			Big Lots trash and snowmelt input				
			Stormwater inputs				
10	WF1	Blanche Hall Preserve to Portage Creek			x	x	

Table 1d. Axtell Creek general water quality evaluation at stream sample stations distributed across the length of the stream. Stretchs were identified in a riparian corridor survey conducted during the watershed management planning process. Selected upstream features indicate watershed characteristics that likely influence water quality at each sampling station.

Stretch	Representative	Stretch	Selected	Good		Poor	
#	Sample Station	Description	Upstream Features	Wet	Dry	Wet	Dry
1	AX3	Kalamazoo Well Field at Maple			x	x	
			Forested wetland				
			Residential runoff				
2	AX2	Maple Street to Howard Street					
			Channelized				
			Urban runoff				
3	AX2	Howard Street to Senior Apartments					
			Mown riparian				
			Urban runoff				
4	AX2	Apartments to Westnedge Avenue				x	x
			Commercial runoff				
			Urban runoff				
5	AX1	Crosstown Ponds					
			Bank erosion				
			Urban runoff				
			Dense waterfowl				
6	AX1	Jasper Street to Portage Creek				x	x
			Channelized				

Table 2. Monthly TSS and TP loading to Arcadia Creek and Portage Creek and monthly basin rainfall total.

	Arcadia Creek			Portage Creek		Basin
Date	*TSS (lbs)*	*TP (lbs)*		*TSS (lbs)*	*TP (lbs)*	*Rain (inches)*
Nov-01	307	16		12,821	77	
Dec-01	532	36		39,357	291	
Jan-02	1,407	42		-1,268	182	0.27
Feb-02	12,049	74		41,685	275	1.14
Mar-02	37,946	141		369,583	1,064	1.8
Apr-02	60,016	162		237,591	767	2.45
May-02	97,200	237		420,818	1,203	3.32
Jun-02	8,317	56		134,296	525	1
Jul-02	48,141	119		544,151	1,674	1.83
Aug-02	455,226	832		588,013	1,794	5.23
Sep-02	9,427	63		137,379	481	1.07
Oct-02	42,887	126		169,639	577	1.72
Nov-02	17,543	86		118,868	426	1.58
Dec-02	16,245	83		160,804	552	
Jan-03	807	38		60,383	255	
Feb-03	5,448	45		94,878	350	
Mar-03	8,395	60		299,420	961	
Apr-03	75,102	167		721,388	2,148	
2002 load	**806,404**	**2,023**		**2,921,559**	**9,521**	
Total load	**896,994**	**2,385**		**4,149,805**	**13,603**	

Table 3. Comparison of TMDL related loading from Portage and Arcadia Creek as measured by the MDEQ in 1998 and Kieser & Associates in 2002.

	Portage Creek TP Load (lbs)			**Arcadia Creek TP Load (lbs)**			**Basin**
Month	*DEQ 1998*	*K&A 2002*		*DEQ 1998*	*K&A 2002*		*2002 rain (inches)*
April	1618	767		215	162		2.45
May	1023	1203		223	237		3.32
June	593	525		215	56		1.00
Average	**1078**	**832**		**218**	**152**		**2.26**
July	612	1674		223	119		1.83
August	612	1794		223	832		5.23
September	593	481		215	63		1.07
Average	**606**	**1316**		**220**	**338**		**2.71**
Overall average	**842**	**1074**		**219**	**245**		

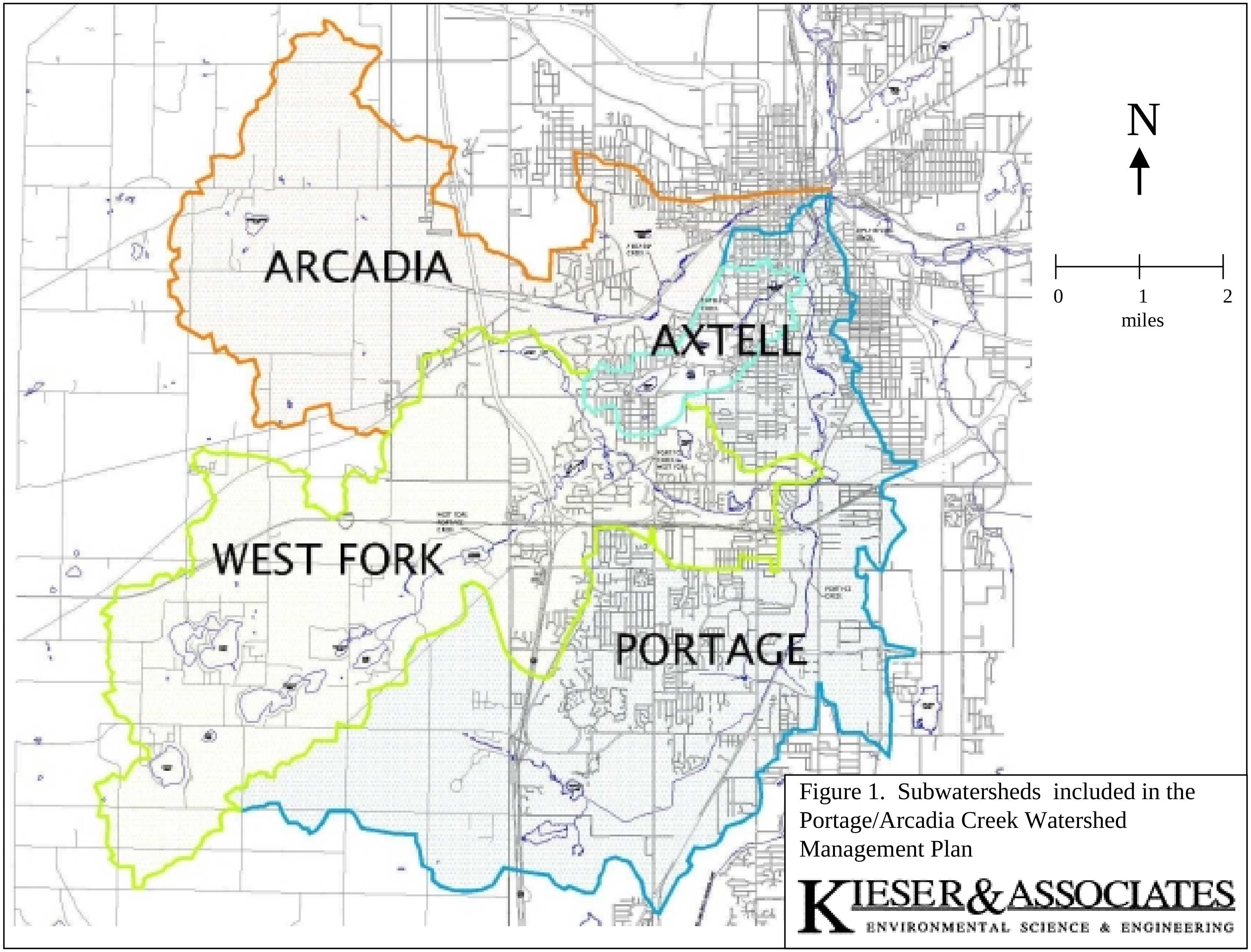

Figure 1. Subwatersheds included in the Portage/Arcadia Creek Watershed Management Plan

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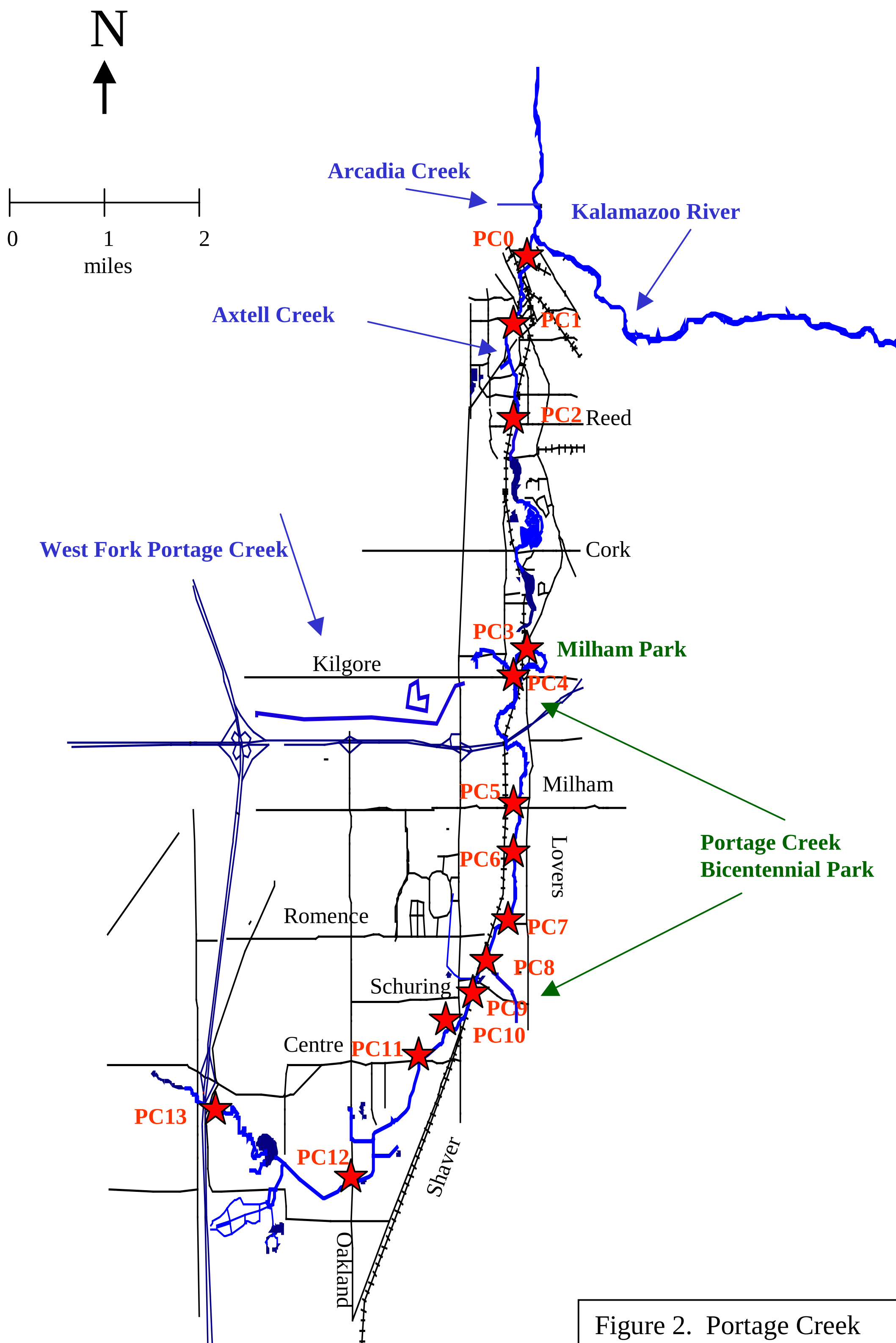

Figure 2. Portage Creek sampling stations

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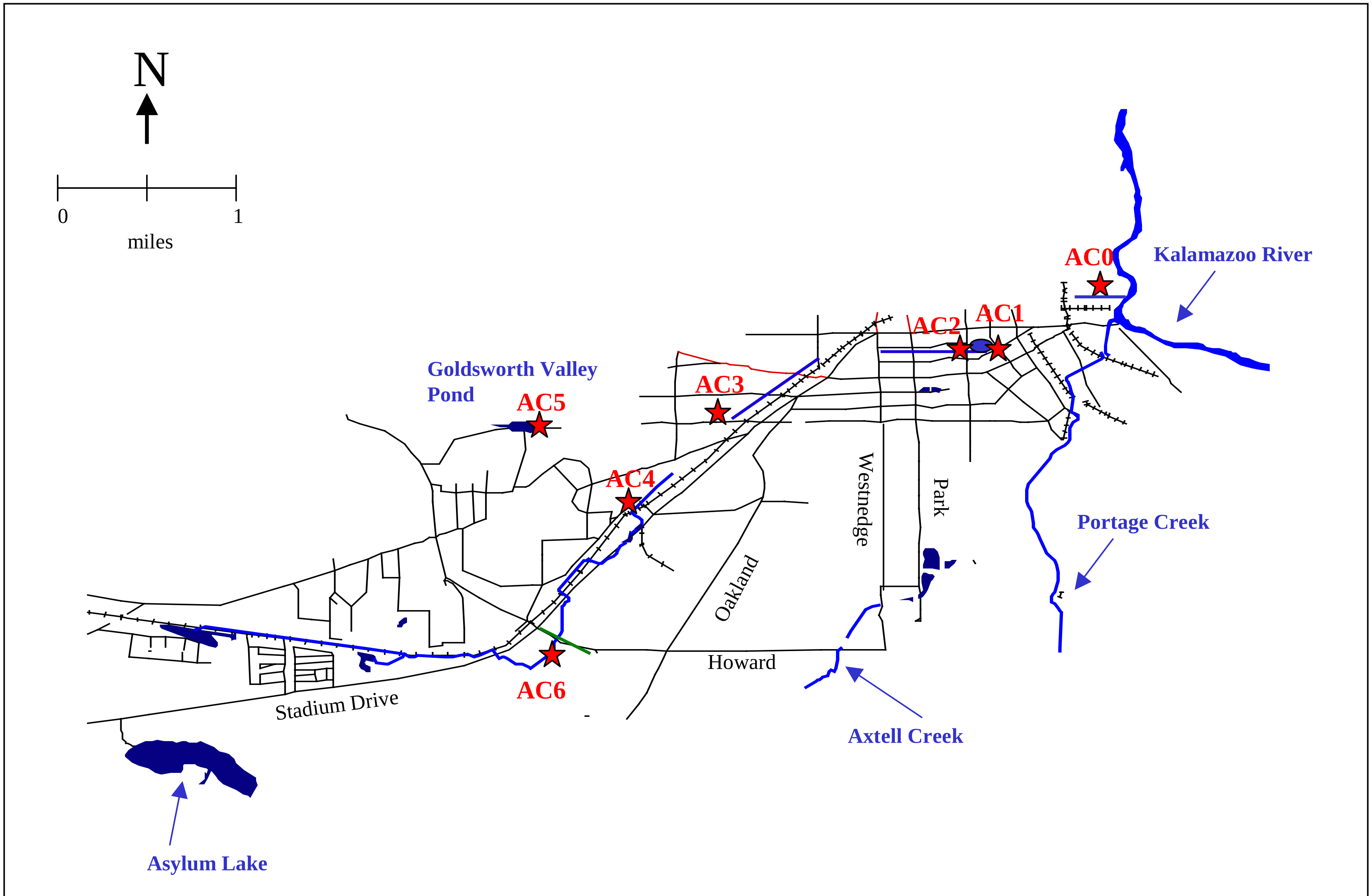

Figure 3. Arcadia Creek sampling stations

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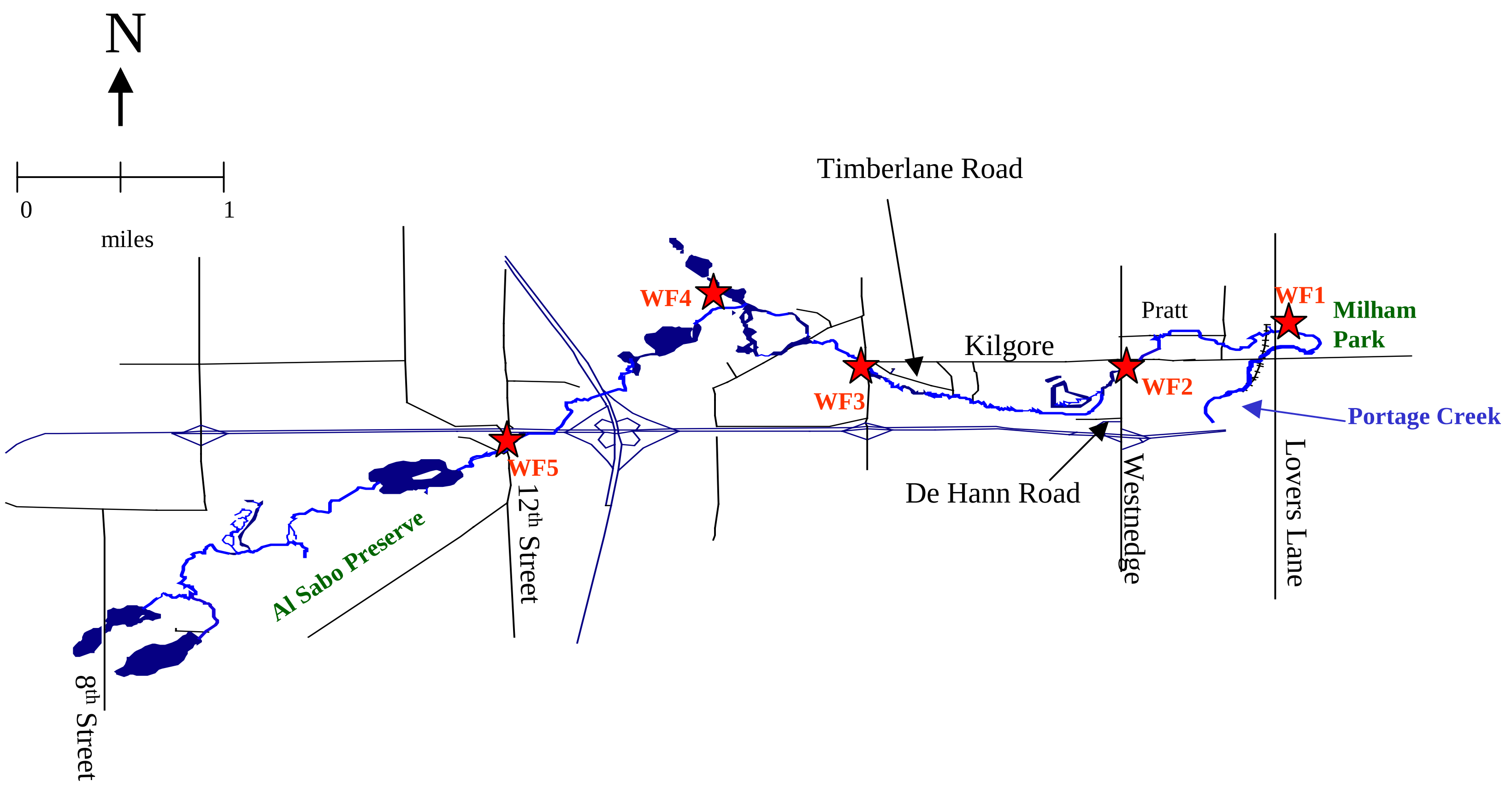

Figure 4. West Fork Portage Creek sampling stations

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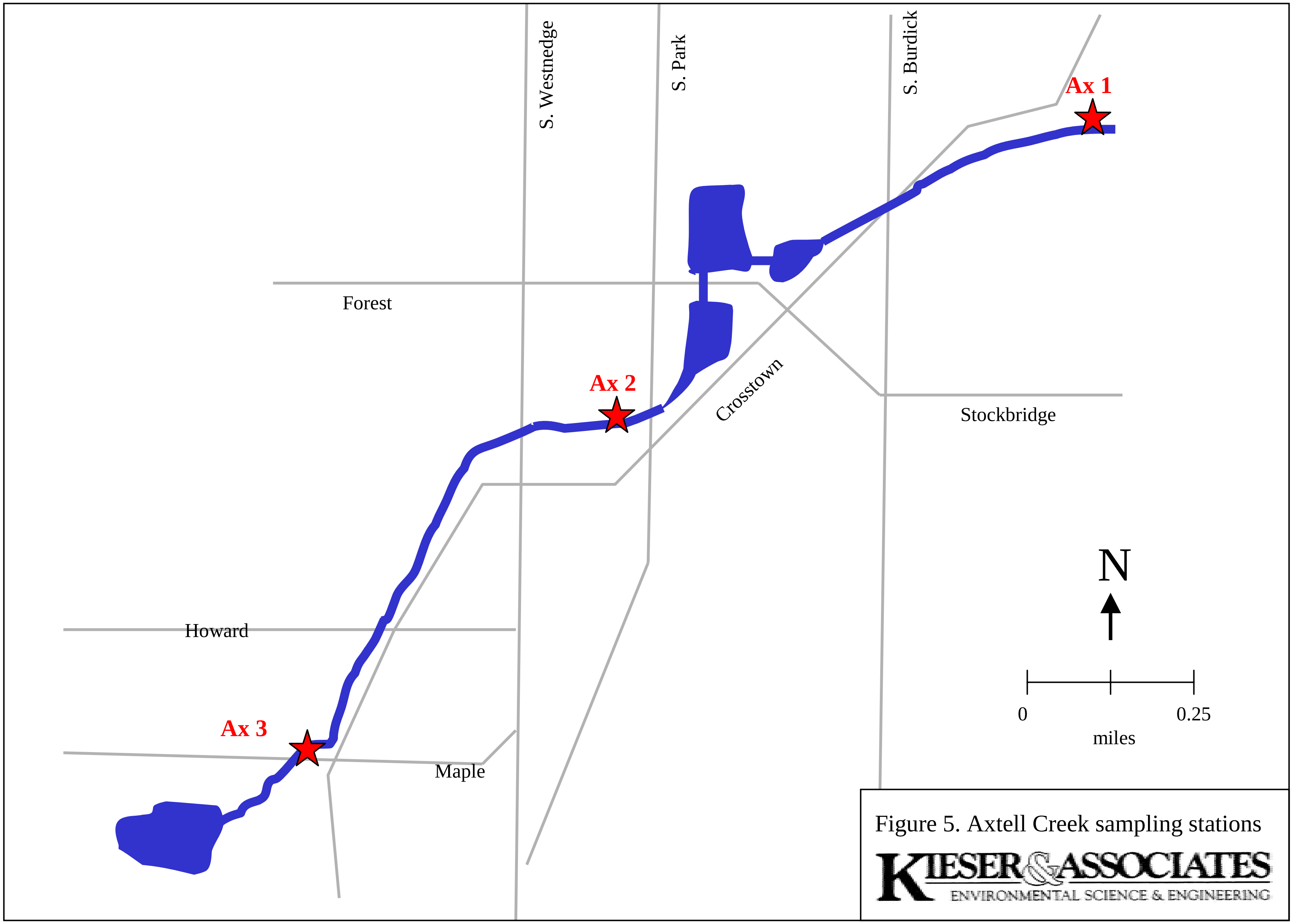

Figure 5. Axtell Creek sampling stations

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Figure 6. Portage Creek Stage Discharge Relationship

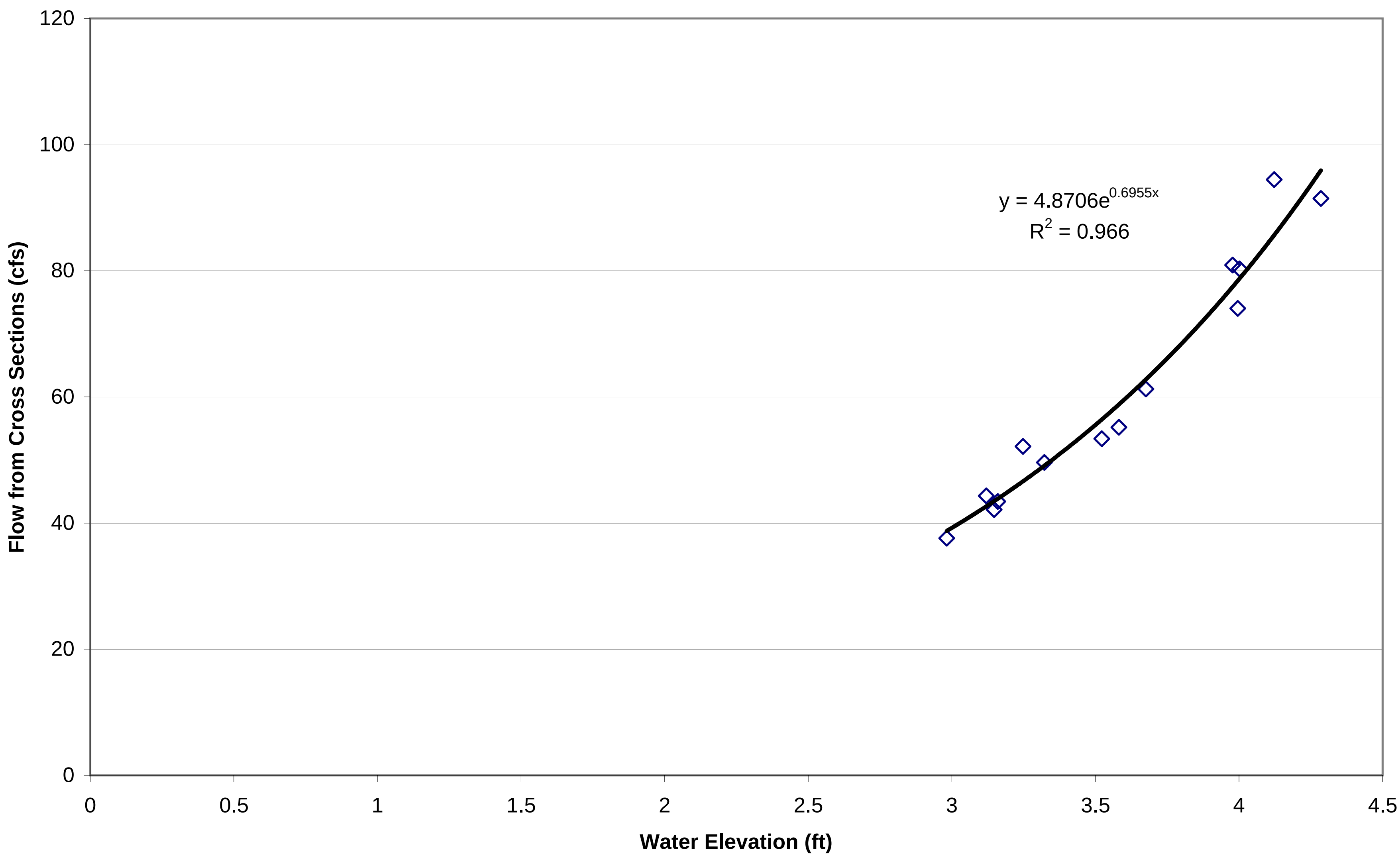

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Figure 7. Arcadia Creek Weir Stage Discharge Relationship

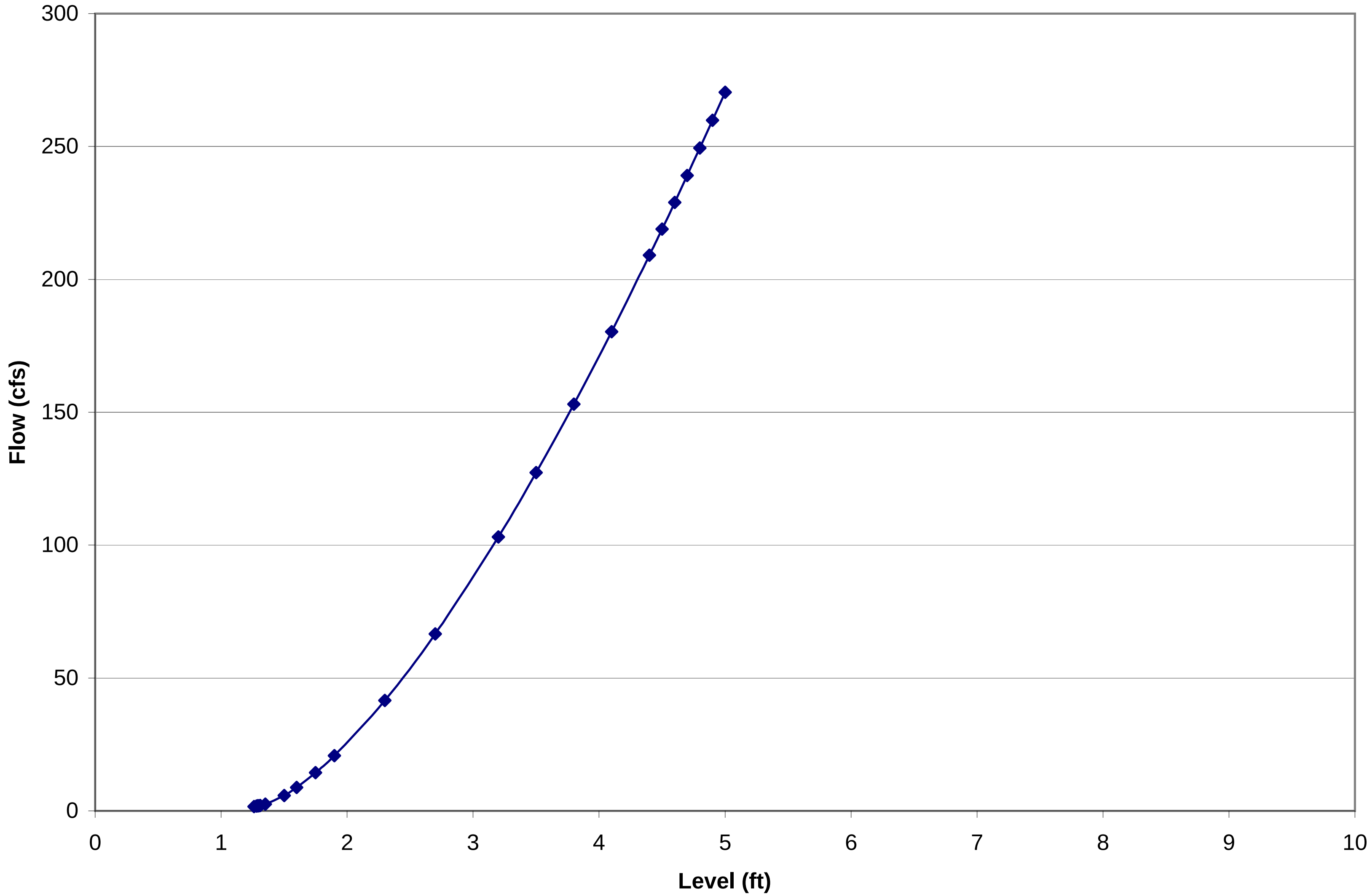

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Figure 8. Portage Creek Maximum Hourly Flow Rate and Total Hourly Rainfall

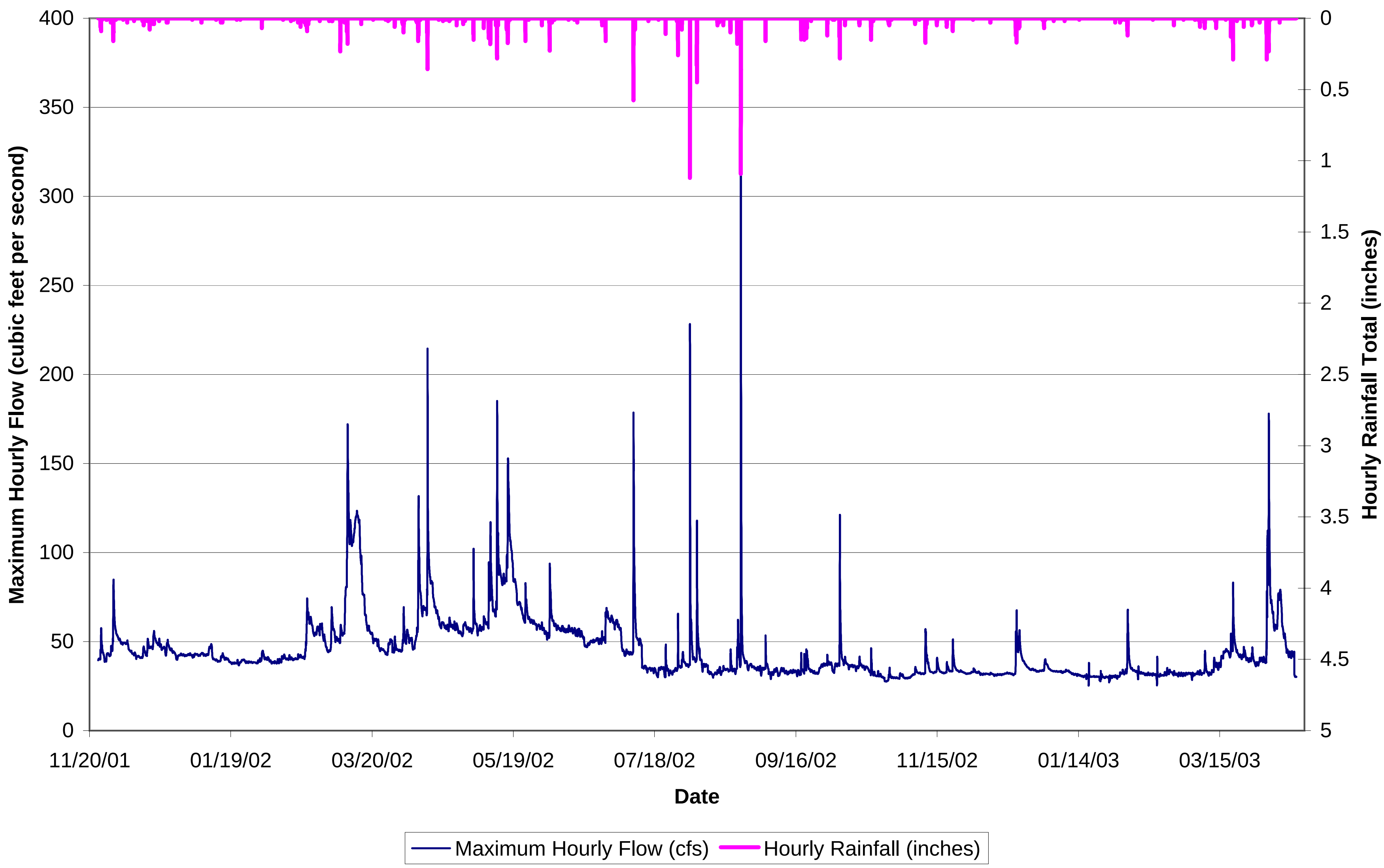

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Figure 9. Arcadia Creek Maximum Hourly Flow and Total Rain

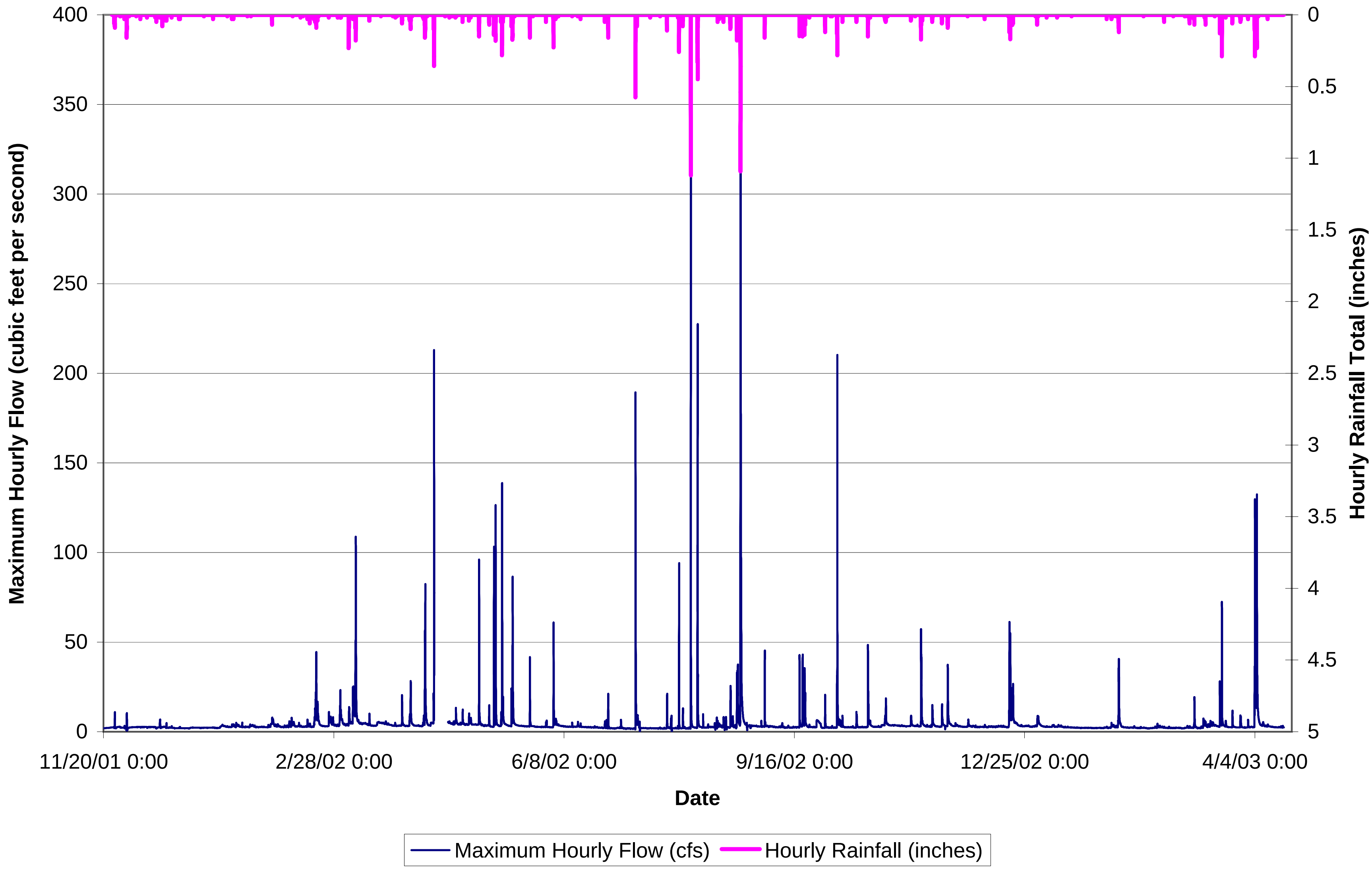

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Figure 10. Portage Creek Total Phosphorus Concentration vs. Flow During Elevated (11/2001 - 6/2002) and Low Baseflow (7/2002 - 4/2003) Time Periods

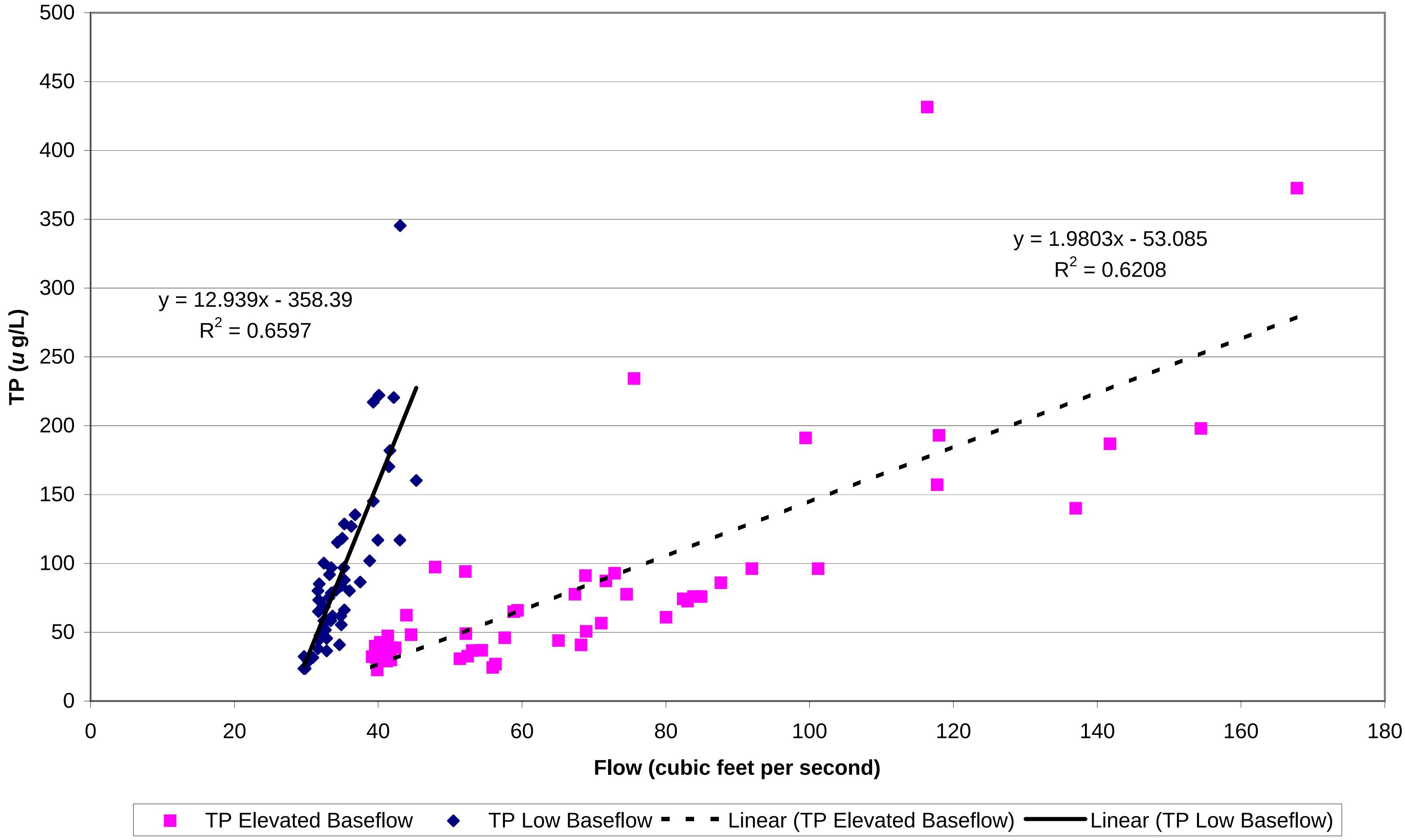

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Figure 11. Portage Creek Total Suspended Solids Concentration vs. Flow During Elevated (11/2001 - 6/2002) and Low Baseflow (7/2002 - 4/2003) Time Periods

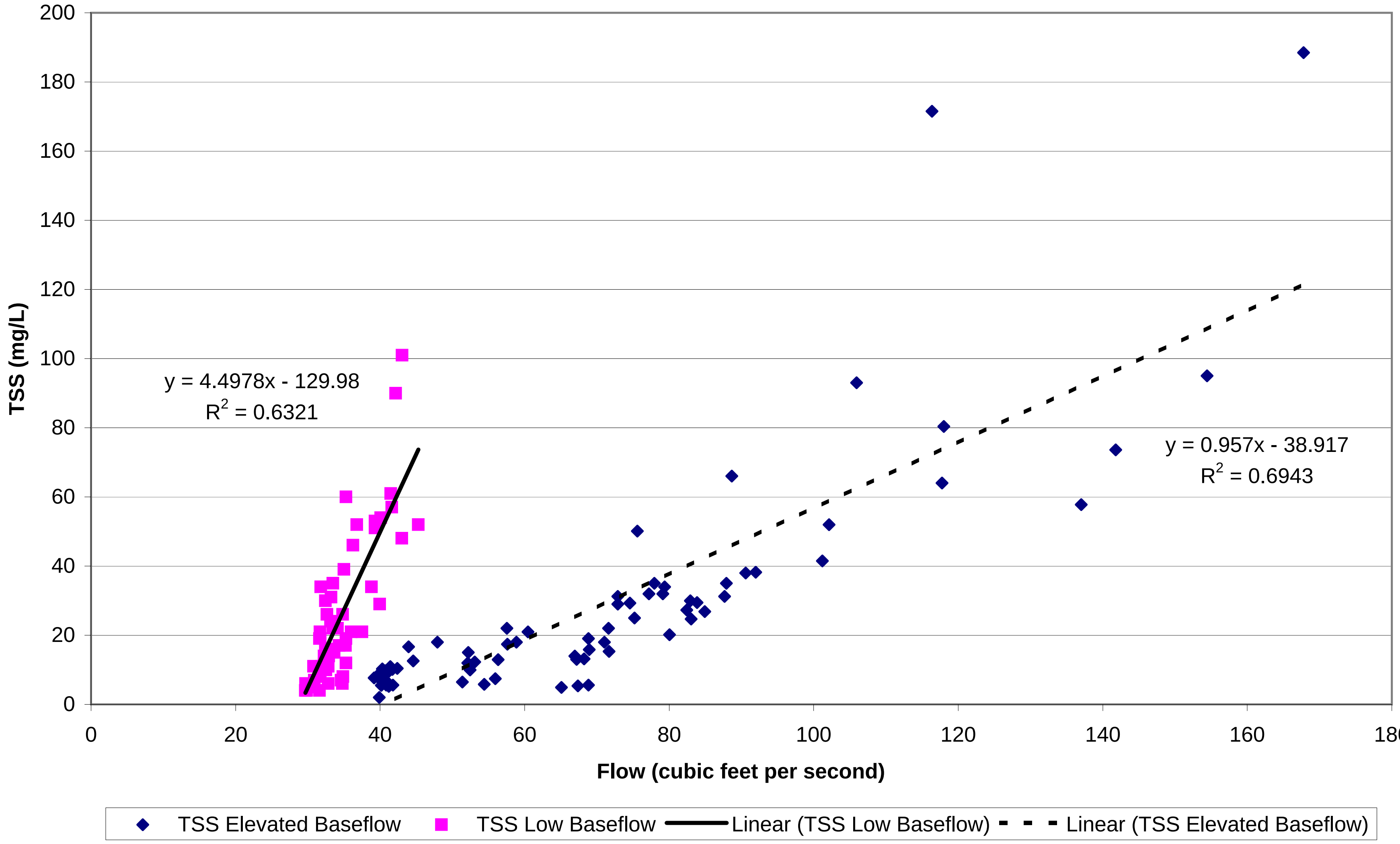

Figure 12. Arcadia Creek Total Phosphorus Concentration vs. Flow

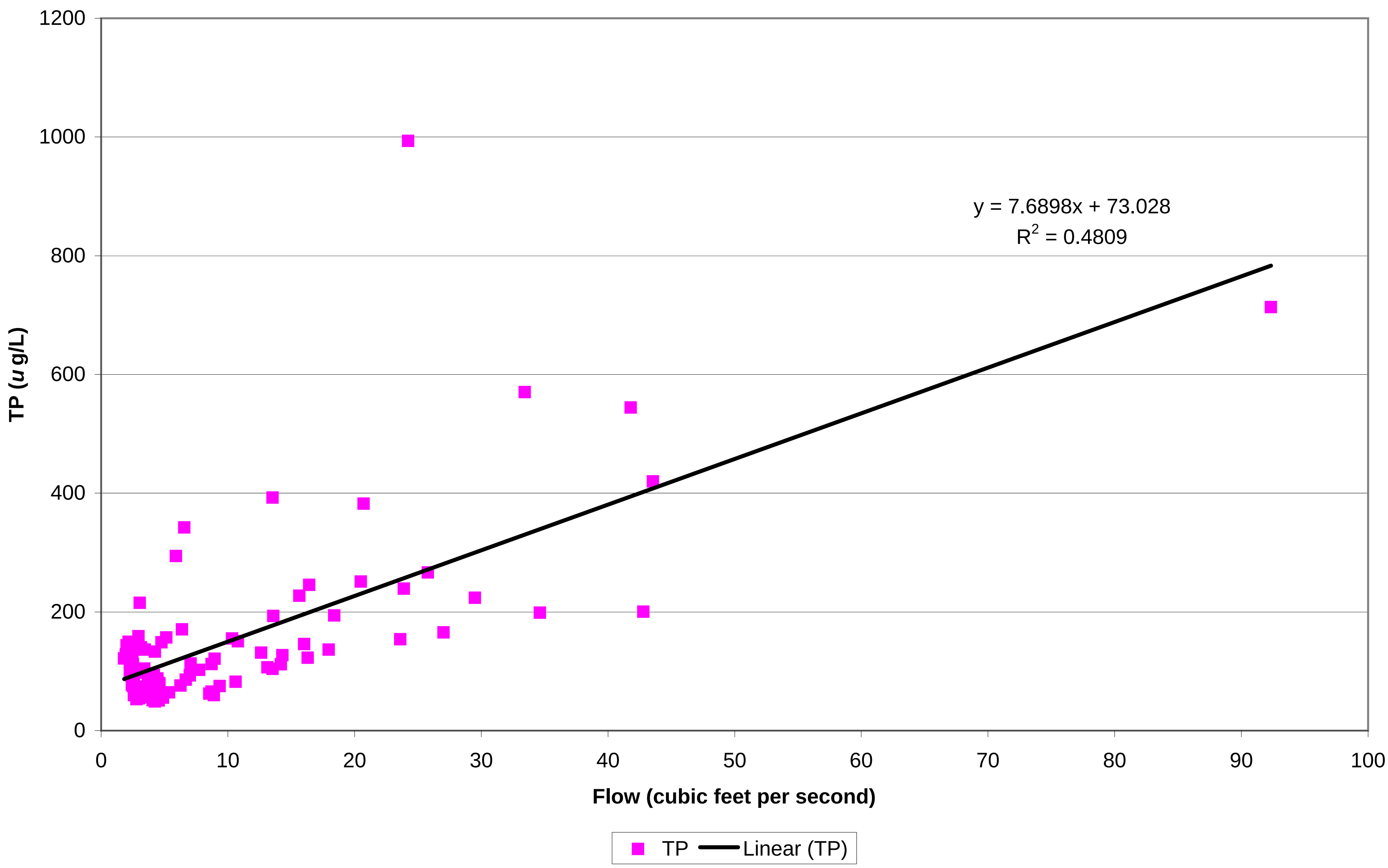

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Figure 13. Arcadia Creek Total Suspended Solids Concentration vs. Flow

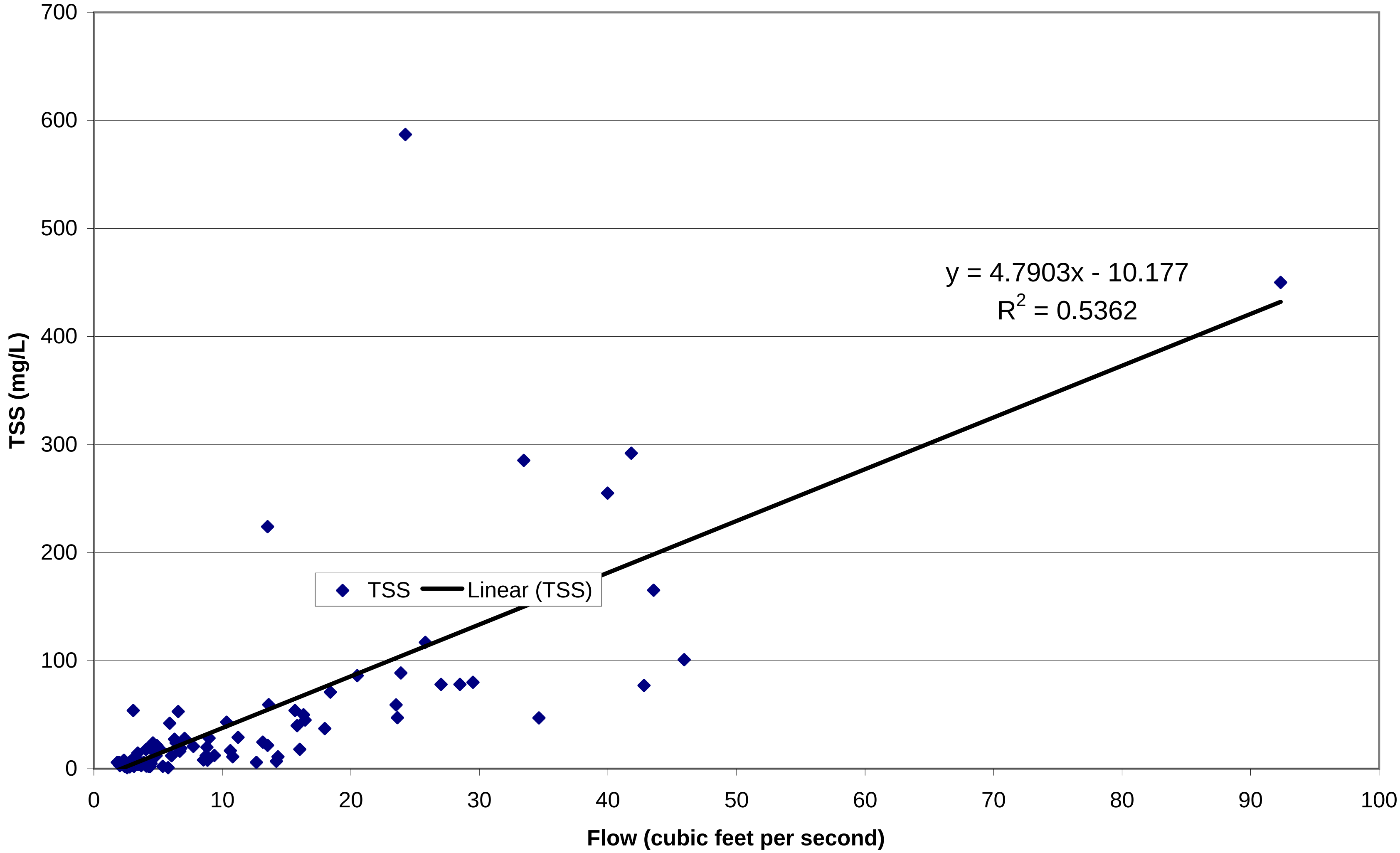


Figure 14. Monthly Portage Creek Total Suspended Solids Load to the Kalamazoo River

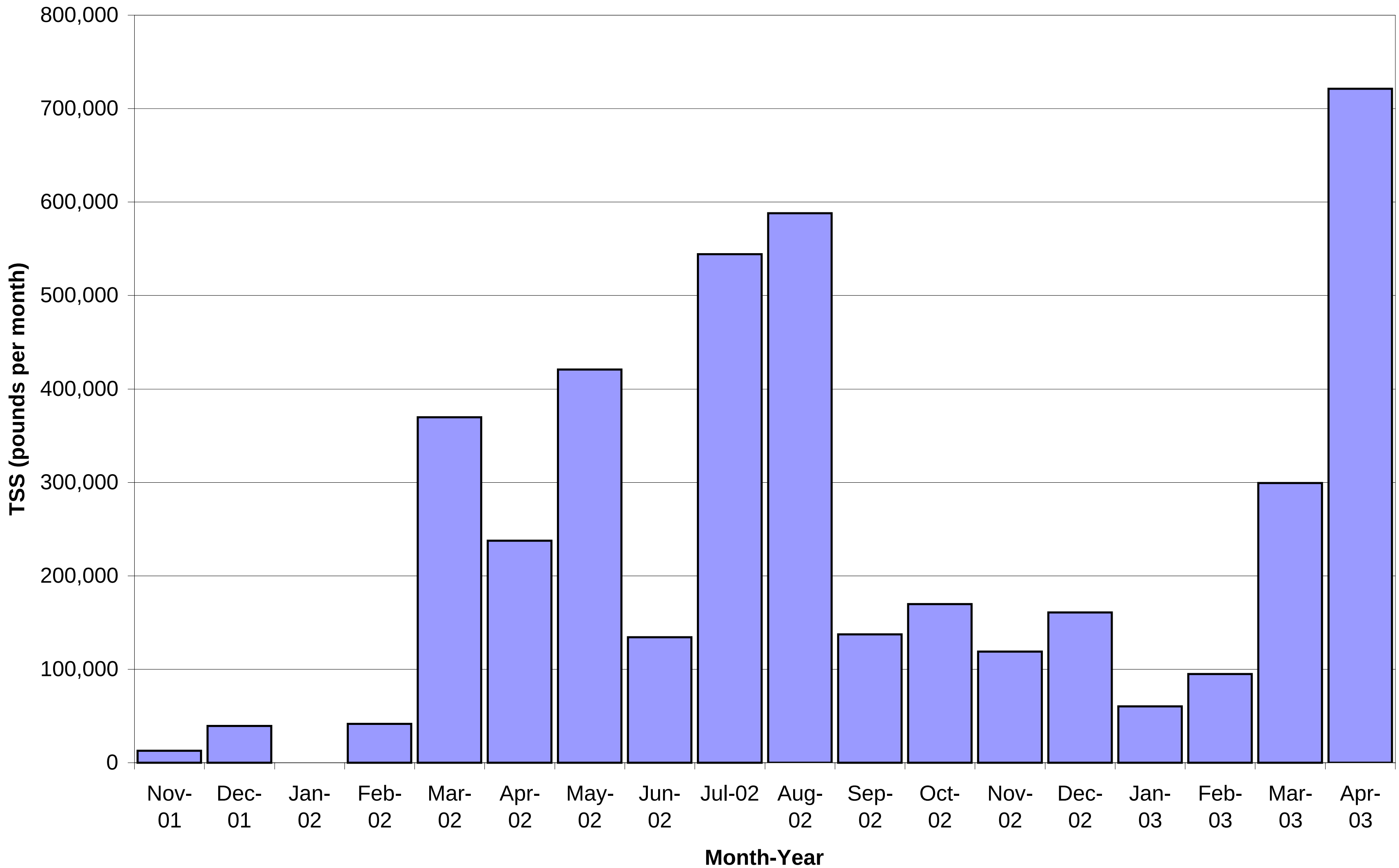


Figure 15. Monthly Portage Creek Total Phosphorus Load to the Kalamazoo River

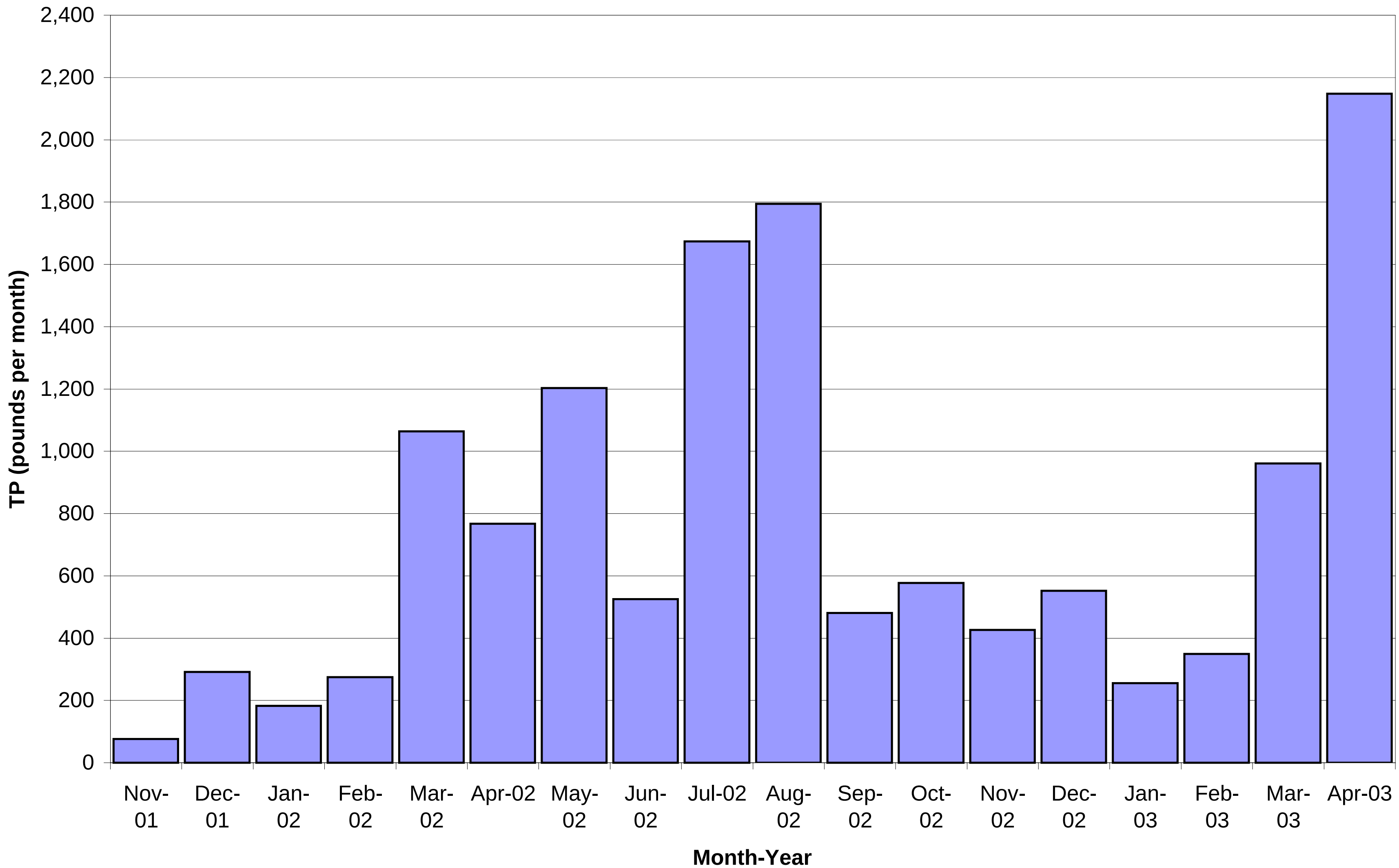


Figure 16. Monthly Arcadia Creek Total Suspended Solids Load to the Kalamazoo River

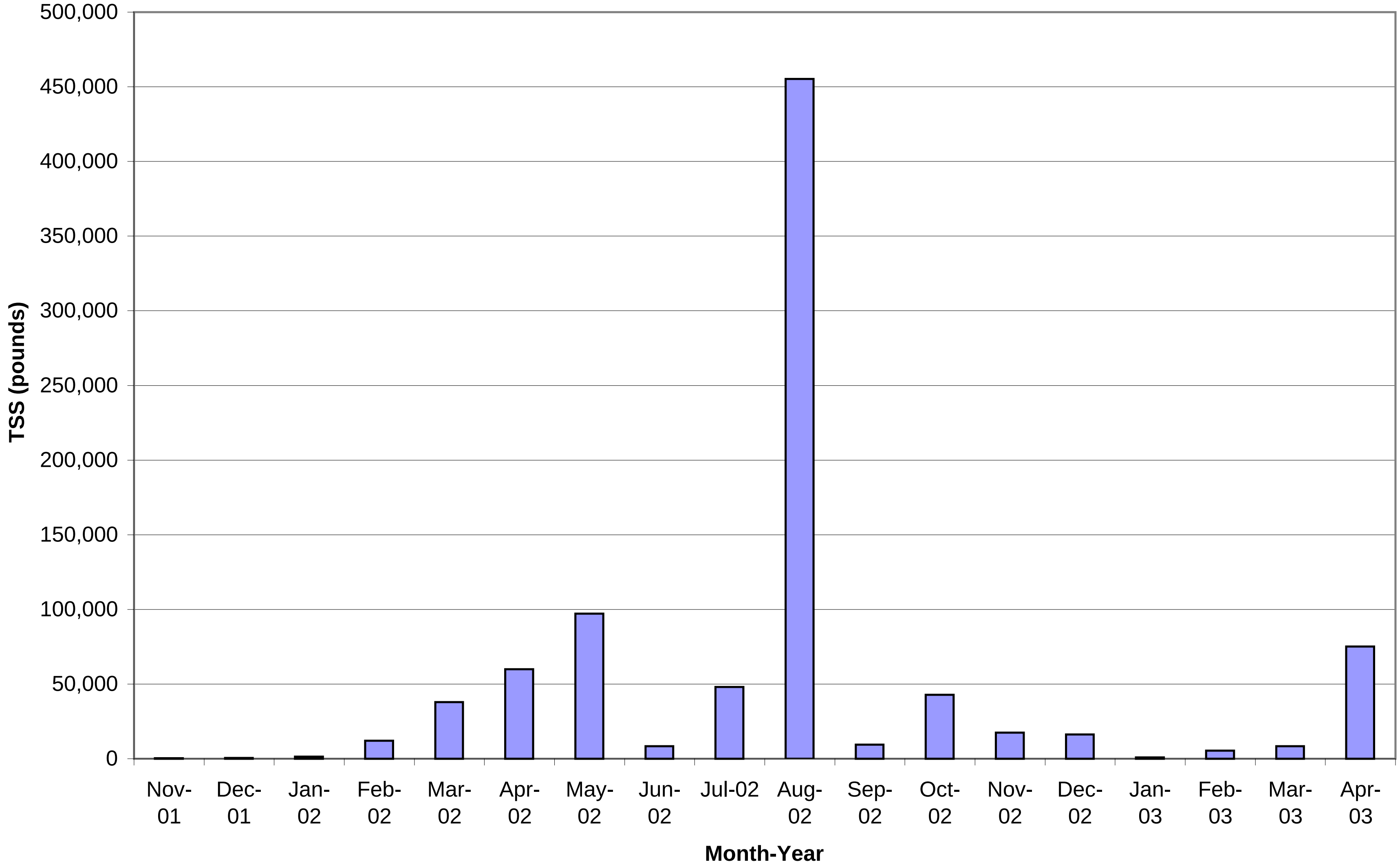
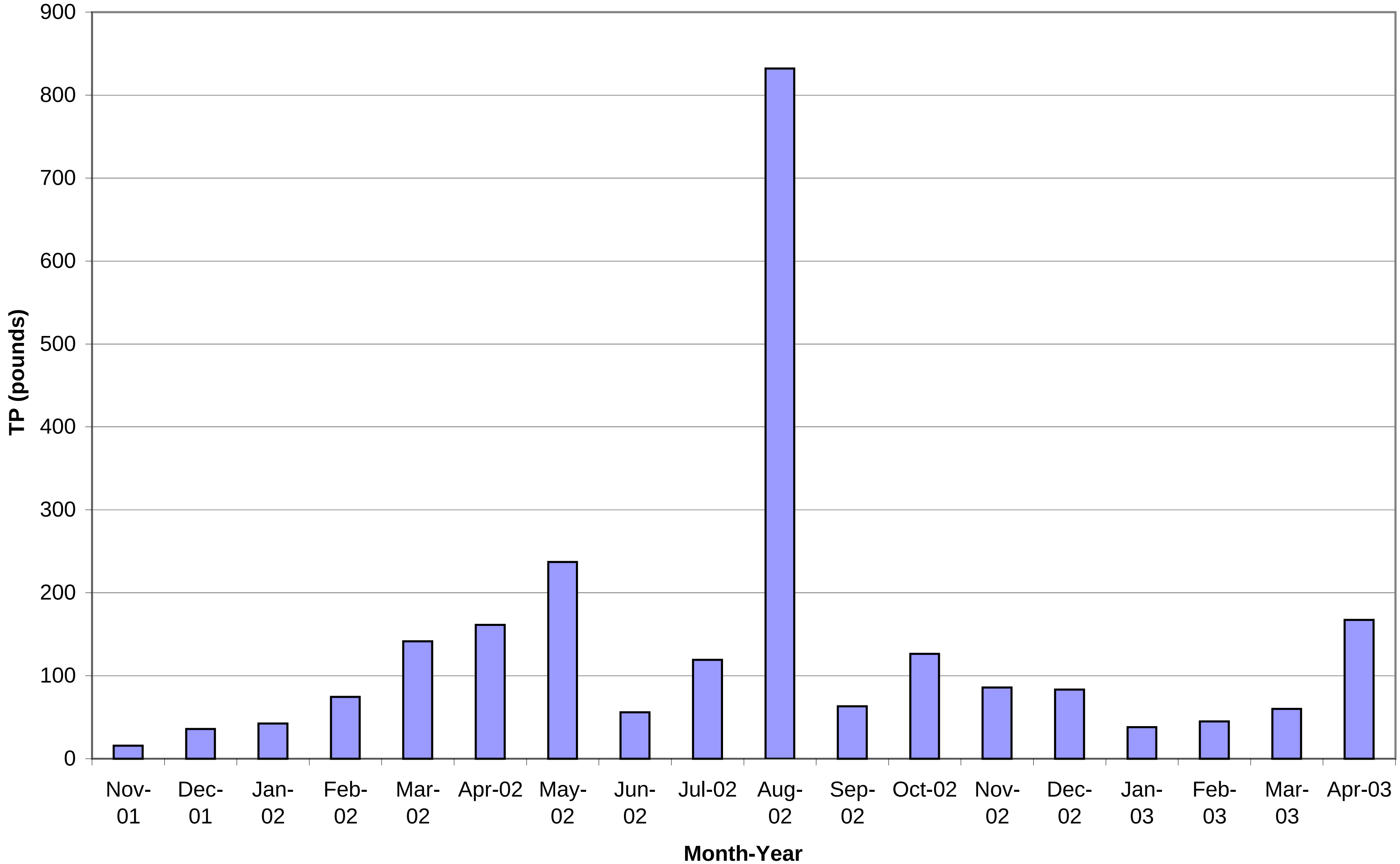


Figure 17. Monthly Arcadia Creek Total Phosphorus Load to the Kalamazoo River



Attachment A

Portage Creek Additional Sampling Report for the City of Portage

February 18, 2003

Mr. W. Christopher Barnes, P.E.
City Engineer
City of Portage
Department of Transportation & Utilities
7719 S. Westnedge Avenue
Portage, MI 49002

RE: Summary of Results of Portage Creek Supplemental Sampling

Dear Mr. Barnes:

KIESER & ASSOCIATES (K&A) has completed the fourth and final round of quarterly sampling of Portage Creek and the Pharmacia outfall for the Summer 2002 period. A dry weather sampling took place on September 4, 2002, and the wet weather sampling event occurred on September 20, 2002. In addition to these dry and wet weather samples, grab samples from the Pharmacia outfall were collected on June 17, July 16, August 12 and August 26, 2002. These additional samples of the outfall were collected to gain a better understanding of the variability in quality of this cooling water discharge.

As noted in the First Quarterly Report (K&A, February 12, 2002), the original project tasks specified the sampling of the Pharmacia outfall and eight stations on Portage Creek. These eight stations are in addition to the five stations already designated in the Portage Creek/Arcadia Creek 319 project. In addition to the data for the specified Portage Creek sites for this study, water quality data for the five Creek locations from the Portage Creek/Arcadia Creek 319 project are also reported here as a courtesy to the City.

This report will first summarize the Summer 2002 dry and wet weather Portage Creek data followed by a summary of all data collected during this study.

Summer 2002 Sampling

The 13 Portage Creek grab sampling locations are located on the main branch of the creek and cover approximately 12 miles between Angling Road in Portage and Upjohn Park in the City of Kalamazoo (Figure 1). The Pharmacia outfall is sampled in the manhole on Gernaat Court. Creek stations designated PC5 through PC13 are located within the City of Portage. Stations PC1 through PC4 are in the City of Kalamazoo.

Both a dry weather and a wet weather event were monitored during Summer 2002. The dry weather sampling occurred on September 4, 2002. The wet weather samples were collected on September 20, 2002 and correspond to a precipitation event of 0.45 inches of rainfall (based on the rainfall recorded at the K&A rain gauge located at the City of Portage Regional Stormwater & Trailways Facility wetland).

Results

Parameters of temperature, pH, specific conductance (conductivity) and dissolved oxygen (DO) were measured in the field. Water quality samples were submitted to Upstate Freshwater Institute (UFI) in Syracuse, New York, for analysis of total phosphorus (TP) and soluble reactive phosphorus (September 4, 2002 samples only). The total suspended solids (TSS) analyses were conducted by KAR Laboratories, in Kalamazoo, MI. Additionally, alkalinity, dissolved calcium, dissolved iron and turbidity were analyzed on the Pharmacia outfall sample and stations PC7 (upstream of Pharmacia) and PC6 (downstream of Pharmacia) as these parameters have been observed at elevated levels in the Pharmacia discharge in previous reports. Alkalinity, dissolved calcium, dissolved iron and turbidity samples were also submitted to KAR Laboratories for analysis. All analytical laboratory reports are presented in Appendix A. (Laboratory reports contain all data from the Portage Creek/Arcadia Creek 319 project. Only data from sites PC1 through PC13, the Consolidated Drain and Gernaat Court are discussed in this report.)

A thermistor was installed in the Pharmacia outfall manhole (Gernaat Court) on January 8, 2002 to continuously monitor temperature in the Pharmacia cooling water discharge to Portage Creek. As noted in the Winter 2002 Quarterly report (K&A, June 2002), the thermistor became detached from the connecting wire and data were lost. A new thermistor was installed in the Gernaat manhole on May 22, 2002 and continuously collected data at 5 minute intervals until September 16, 2002, when the instrument was disconnected by K&A personnel.

Stream flow measurements were also conducted at PC1 and PC5 during the dry and wet weather monitoring events. In addition, U.S. Geological Survey (USGS) data are available for stations PC4 and PC10. Flow accrual graphs of these sites along Portage Creek are presented in Figures 2 and 3. The decreases in flow noted between upstream PC5 and downstream PC4 during both the wet and dry September 2002 events are likely explained by the two City of Portage production wells (Garden Lane and Portage Creek) situated between these sampling sites. Flows measured by K&A for the September 4, 2002 event were 34.6 cubic feet per second (cfs) while the USGS data show a flow of 20 cfs at the downstream PC4 for this same event. Similarly, flows measured by K&A at PC5 for the September 20, 2002 event were 41.1 cfs while the USGS data for PC4 show a flow of 19 cfs at this downstream site during the same event.

Water quality results of the Portage Creek and Pharmacia dry weather and wet weather Summer 2002 monitoring are presented in Tables 1 and 2, respectively. Pharmacia data are displayed in bold and are positioned between PC6 and PC7 corresponding to the location of the outfall between these two sampling sites. Also, the data collected from the Consolidated Drain at Garden Lane are included in the tables between sampling locations PC8 and PC9, again corresponding to the location of the outfall of the Drain to Portage Creek. These Consolidated Drain data are presented in bold. All samples collected at the Pharmacia outfall are shown in Table 3. Figures 4-6 graphically display selected water quality parameters for the September 4 dry weather monitoring while Figures 7-9 present the same parameters for the September 20, 2002 wet weather event. The temperature data for the Pharmacia cooling water outfall are presented in Table 4. The thermistor in the Gernaat Court manhole recorded temperature of the cooling water at five minute intervals. These data are displayed as daily highs, daily lows, daily average temperatures and daily temperature fluctuations.

Discussion

A 2.6 °C temperature increase was detected between the PC7 station (upstream Pharmacia) and the PC6 station (downstream Pharmacia) during the September 4, 2002 dry weather sampling. A 1.3 °C increase between these stations was observed during the September 20, 2002 wet weather event. Dissolved oxygen levels were at the lowest levels observed in all 13 monitored stations at site PC13 during both the September 4 and September 20, 2002 events. As this station is at the outlet of a natural wetland complex, the lower DO levels are likely a natural variation observed in a wetland environment during warmer, summer conditions. The observed DO conditions were greater than the 5 mg/L Michigan Department of Environmental Quality criterion. A general increase in conductivity levels from upstream PC13 to downstream PC1 has been observed in past sampling data as well as in both September 2002 events. The upstream sampling locations (PC13-PC10) displayed specific conductance levels in the 300-450 umhos/cm range. As the creek becomes more urban, the specific conductance ranged from 400-600 umhos/cm during the Summer 2002 sampling.

Total suspended solids (TSS) levels during the September 4, 2002 dry weather event were typically < 10 mg/L. Consistent exceptions in dry weather have been noted at Centre Avenue (PC11) where waterfowl appear to be encouraged to reside at upstream private residences along the Creek. Wet weather conditions saw increases below the Consolidated Drain confluence with more noticeable increases through the City of Kalamazoo. Total phosphorus (TP) concentrations were lowest in the upper-most stream reaches in September dry weather with a noticeable increase in TP at station PC11, consistent with TSS levels. TP levels remained quite consistent until PC3 where these increased by 50-60% downstream of Milham Park. The highest TP concentrations observed during the September 20, 2002 (wet weather) monitoring were at PC6 and PC1, with levels at 146 and 104 ug/L, respectively. The TP spike observed at PC6 is likely not attributed to the Pharmacia outfall at this time since the Pharmacia outfall TP was measured at 32.56 mg/L during this event. The spike at PC1 detected during this sampling likely resulted from inputs from the highly-developed urban watershed influencing water quality at this location. The significant TP increase detected downstream of the Consolidated Drain outfall (between PC9 and PC8) during the previous May 8, 2002 sampling was not observed during the Summer 2002 monitoring, though TP concentrations did show a minor increase of 10 ug/L between these sites during the September 20, 2002 event. Possible causes of this past observed TP spike will be discussed in the following **Study Summary** section.

The Pharmacia data, presented in Table 3, represent samples taken from the Gernaat Court manhole during the seasonal rounds of dry and wet weather sampling as well as grab samples collected at selected intervals between the seasonal monitoring. The additional samples were collected from the Gernaat Court manhole to gain a more complete understanding of the fluctuation in the quality of the cooling water. As shown in Table 3, TP concentrations measured in the Pharmacia outfall were below 33 ug/L for three samples analyzed during the Summer 2002 period (August 26, Sept. 4 and September 20, 2002). All other measured parameters were within the range previously observed for this outfall. As displayed in Table 4, temperature fluctuations in the Pharmacia cooling water have been as low as 1.46 °C (July 6 and July 7, 2002) to as high as 10.84 °C (August 14, 2002) during a 24-hour period. Normal summer diurnal stream fluctuations have been observed in Portage Creek upstream of Gernaat Court to vary by as much as 6.3 °C (July 13, 2002) over a 24-hour period. Actual measured Portage Creek temperatures upstream of the Pharmacia outfall have been recorded as high as 24.4 °C (July 22, 2002).

Study Summary

Eight sampling events were conducted during this study, representing seasonal, wet and dry weather monitoring. The study began in November 2001 and continued to September 2002. The 13 sampling stations, the Consolidated Drain outfall and Pharmacia outfall at Gernaat Court were sampled on the following dates: November 30 and December 10, 2001; February 25 and March 8, 2002; May 8 and June 17, 2002; September 4 and September 20, 2002. Additional Gernaat Court samples were collected to aid in evaluating downstream impacts of the Pharmacia outfall on Portage Creek. In addition to the above sampling dates, these Gernaat Court samples were collected on the following dates: April 4, May 15, June 3, July 16, August 12 and August 26, 2002. In addition, Consolidated Drain samples were also collected to further examine downstream effects of this outfall on the creek.

Each of the 13 sampling locations was plotted individually for conductivity, temperature, pH, dissolved oxygen, total suspended solids, total phosphorus and soluble reactive phosphorus. These graphs are presented in Appendix B along with a summary table which presents all collected grab samples from the study.

General trends from this study show that conductivity increases from upstream to downstream. As the Portage Creek watershed becomes increasingly urban downstream, the conductivity levels (a general indicator of pollutant contributions) increase. PC13, the most upstream sampling location in this study, displayed minor fluctuations in the measured water quality parameters throughout this seasonal monitoring study (with the exception of seasonal temperature variations). This site represents the least impacted portion of Portage Creek. Conductivity was consistently in the 300-405 umhos/cm range, TSS concentrations were measured below 8 mg/L for each of the eight samples. TP levels typically ranged from 10.83 - 27.64 ug/L with the highest level measured during the September 20, 2002 wet weather event at 39.34 ug/L.

The May 8, 2002, spring wet weather sampling displayed the highest TP concentrations in PC7 (171.3 ug/L), PC8 (226.1 ug/L), PC10 (102.1 ug/L), PC11 (115.0 ug/L) and PC12 (105.3 ug/L). The Consolidated Drain TP concentration (which is a combination of both the Consolidated Drain and the untreated Schuring Drain) was measured at levels over 300 ug/L for this same event. This May 8, 2002 Consolidated Drain outfall TP concentration was likely due to contributions from the Schuring Drain and to a lesser extent to phosphorus release from treatment wetland soils during warmer temperatures and low DO conditions. This would help explain the levels observed downstream at sites PC8 and PC7 during this monitoring. It should be noted that these high TP levels were not detected in the furthest upstream PC13 site (27.6 ug/L) or at sampling location PC9 (58.5 ug/L) for the May 8, 2002 event. This suggests that local sources of stormwater directly upstream of these sampling locations contribute to these observed TP spikes. TP concentrations detected in PC1 during May, June and September 20, 2002 sampling were above 100 ug/L. The September 20, 2002 wet weather samples from PC2 and PC6 were also elevated at 89 and 146 ug/L TP, respectively.

Study Conclusions

We provide the following conclusions of this study of the 13 Portage Creek sampling locations, the Consolidated Drain outfall and the Pharmacia outfall at Gernaat Court.

C Temperature data indicate that the contributions of the Pharmacia cooling water discharge may exacerbate instream diurnal fluctuations and increase stream baseflow to the detriment of the coldwater habitat during critical warm weather periods. Temperature increases were consistently observed downstream of the Pharmacia outfall to Portage Creek (between PC7 and PC6). Daily temperature fluctuations in the outfall discharge were recorded at >10 ^{o}C on two occasions (July 22 and August 14, 2002). This may create a barrier to fish migration and elimination of habitat in these reaches downstream of the cooling water discharge. This is especially true for summer months when coldwater fish are stressed by seasonally warmer ambient temperatures. Observed downstream (PC6) temperature increases are much more pronounced during the colder fall/winter months where an increase of 11 ^{o}C was recorded during November 27, 2002 sampling. Other water quality parameters measured in the Pharmacia outfall were generally within the range observed at the upstream PC7 station with the exception of wet weather conditions where stormwater mixed with the discharge and elevated downstream TP and TSS levels.

C Low levels of iron and turbidity measured at Gernaat Court in the Pharmacia discharge do not appear to significantly change instream water quality. Discharge levels appear to increase during wet weather events when stormwater is mixed with the discharge.

C Dissolved oxygen (DO) levels were above the MDEQ criterion of 5 mg/L for nearly all samples collected during this study, with the exception of the May 8, 2002 PC6 (4.2 mg/L) and PC12 (0.3 mg/L) samples. The DO of the Pharmacia outfall was recorded at its lowest levels of 5.5 mg/L during this same event which may have contributed to the lowered PC6 concentration. It is suspected that stagnant wetland conditions resulted in the 0.3 mg/L DO reading at PC12 on this date.

C TP concentrations were elevated downstream of the Consolidated Drain outfall (between PC9 and PC8) during the spring May 2002 sampling. This is likely caused by unmitigated stormwater from the Schuring Drain and to a lesser extent, phosphorus release from the treatment wetland soils during warmer temperature periods with low dissolved oxygen conditions in the treatment wetland. The sampling location at the downstream PC8 station may have caused biased results due to the close proximity of the location to the Consolidated Drain outfall (approximately 250-300 feet upstream of PC8). The PC8 site may be more representative of Consolidated Drain and Schuring Drain conditions than downstream mixed Portage Creek conditions.

C Periodic TP and TSS spikes observed at PC 11 during dry weather conditions may correlate with the private pond complex just south of Centre Avenue that attracts a large Canada geese population which may contribute to elevated phosphorus levels. PC11 generally displayed higher TP levels during the study than those observed both at upstream PC12 and, to a lesser extent, at downstream PC10. Wet weather spikes noted at PC11 are likely a result of these upstream conditions as well as stormwater outfalls discharging to the creek on the north side of Centre Avenue immediately upstream of the sampling point.

C Consolidated Drain summer temperatures were approximately one degree cooler than those measured at upstream PC9 during the September 4, 2002 dry weather sampling. Groundwater inputs from the Consolidated Drain system during the warmer months would likely explain this cooler water addition to Portage Creek.

C PC12 measured parameters were quite consistent throughout this study with the exception of wet weather influences on TP levels noted on March 8 and May 8, 2002.

C Sampling station PC9 exhibited very stable measured parameters throughout the study, while PC8, just downstream from the Consolidated Drain outfall was significantly influenced by the Consolidated and Schuring Drain inputs. Wet weather events displayed a greater influence at this sampling location with the Schuring Drain contributing untreated stormwater to the downstream system.

C Stormwater outfalls to Portage Creek at Oakland Drive, Centre Avenue and South Westnedge Avenue show periodic impacts on stream water quality during wet weather events compared to downstream outfalls to the Creek between Milham Avenue to Kilgore Road.

Recommendations

The following recommendations are provided to the City of Portage based on monitoring completed by K&A.

Continue monitoring temperature, TP and TSS of the Pharmacia outfall to Portage Creek and include flow/discharge measurements if possible to quantify inputs and further assess impacts to the receiving water.

- Collect additional data on the discharge of the unmitigated Schuring Drain stormwater and the Regional Stormwater and Trailways Facility to the Consolidated Drain discharge to determine potential water quality benefits gained from improvements within the Schuring Drain system as well as continued function of the treatment system.
- Educate property owners upstream of sampling location PC11 (Centre Avenue) on the water quality impacts (increased TP and TSS loads) of large populations of resident waterfowl on Portage Creek.
- Increase riparian buffer zones where feasible to increase shading (minimizing stream temperature fluctuations), stabilize shoreline areas and provide additional wildlife habitat.
- Maintain a seasonal stream water quality sampling program at selected stations on Portage Creek to track improvements associated with ongoing stormwater outfall disconnections. Recommended stations might include PC13, 12, 11, 10, 9, 7 and 5.

This concludes the Portage Creek Supplemental Sampling and final report. If you have further questions, please contact us. We would be happy to provide costs for implementing sampling recommendations if requested.

Sincerely,
KIESER & ASSOCIATES

Mark S. Kieser
Senior Scientist

MSK/PHM
enclosures

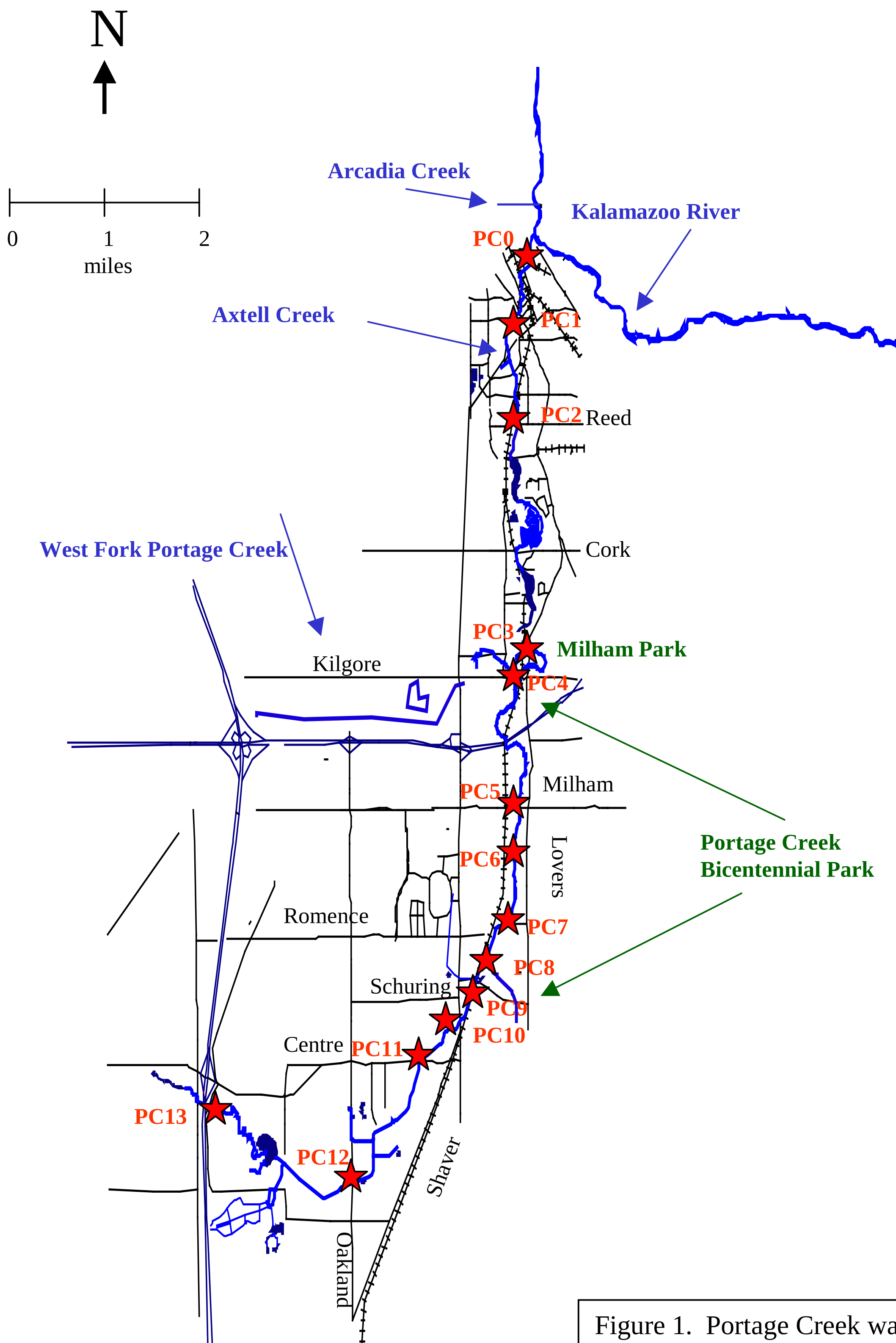


Figure 1. Portage Creek water quality sampling stations

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Figure 2. Portage Creek

Flow Accrual

Dry weather sampling September 4, 2002

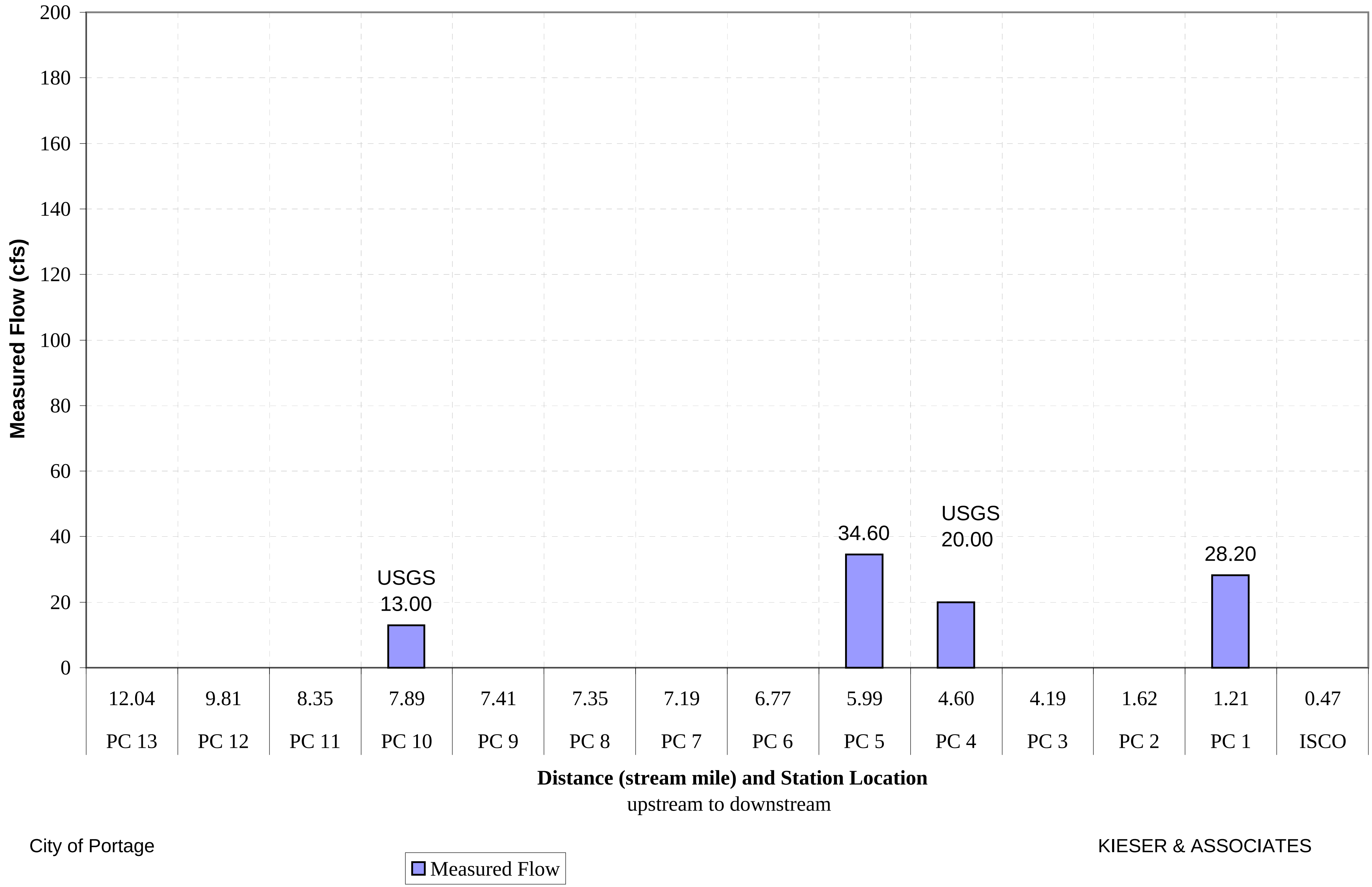

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Figure 3. Portage Creek

Flow Accrual

Wet weather sampling September 20, 2002

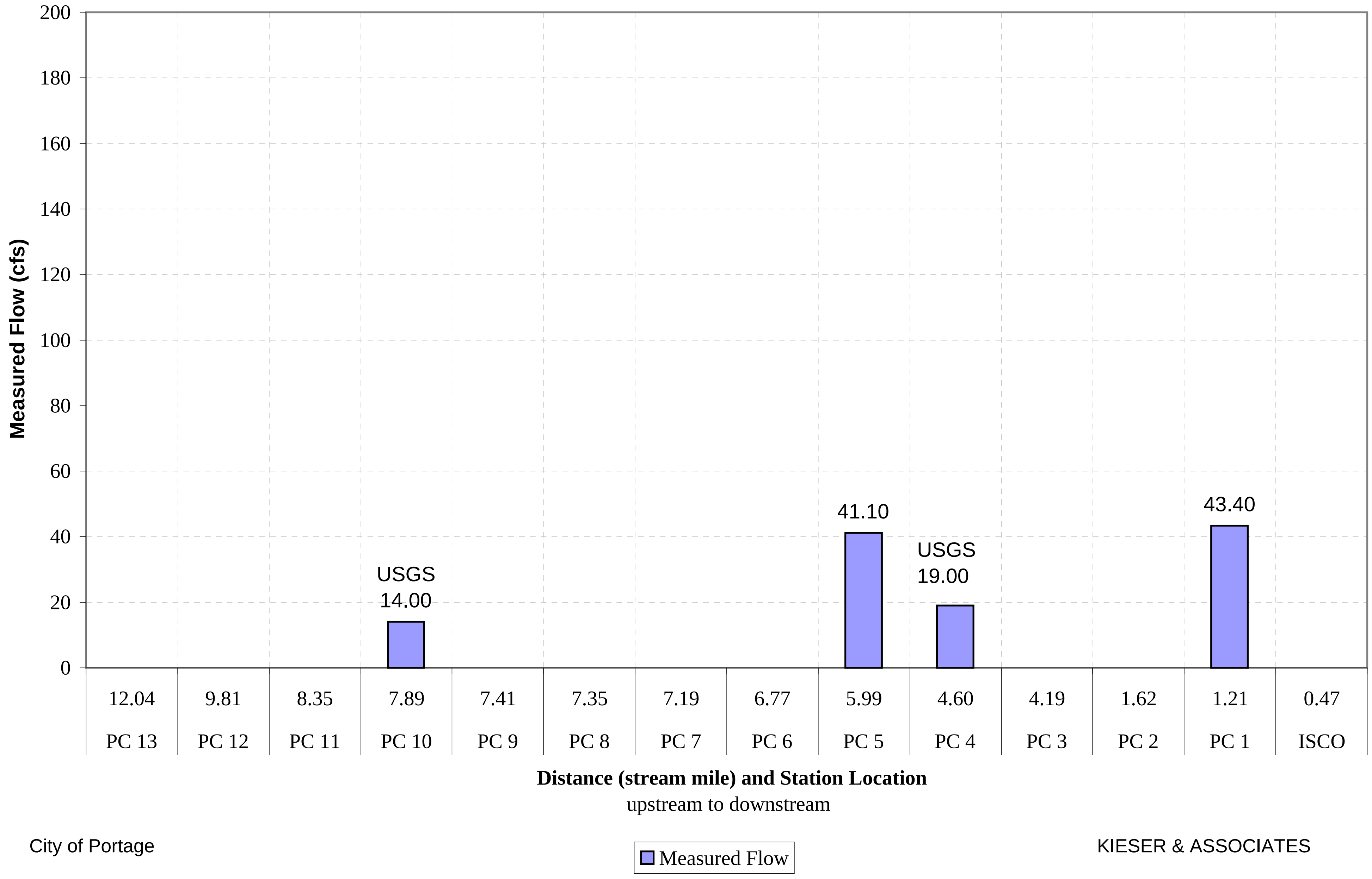

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Figure 4. Portage Creek

Dissolved Oxygen, Temperature and pH

Dry weather September 4, 2002

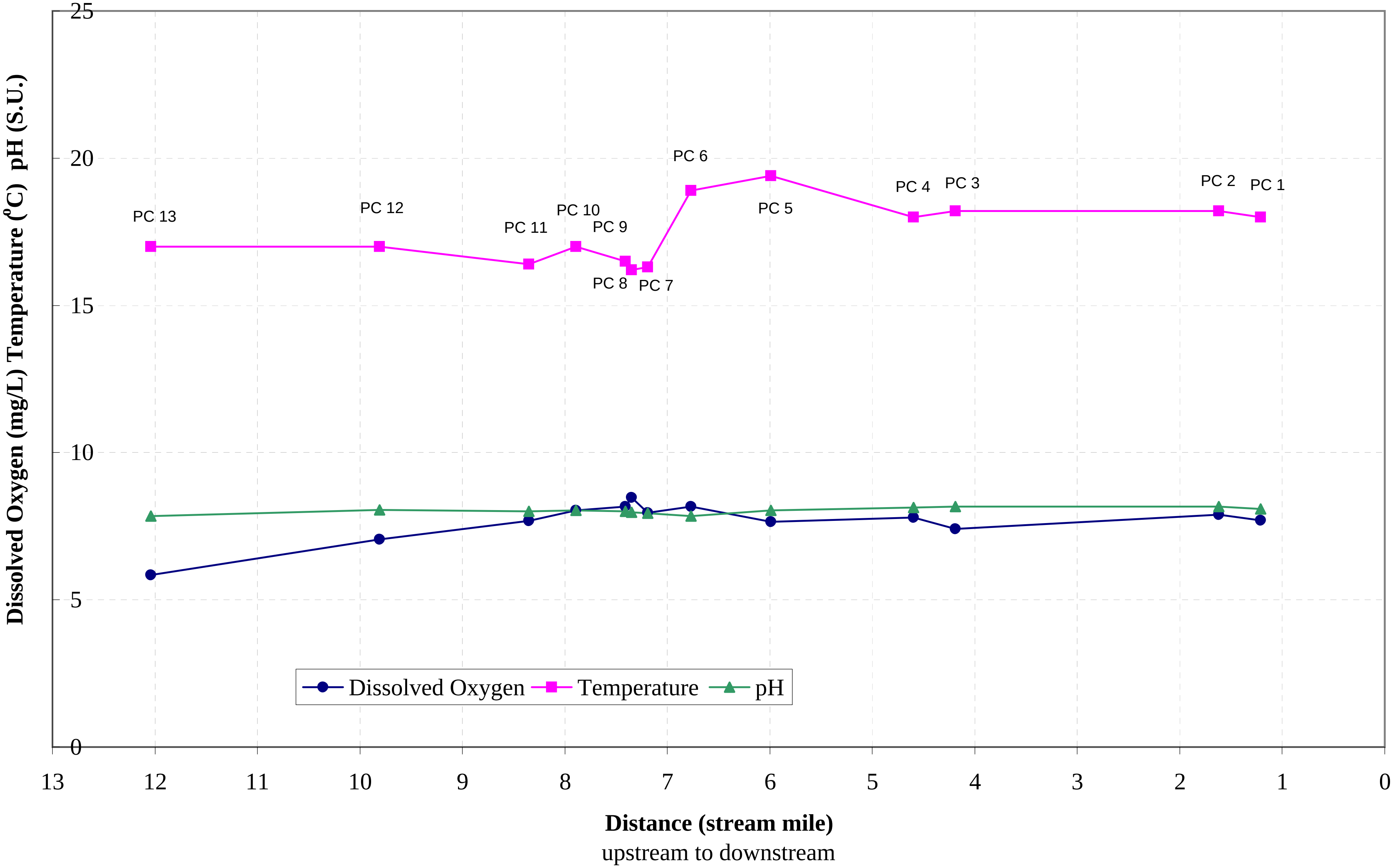

Figure 5. Portage Creek

Conductivity

Dry weather September 4, 2002

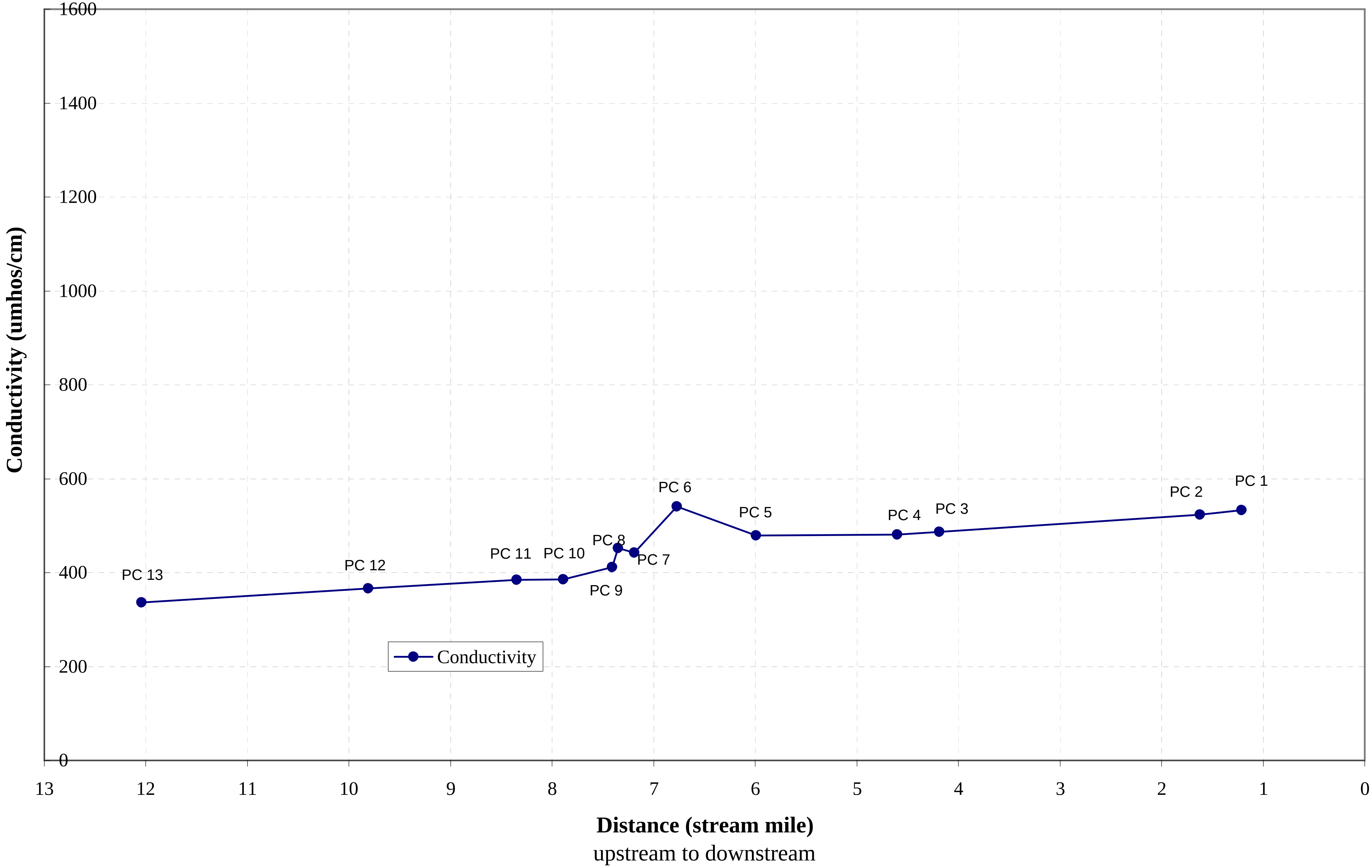

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Figure 6. Portage Creek

Total Suspended Solids and Total Phosphorus

Dry weather September 9, 2002

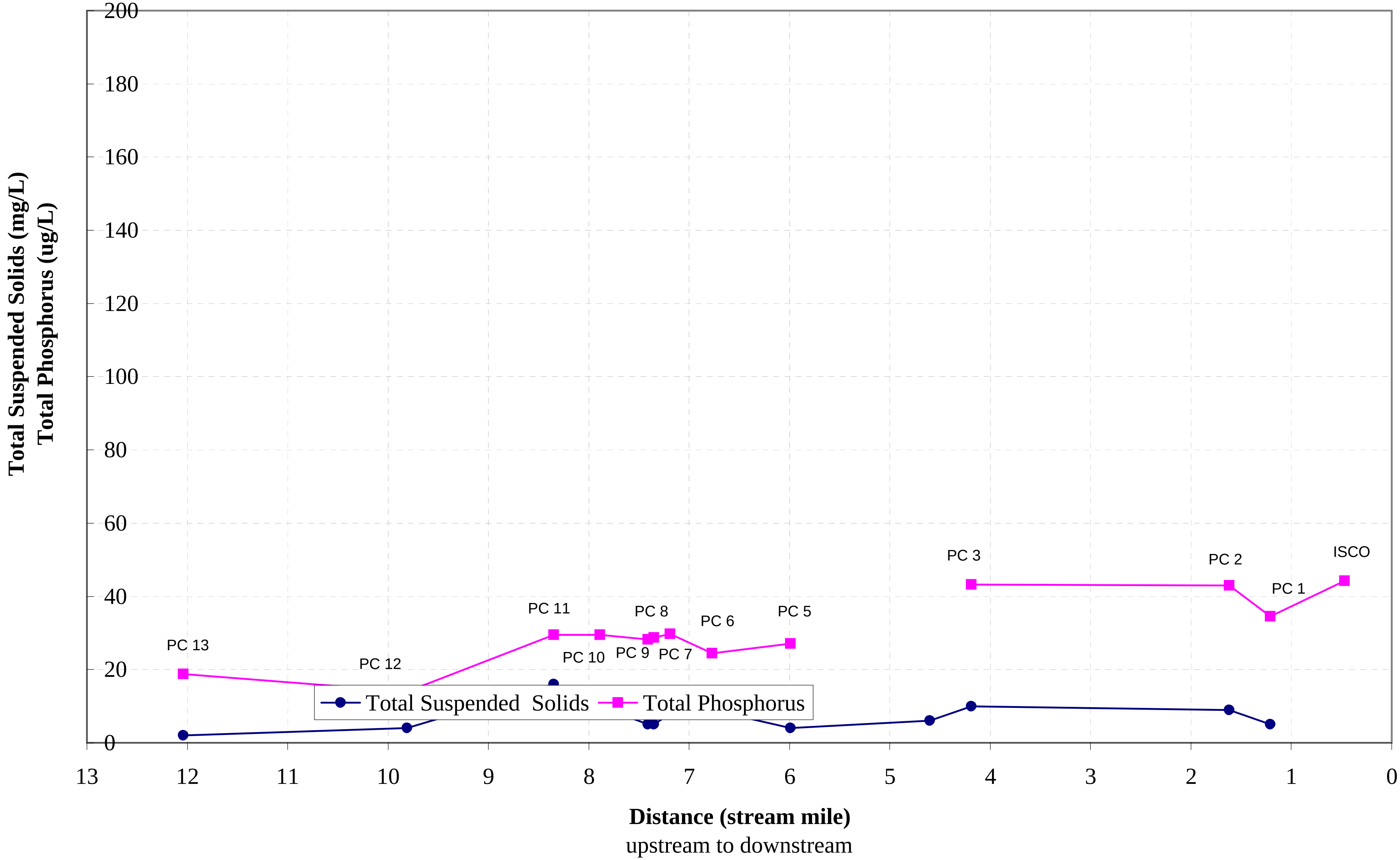

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Figure 7. Portage Creek

Dissolved Oxygen, Temperature and pH

Wet weather September 20, 2002

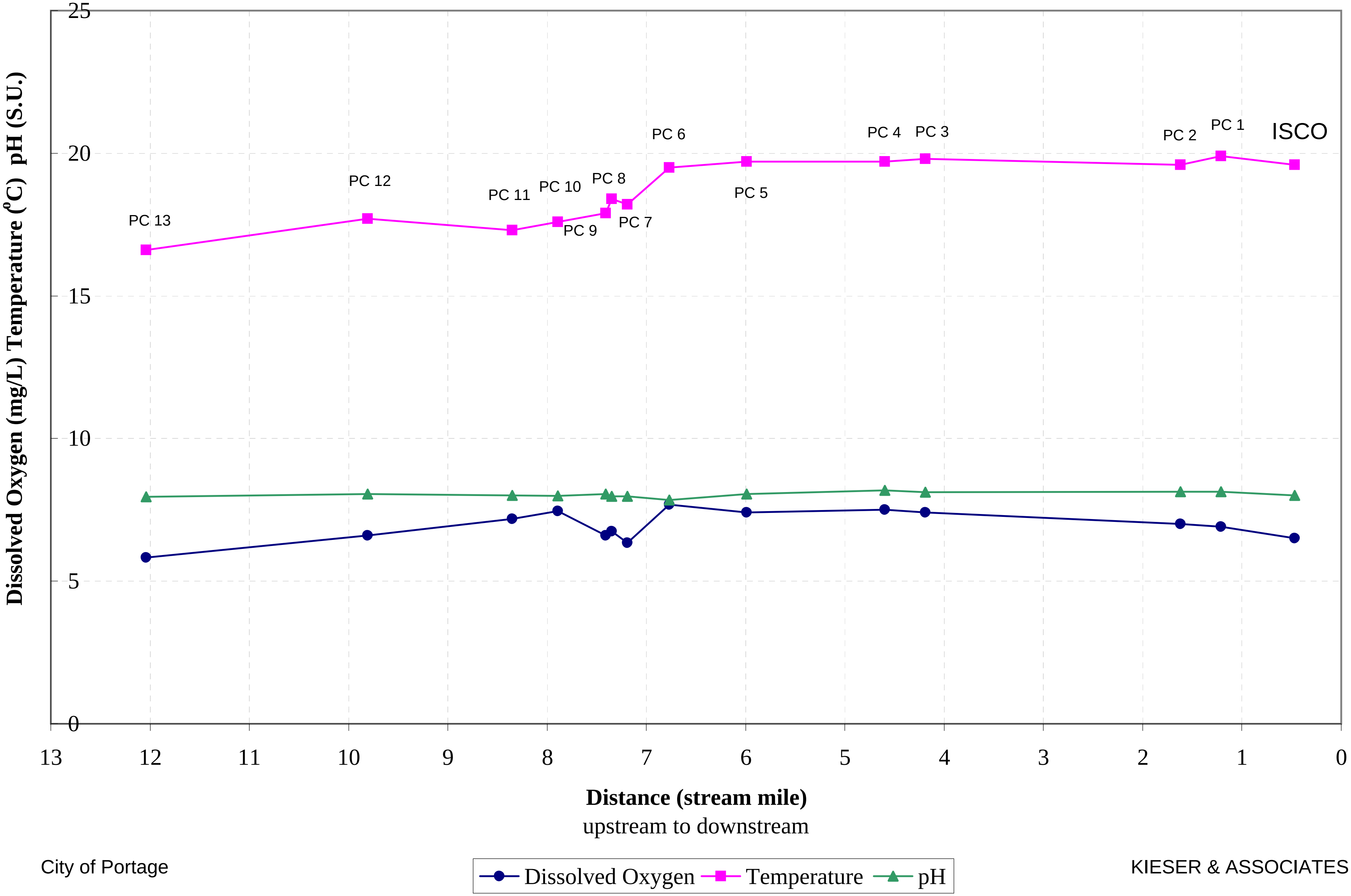

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Figure 8. Portage Creek

Conductivity

Wet weather September 20, 2002

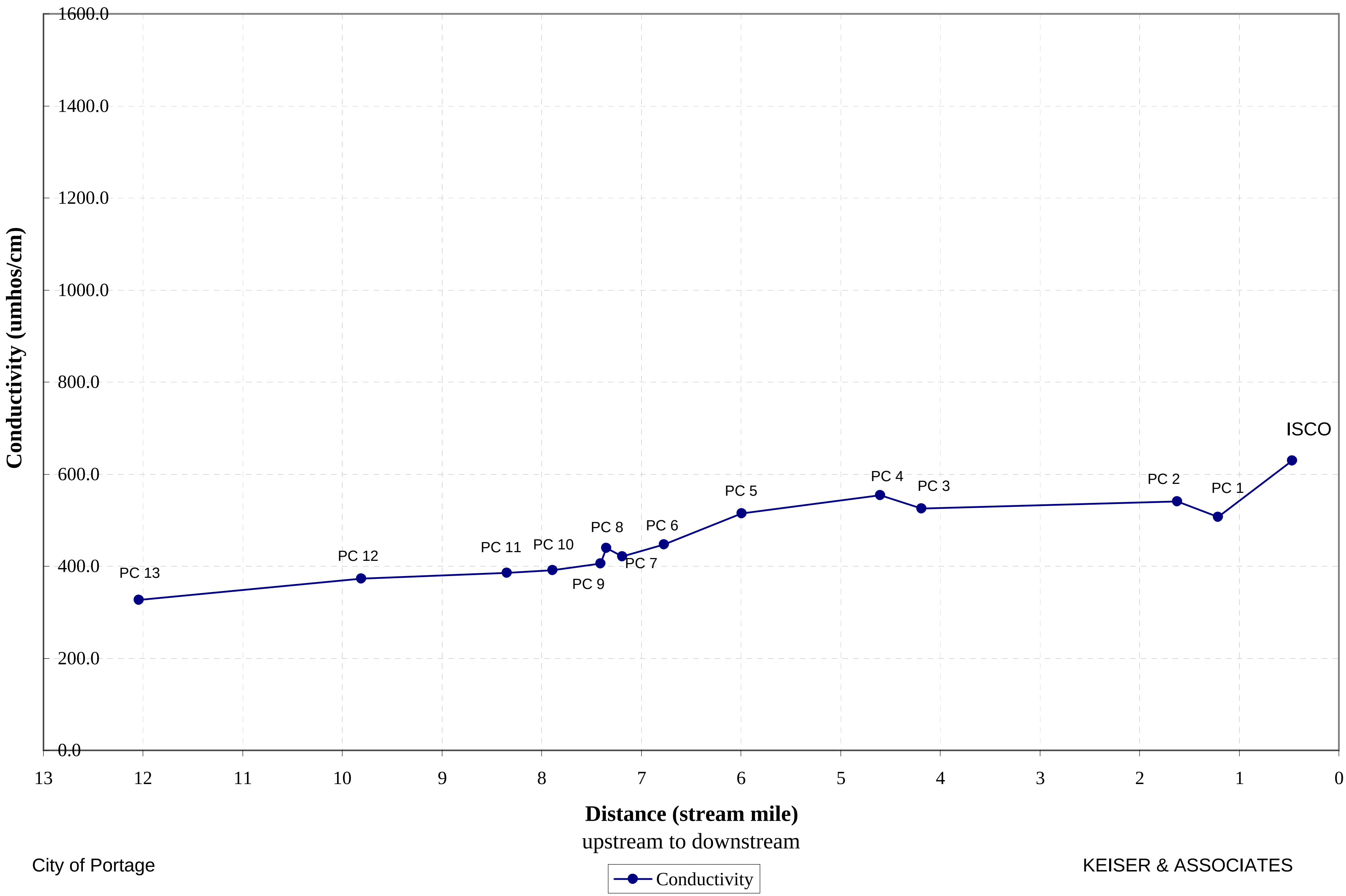

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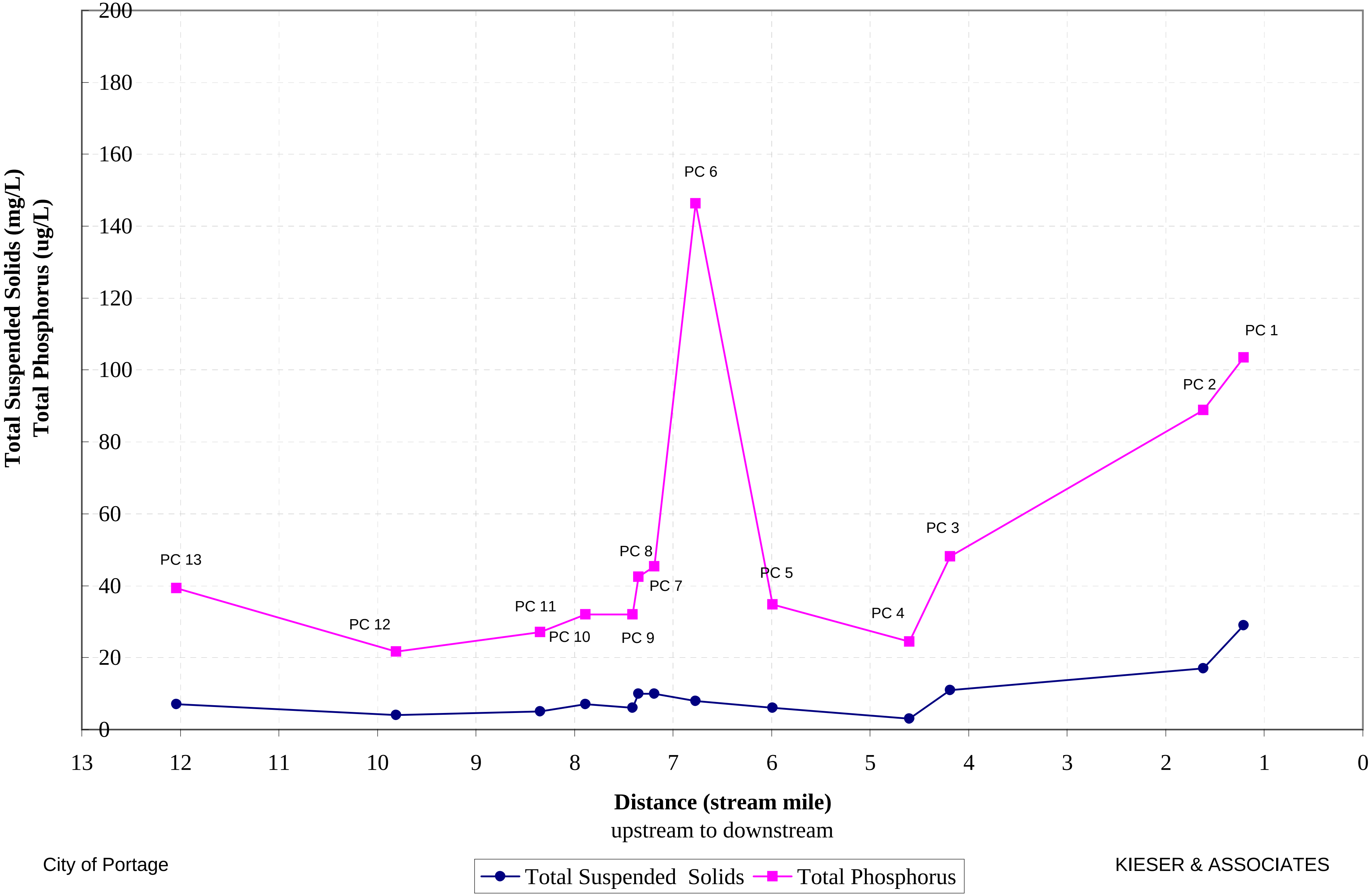
Figure 9. Portage Creek

Total Suspended Solids and Total Phosphorus

Dry weather September 20, 2002



City of Portage

KIESER & ASSOCIATES

Table 1. Portage Creek Dry Weather Monitoring Results
September 4, 2002

Station	Stream Mile	Wet/Dry	Flow (cfs)	Conductivity (umhos/cm)	Temperature (^oC)	pH (S.U.)	D.O. (mg/L)	TSS (mg/L)	TP (ug/L)	SRP (ug/L)	Alkalinity (mg/L)	Calcium (mg/L)	Iron (mg/L)	Turbidity (NTU)
PC 13	12.04	Dry		336	17.00	7.85	5.85	2	18.72	9.92				
PC 12	9.81	Dry		366	17.00	8.05	7.06	4	14.02	2.98				
PC 11	8.35	Dry		385	16.40	8.00	7.68	16	29.52	9.12				
PC 10	7.89	Dry	13.00	386	17.00	8.04	8.03	10	29.53	9.44				
PC 9	7.41	Dry		412	16.50	8.01	8.16	5	28.19	9.92				
Con.Drain	**na**	**Dry**		**575**	**15.40**	**7.77**	**7.96**	**3**	**29.79**	**4.27**				
PC 8	7.35	Dry		452	16.20	7.98	8.47	5	28.79	3.79				
PC 7	7.19	Dry		442	16.30	7.94	7.95	8	29.79	11.86	210	62.7	<.01	6.2
Pharmacia	**na**	**Dry**		**578**	**21**	**7.8**	**7.9**	**2.0**	**31.13**	**23.7**	**255**	**80.2**	**0.01**	**4.2**
PC 6	6.77	Dry		541	18.90	7.85	8.17	9	24.42	13.80	241	73.5	<.01	4.4
PC 5	5.99	Dry	34.60	479	19.40	8.04	7.65	4	27.11	9.76				
PC 4	4.60	Dry	20.00	481	18.00	8.13	7.80	6	*	*				
PC 3	4.19	Dry		487	18.20	8.16	7.40	10	43.28	20.74				
PC 2	1.62	Dry		523	18.20	8.17	7.90	9	42.95	7.34				
PC 1	1.21	Dry	28.20	533	18.00	8.09	7.70	5	34.49	9.76				

* Sample bottle broken during shipment

Table 2. Portage Creek Wet Weather Monitoring Results
September 20, 2002
24-hour rainfall 0.45 inches (K&A rain gauge data)

Station	Stream Mile	Wet/Dry	Flow (cfs)	Conductivity (umhos/cm)	Temperature (^oC)	pH (S.U.)	D.O. (mg/L)	TSS (mg/L)	TP (ug/L)	SRP (ug/L)	Alkalinity (mg/L)	Calcium (mg/L)	Iron (mg/L)	Turbidity (NTU)
PC 13	12.04	wet		327.1	16.60	7.96	5.83	7	39.34					
PC 12	9.81	wet		372.6	17.70	8.06	6.60	4	21.67					
PC 11	8.35	wet		385.8	17.30	8.00	7.18	5	27.04					
PC 10	7.89	wet	14.00	391.5	17.60	7.99	7.46	7	31.97					
PC 9	7.41	wet		405.6	17.90	8.05	6.60	6	32.07					
Con. Drain	**na**	**wet**		**581.0**	**17.60**	**7.82**	**6.80**	**7**	**44.51**					
PC 8	7.35	wet		439.3	18.40	7.98	6.75	10	42.51					
PC 7	7.19	wet		421.4	18.20	7.97	6.35	10	45.31		195	60.2	0.01	10.6
Pharmacia	**na**	**wet**		**606**	**20**	**7.8**	**7.1**	**1.0**	**32.56**		**261**	**86.3**	**0.01**	**5.3**
PC 6	6.77	wet		447.2	19.50	7.85	7.68	8	146.31		222	68.1	0.01	7.3
PC 5	5.99	wet	41.10	515.0	19.70	8.06	7.40	6	34.77					
PC 4	4.60	wet	19.00	554.0	19.70	8.19	7.50	3	24.48					
PC 3	4.19	wet		525.0	19.80	8.12	7.40	11	48.13					
PC 2	1.62	wet		541.0	19.60	8.14	7.00	17	88.87					
PC 1	1.21	wet	43.40	507.0	19.90	8.13	6.90	29	103.51					

Table 3. Pharmacia Outfall Grab Sampling Results

Date Time EST	Station	Wet/Dry	Conductivity (umhos/cm)	Temperature (°C)	pH (S.U.)	DO (mg/L)	TSS (mg/L)	TP (ug/L)	SRP (ug/L)	Alkalinity (mg/L)	Calcium (mg/L)	Iron (mg/L)	Turbidity (NTU)
11/30/01 11:10 AM	Gernaat Ct	dry	609	19	7.6	7.2	5.3	23.34		245	86.8	0.01	4
12/10/01 9:50 AM	Gernaat Ct	dry	569	20	8.0	8.3	6.6	18.57		245	84.2	0.02	3
2/25/02 12:20 PM	Gernaat Ct	dry	615	18	7.6	8.3	6.2	35.96		258	57.4	<0.01	6
3/8/02 12:20 PM	Gernaat Ct	wet	1293	10	6.2	10.4	26.8	88.15		130	46.0	0.02	42
4/4/02 9:15 AM	Gernaat Ct	dry	633	16	8.0	8.9	3.8	30.39		254	77.2	<0.01	8
5/8/02 2:45 PM	Gernaat Ct	wet	645	20	6.9	5.5	8.0	37.01	1.3	226	80.8	<0.01	2
5/15/02 9:10 AM	Gernaat Ct	dry	657	19	7.9	8.5	3.3	23.09		255	89.8	<0.01	3
6/3/02 12:35 PM	Gernaat Ct	wet	n/a	18	8.0	7.7	7.0	55.60		238	80.5	<0.01	12
6/17/02 11:05 AM	Gernaat Ct	dry	732	20	7.8	8.9	3.0	34.46		268	91.0	<0.01	<1
7/16/02 1:52 PM	Gernaat Ct	dry	753	24	7.9	7.8	4.0			268	87.4	0.01	3.5
8/12/02 12:53 PM	Gernaat Ct	dry	699	22	7.7	8.2	4.0			260	85.8	0.01	3.0
8/26/02 1:30 PM	Gernaat Ct	dry	669	18	7.9	8.5	4.0	26.56		260	84.3	0.01	3.9
9/4/02 10:55 AM	Gernaat Ct	dry	578	21	7.8	7.9	2.0	31.13	23.7	255	80.2	0.01	4.4
9/20/02 1:20 PM	Gernaat Ct	wet	606	20	7.8	7.1	1.0	32.56		261	86.3	0.01	5.3

*Shaded data are also shown in Tables 1 and 2

Table 4. Pharmacia Cooling Water Outfall Daily Temperature Monitoring Data

Date	High (°C)	Low (°C)	Daily Average (°C)	Daily Fluctuation (°C)
1/8/2002	21.76	19.48	19.94	2.28
1/9/2002	23.79	17.85	20.76	5.94
1/10/2002	22.60	14.67	18.58	7.93
1/11/2002	17.69	14.83	16.41	2.86
1/12/2002	16.89	13.89	15.30	3.00
1/13/2002	19.37	13.89	15.69	5.48
1/14/2002	16.11	14.36	15.23	1.75
1/15/2002	17.53	14.83	16.13	2.70
1/16/2002	18.33	15.63	16.83	2.70
1/17/2002	16.74	13.59	15.57	3.15
1/18/2002	17.69	14.52	16.10	3.17
THERMISTOR LOST				
5/22/2002	22.56	21.01	21.69	1.55
5/23/2002	21.01	16.81	20.04	4.20
5/24/2002	21.01	16.81	21.01	4.20
5/25/2002	22.56	18.59	19.43	3.97
5/26/2002	21.32	17.11	18.83	4.21
5/27/2002	20.71	16.22	18.54	4.49
5/28/2002	23.19	15.92	19.31	7.27
5/29/2002	24.14	16.22	19.62	7.92
5/30/2002	20.71	17.70	19.74	3.01
5/31/2002	23.82	19.19	20.30	4.63
6/1/2002	24.14	18.00	20.33	6.14
6/2/2002	23.19	18.00	20.47	5.19
6/3/2002	20.71	15.92	19.71	4.79
6/4/2002	23.51	18.89	20.85	4.62
6/5/2002	23.51	19.79	21.00	3.72
6/6/2002	22.87	18.00	20.86	4.87
6/7/2002	24.78	18.29	20.15	6.49
6/8/2002	23.19	17.70	19.98	5.49
6/9/2002	20.40	16.81	19.38	3.59
6/10/2002	22.25	17.11	19.96	5.14
6/11/2002	22.56	17.11	19.96	5.45
6/12/2002	21.32	17.70	19.25	3.62
6/13/2002	21.93	17.11	19.35	4.82
6/14/2002	22.87	15.34	20.03	7.53
6/15/2002	22.56	15.34	19.53	7.22
6/16/2002	22.56	17.11	19.63	5.45
6/17/2002	21.01	16.51	18.61	4.50
6/18/2002	18.59	16.22	17.41	2.37
6/19/2002	19.49	16.22	17.31	3.27
6/20/2002	19.49	15.63	17.20	3.86
6/21/2002	17.40	15.92	16.75	1.48
6/22/2002	19.79	16.22	17.20	3.57
6/23/2002	20.71	15.92	16.75	4.79

6/24/2002	19.19	15.92	16.80	3.27
6/25/2002	19.19	16.22	16.90	2.97
6/26/2002	23.51	14.76	16.67	8.75
6/27/2002	21.01	14.76	16.99	6.25
6/28/2002	22.87	17.11	19.56	5.76
6/29/2002	22.56	18.89	19.64	3.67
6/30/2002	21.01	16.51	18.96	4.50
7/1/2002	20.40	18.89	19.61	1.51
7/2/2002	20.40	16.22	18.90	4.18
7/3/2002	20.09	16.22	17.79	3.87
7/4/2002	17.40	14.76	16.06	2.64
7/5/2002	24.46	15.05	16.94	9.41
7/6/2002	16.81	15.34	15.98	1.47
7/7/2002	16.81	15.34	16.08	1.47
7/8/2002	20.09	15.34	17.36	4.75
7/9/2002	22.87	16.51	19.24	6.36
7/10/2002	21.01	16.51	19.19	4.50
7/11/2002	21.01	16.22	18.98	4.79
7/12/2002	22.87	16.51	19.32	6.36
7/13/2002	23.19	18.00	19.68	5.19
7/14/2002	19.79	15.34	18.14	4.45
7/15/2002	22.87	18.29	19.83	4.58
7/16/2002	24.14	15.92	20.09	8.22
7/17/2002	20.71	15.63	19.25	5.08
7/18/2002	19.79	15.34	16.93	4.45
7/19/2002	23.19	15.34	19.32	7.85
7/20/2002	20.71	16.51	19.50	4.20
7/21/2002	22.56	15.63	18.63	6.93
7/22/2002	25.74	15.34	17.08	10.40
7/23/2002	23.82	15.92	18.54	7.90
7/24/2002	23.82	16.51	20.11	7.31
7/25/2002	22.25	16.22	19.87	6.03
Date	**High (^{o}C)**	**Low (^{o}C)**	**aily Avera (^{o}C)**	**ly Fluctuation (^{o}C)**
7/26/2002	23.82	19.49	20.56	4.33
7/27/2002	21.63	17.40	20.38	4.23
7/28/2002	23.82	16.81	20.14	7.01
7/29/2002	25.10	19.19	20.37	5.91
7/30/2002	23.19	17.40	20.19	5.79
7/31/2002	22.87	17.11	20.24	5.76
8/1/2002	22.56	16.51	19.69	6.05
8/2/2002	24.14	17.40	20.10	6.74
8/3/2002	21.93	17.11	19.94	4.82
8/4/2002	26.07	16.81	20.08	9.26
8/5/2002	23.51	18.89	20.42	4.62
8/6/2002	24.46	16.22	19.87	8.24
8/7/2002	21.32	16.22	20.05	5.10
8/8/2002	24.78	17.40	21.18	7.38
8/9/2002	24.46	18.29	21.22	6.17
8/10/2002	22.25	17.70	20.79	4.55
8/11/2002	24.14	15.92	19.72	8.22
8/12/2002	23.51	18.00	20.61	5.51

8/13/2002	24.14	18.59	20.44	5.55
8/14/2002	27.06	16.22	19.60	10.84
8/15/2002	25.74	17.40	21.20	8.34
8/16/2002	21.93	19.49	20.66	2.44
8/17/2002	23.51	16.81	20.82	6.70
8/18/2002	24.14	16.51	20.72	7.63
8/19/2002	21.63	16.22	20.16	5.41
8/20/2002	25.10	16.51	20.41	8.59
8/21/2002	24.78	16.81	20.85	7.97
8/22/2002	22.25	16.22	20.41	6.03
8/23/2002	22.56	17.11	20.57	5.45
8/24/2002	21.63	16.81	20.37	4.82
8/25/2002	23.51	16.22	19.90	7.29
8/26/2002	24.46	16.22	18.23	8.24
8/27/2002	24.46	18.59	20.13	5.87
8/28/2002	25.10	18.59	20.69	6.51
8/29/2002	22.87	17.70	20.33	5.17
8/30/2002	23.82	19.79	20.94	4.03
8/31/2002	23.51	15.92	19.56	7.59
9/1/2002	21.93	16.81	20.67	5.12
9/2/2002	22.87	16.81	20.32	6.06
9/3/2002	25.42	19.49	20.69	5.93
9/4/2002	23.51	16.81	20.40	6.70
9/5/2002	24.46	16.51	20.64	7.95
9/6/2002	24.14	19.19	20.63	4.95
9/7/2002	21.93	16.81	20.14	5.12
9/8/2002	21.93	16.22	18.26	5.71
9/9/2002	24.46	16.81	20.20	7.65
9/10/2002	23.82	18.29	20.28	5.53
9/11/2002	23.51	19.49	20.61	4.02
9/12/2002	23.19	17.11	20.39	6.08
9/13/2002	23.82	19.19	20.56	4.63
9/14/2002	20.40	17.40	20.40	3.00
9/15/2002	23.82	20.40	20.85	3.42
9/16/2002	21.63	17.40	19.98	4.23

Appendix A

Analytical Laboratory Results

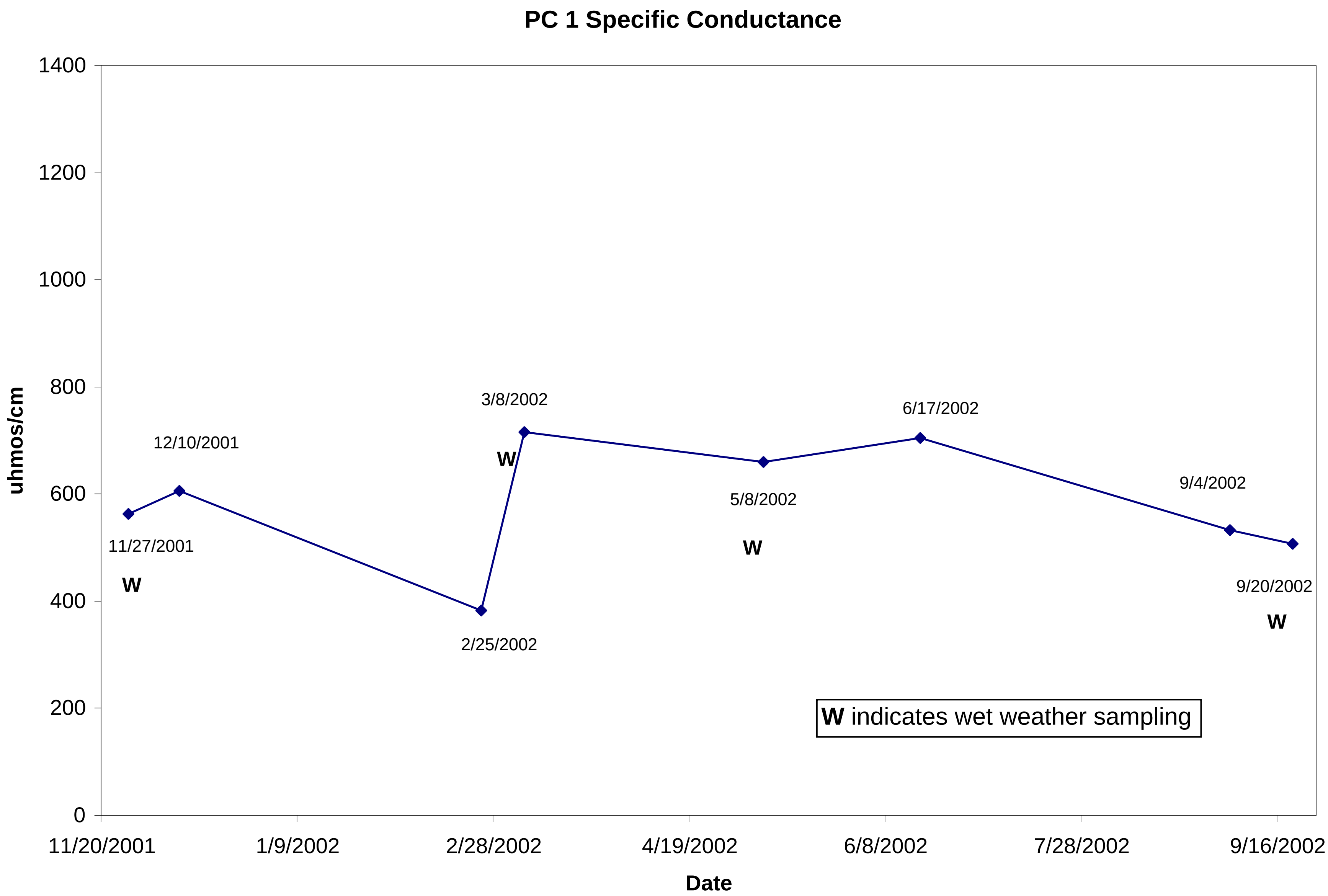
Appendix B

Portage Creek Sampling Stations (with Pharmacia Outfall and Consolidated Drain)

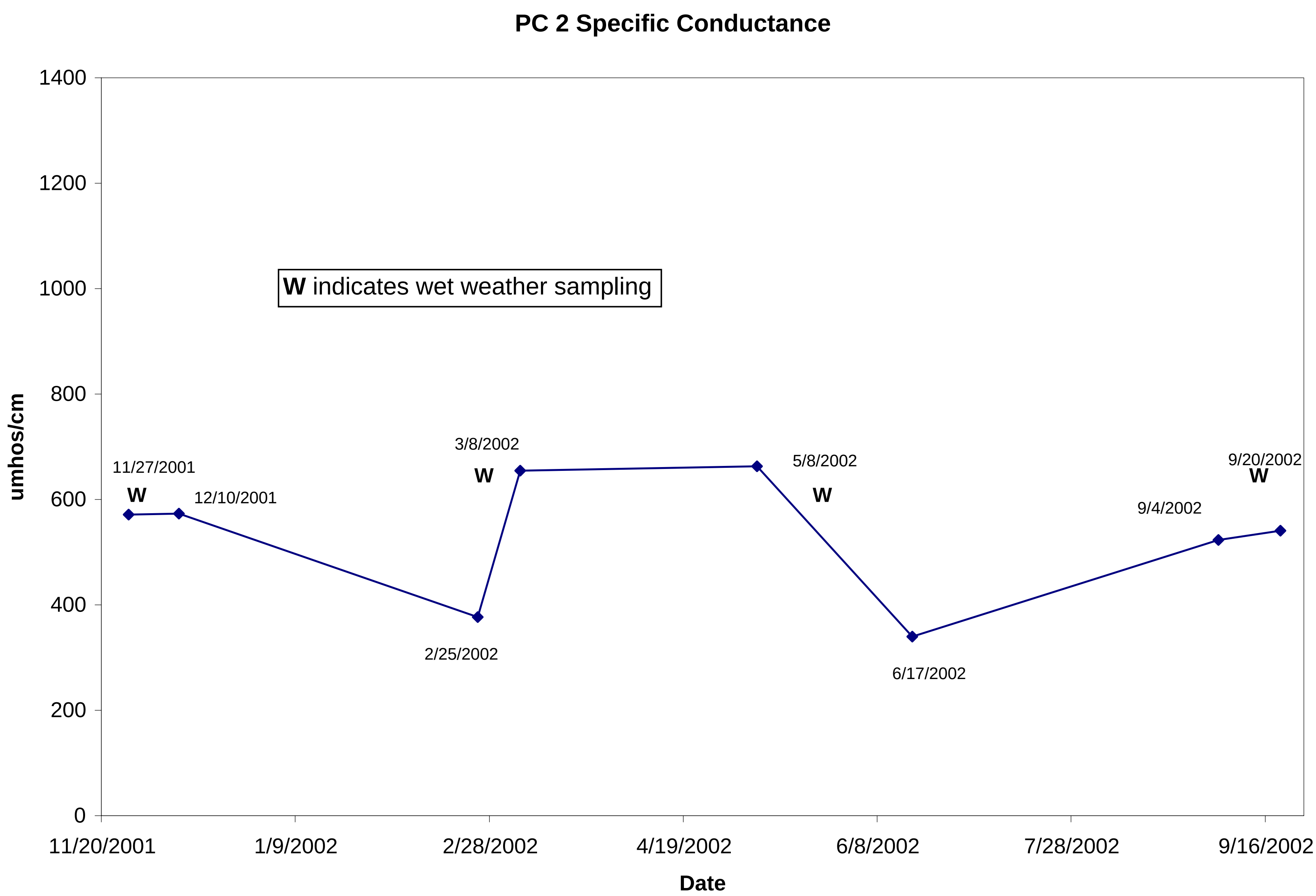
Water Quality Table and Graphs

Portage Creek, Consolidated Drain and Gernaat Court
Grab Sampling Data

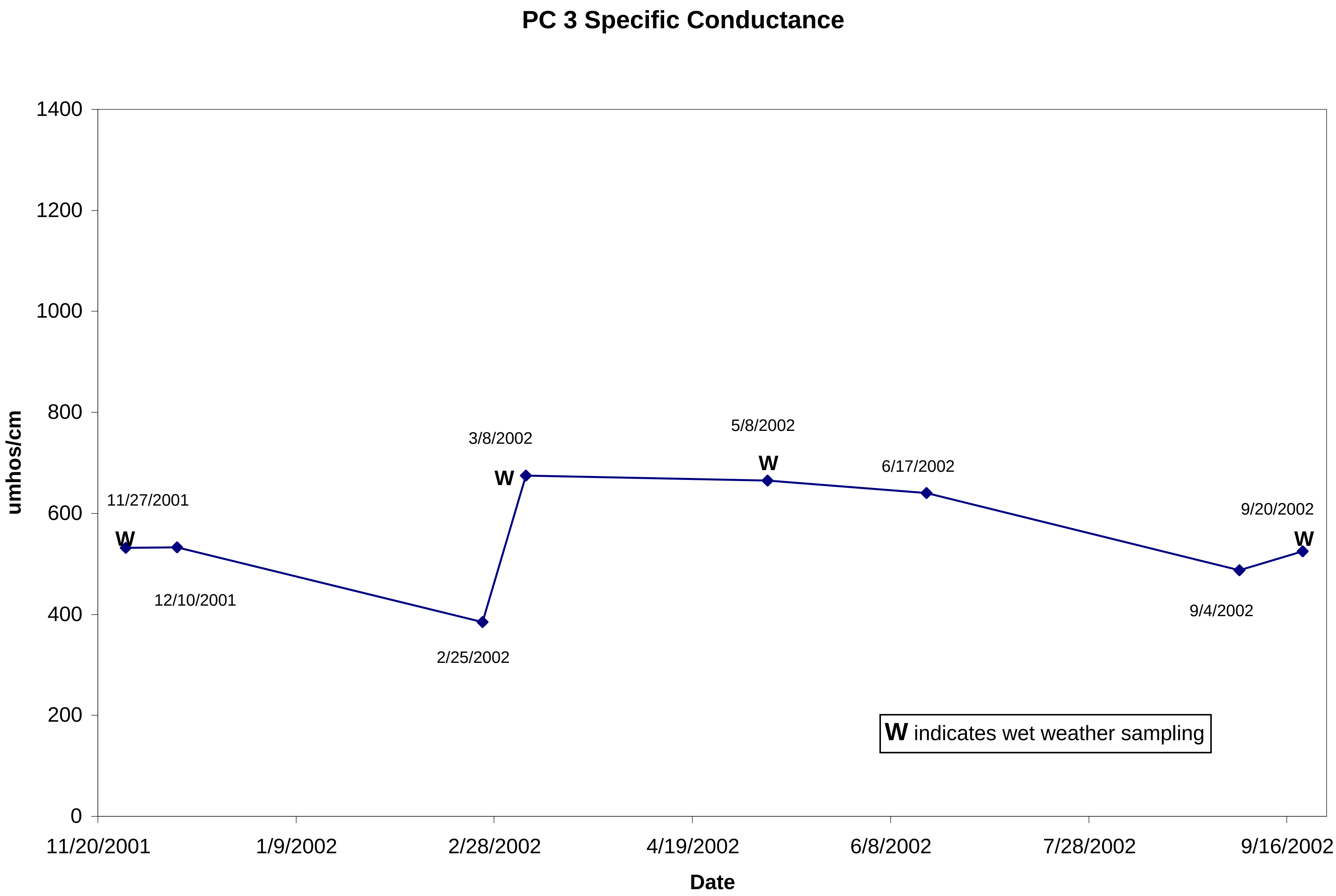
Date	Creek Name	Station	Stream Mile	Wet/Dry	Flow (cfs)	Conductivity (umhos/cm)	Temperature (oC)	pH (SU)	DO (mg/L)	TSS (mg/L)	TP (ug/L)	SRP (ug/L)	Alkalinity (mg/L)	Calcium (mg/L)	Iron (mg/L)	Turbidity (NTU)
11/27/01	Portage Creek	PC 13	12.04	wet		385	10	7.7	7.3	0.8	12.79					
12/10/01	Portage Creek	PC 13	12.04	dry		387	7	8.3	8.3	1.0	10.83					
2/25/02	Portage Creek	PC 13	12.04	dry		386	9	7.8	9.4	1	18.06					
3/8/02	Portage Creek	PC 13	12.04	wet		406	8	5.8	9.3	2.69	20.26					
5/8/02	Portage Creek	PC 13	12.04	wet		402	14	7.0	7.1	6	27.64	0.2				
6/17/02	Portage Creek	PC 13	12.04	dry		404	19	7.7	5.1	1	21.93					
9/4/02	Portage Creek	PC 13	12.04	dry		336	17.00	7.85	5.85	2	18.72	9.92				
9/20/02	Portage Creek	PC 13	12.04	wet		327.1	16.60	7.96	5.83	7	39.34					
11/27/01	Portage Creek	PC 12	9.81	wet		429	9	7.8	8.4	1.9	14.55					
12/10/01	Portage Creek	PC 12	9.81	dry		433	6	8.9	9.1	1.9	12.94					
2/25/02	Portage Creek	PC 12	9.81	dry		419	8	7.7	9.7	3.3	16.71					
3/8/02	Portage Creek	PC 12	9.81	wet		258	7	5.4	8.9	13.13	30.39					
5/8/02	Portage Creek	PC 12	9.81	wet		456	11	6.9	0.3	35	105.27	1.5				
6/17/02	Portage Creek	PC 12	9.81	dry		456	18	8.1	8.4	4	23.22					
9/4/02	Portage Creek	PC 12	9.81	dry		366	17.00	8.05	7.06	4	14.02	2.98				
9/20/02	Portage Creek	PC 12	9.81	wet		372.6	17.70	8.06	6.60	4	21.67					
11/27/01	Portage Creek	PC 11	8.35	wet		439	9	7.8	8.8	7.8	59.45					
12/10/01	Portage Creek	PC 11	8.35	dry		542	6	8.6	10.2	15.2	32.64					
2/25/02	Portage Creek	PC 11	8.35	dry		441	8	7.6	9.3	4.32	9.95					
3/8/02	Portage Creek	PC 11	8.35	wet		243	7	5.6	10.1	11.36	33.1					
5/8/02	Portage Creek	PC 11	8.35	wet		413	12	6.9	8.0	31	114.96	2.6				
6/17/02	Portage Creek	PC 11	8.35	dry		475	18	8.0	8.4	13	90.78					
9/4/02	Portage Creek	PC 11	8.35	dry		385	16.40	8.00	7.68	16	29.52	9.12				
9/20/02	Portage Creek	PC 11	8.35	wet		385.8	17.30	8.00	7.18	5	27.04					
11/27/01	Portage Creek	PC 10	7.89	wet	16.00	444	9	7.9	9.1	2.2	18.07					
12/10/01	Portage Creek	PC 10	7.89	dry	18.00	450	5	8.6	10.4	27.5	27.71					
2/25/02	Portage Creek	PC 10	7.89	dry	19.00	446	8	7.6	10.9	3.8	12.26					
3/8/02	Portage Creek	PC 10	7.89	wet	27.00	243	6	5.5	10.3	14.02	41.88					
5/8/02	Portage Creek	PC 10	7.89	wet	33.00	432	12	7.0	8.4	29	102.05	1.8				
6/17/02	Portage Creek	PC 10	7.89	dry	15.39	489	17	8.0	8.9	7	81.14					
9/4/02	Portage Creek	PC 10	7.89	dry	13.00	386	17.00	8.04	8.03	10	29.53	9.44				
9/20/02	Portage Creek	PC 10	7.89	wet	14.00	391.5	17.60	7.99	7.46	7	31.97					
11/27/01	Portage Creek	PC 9	7.41	wet		464	9	7.8	9.3	1.9	18.77					
12/10/01	Portage Creek	PC 9	7.41	dry		470	5	8.7	11.0	2.0	18.57					
2/25/02	Portage Creek	PC 9	7.41	dry		474	8	7.6	11.0	3.5	16.86					
3/8/02	Portage Creek	PC 9	7.41	wet		288	6	5.6	10.5	15.41	44.92					
5/8/02	Portage Creek	PC 9	7.41	wet		452	12.1	6.93	8.73	17	58.45	4.2				
6/17/02	Portage Creek	PC 9	7.41	dry		520	17	7.95	10	6	74.81					
9/4/02	Portage Creek	PC 9	7.41	dry		412	16.50	8.01	8.16	5	28.19	9.92				
9/20/02	Portage Creek	PC 9	7.41	wet		405.6	17.90	8.05	6.60	6	32.07					
11/27/01	Portage Creek	PC 8	7.35	wet		520	10	7.7	6.9	4.0	34.25					
12/10/01	Portage Creek	PC 8	7.35	dry		521	6	8.2	8.1	2.7	22.44					
2/25/02	Portage Creek	PC 8	7.35	dry		744	9	7.5	9.7	5.2	21.80					
3/8/02	Portage Creek	PC 8	7.35	wet		761	6	6.3	10.3	23.5	57.75					
5/8/02	Portage Creek	PC 8	7.35	wet		411	12	6.9	8.8	58	226.05	20.7				
6/17/02	Portage Creek	PC 8	7.35	dry		620	18	7.9	9.4	25	142.18					
9/4/02	Portage Creek	PC 8	7.35	dry		452	16.20	7.98	8.47	5	28.79	3.79				
9/20/02	Portage Creek	PC 8	7.35	wet		439.3	18.40	7.98	6.75	10	42.51					
11/27/01	Portage Creek	PC 7	7.19	wet		474	9	9.1	9.2	1.9	24.05		208	64.5	0.06	5.0
12/10/01	Portage Creek	PC 7	7.19	dry		476	5	8.6	11.2	2.5	16.46		205	65.7	0.04	1.5
2/25/02	Portage Creek	PC 7	7.19	dry		520	7	7.5	10.5	4.6	18.18		200	57.1	0.05	4.3
3/8/02	Portage Creek	PC 7	7.19	wet		776	6	6.3	10.3	17.3	51.34		182	66.7	0.10	22
5/8/02	Portage Creek	PC 7	7.19	wet		255	12	7.0	8.5	61	171.28	11.6	112	36.7	0.04	20
6/17/02	Portage Creek	PC 7	7.19	dry		533	17	8.0	9.5	6	29.96		208	66.3	0.01	1
9/4/02	Portage Creek	PC 7	7.19	dry		442	16.30	7.94	7.95	8	29.79	11.86	210	62.7	<.01	6.2
9/20/02	Portage Creek	PC 7	7.19	wet		421.4	18.20	7.97	6.35	10	45.31		195	60.2	0.01	10.6
11/27/01	Portage Creek	PC 6	6.77	wet		616	20	7.8	7.9	8.4	26.51		245	86.1	0.01	5.0
12/10/01	Portage Creek	PC 6	6.77	dry		522	12	8.4	9.6	2.8	20.33		230	75.6	0.01	2.6
2/25/02	Portage Creek	PC 6	6.77	dry		376	10	8.5	8.6	5	20.48		218	56.9	0.03	3.8
3/8/02	Portage Creek	PC 6	6.77	wet		1037	8	6.3	10.0	16.7	57.41		178	64.3	0.07	23.2
5/8/02	Portage Creek	PC 6	6.77	wet		505	15	7.0	4.2	27	79.44	1.6	155	50.3	0.01	70.3
6/17/02	Portage Creek	PC 6	6.77	dry		621	18	7.9	9.6	5	30.28		235	79.5	0.01	1.0
9/4/02	Portage Creek	PC 6	6.77	dry		541	18.90	7.85	8.17	9	24.42	13.80	241	73.5	<.01	4.2
9/20/02	Portage Creek	PC 6	6.77	wet		447.2	19.50	7.85	7.68	8	146.31		222	68.1	0.01	7.3
11/27/01	Portage Creek	PC 5	5.99	wet	na	523	14	7.9	8.4	4.5	23.69					
12/10/01	Portage Creek	PC 5	5.99	dry	44.79	523	11	8.5	8.6	7.0	24.55					
2/25/02	Portage Creek	PC 5	5.99	dry	36.50	381	9	8.4	7.8	3.88	19.83					
3/8/02	Portage Creek	PC 5	5.99	wet	53.40	930	8	6.2	6.8	21.63	61.13					
5/8/02	Portage Creek	PC 5	5.99	wet	57.60	631	16	7.1	9.8	6	25.71	0.5				
6/17/02	Portage Creek	PC 5	5.99	dry	42.50	652	18	8.2	12.9	2	18.72					
9/3/02	Portage Creek	PC 5	5.99	dry	34.60	479	19.40	8.04	7.65	4	27.11	9.76				
9/20/02	Portage Creek	PC 5	5.99	wet	41.10	515.0	19.70	8.06	7.40	6	34.77					
11/27/01	Portage Creek	PC 4	4.60	wet	48.00	533	12	8.1	9.2	7.4	30.38					
12/10/01	Portage Creek	PC 4	4.60	dry	45.00	530	9	8.4	10.4	11.1	33.34					
2/25/02	Portage Creek	PC 4	4.60	dry	29.00	382	8	8.4	7.9	3.68						
3/8/02	Portage Creek	PC 4	4.60	wet	44.00	877	8	6.1	9.6	36.7	66.53					
5/8/02	Portage Creek	PC 4	4.60	wet	57.00	658	15	7.1	10.5	9	37.14	1.8				
6/17/02	Portage Creek	PC 4	4.60	dry		428	19	8.3	11.0	4	23.54					
9/4/02	Portage Creek	PC 4	4.60	dry	20.00	481	18.00	8.13	7.80	6						
9/20/02	Portage Creek	PC 4	4.60	wet	19.00	554.0	19.70	8.19	7.50	3	24.48					
11/27/01	Portage Creek	PC 3	4.19	wet		532	12	8.1	9.8	16.9	46.44					
12/10/01	Portage Creek	PC 3	4.19	dry		533	9	8.2	11.1	8.1	31.58					
2/25/02	Portage Creek	PC 3	4.19	dry		385	8	8.4	9.2	3.5	16.53					
3/8/02	Portage Creek	PC 3	4.19	wet		675	8	6.1	10.0	6.3	43.9					
5/8/02	Portage Creek	PC 3	4.19	wet		665	15	7.1	10.3	6	26.03	1.0				
6/17/02	Portage Creek	PC 3	4.19	dry		640	19	8.2	8.5	6	77.92					
9/4/02	Portage Creek	PC 3	4.19	dry		487	18.20	8.16	7.40	10	43.28	20.74				
9/20/02	Portage Creek	PC 3	4.19	wet		525.0	19.80	8.12	7.40	11	48.13					
11/27/01	Portage Creek	PC 2	1.62	wet		571	9	6.9	11.0	29.8	67.89					
12/10/01	Portage Creek	PC 2	1.62	dry		573	7	6.4	10.5	5.8	22.79					
2/25/02	Portage Creek	PC 2	1.62	dry		377	7	8.4	11.1	2.9	17.52					
3/8/02	Portage Creek	PC 2	1.62	wet		655	7	6.5	9.4	13.33	50.32					
5/8/02	Portage Creek	PC 2	1.62	wet		663	14	7.1	10.4	16	56.83	8.0				
6/17/02	Portage Creek	PC 2	1.62	dry		340	18	8.3	8.6	11	46.67					
9/4/02	Portage Creek	PC 2	1.62	dry		523	18.20	8.17	7.90	9	42.95	7.34				
9/20/02	Portage Creek	PC 2	1.62	wet		541.0	19.60	8.14	7.00	17	88.87					
11/27/01	Portage Creek	PC 1	1.21	wet	70.73	563	12	7.0	9.5	5.1	41.51					
12/10/01	Portage Creek	PC 1	1.21	dry	47.24	606	9	6.5	11.0	5.0	19.62					
2/25/02	Portage Creek	PC 1	1.21	dry	40.80	383	7	8.3	11.0	3.78	15.22					
3/8/02	Portage Creek	PC 1	1.21	wet	57.80	716	7	6.6	8.7	11.65	41.54					
5/8/02	Portage Creek	PC 1	1.21	wet	44.00	660	14	7.1	10.0	20	99.14	14.5				
6/17/02	Portage Creek	PC 1	1.21	dry	37.00	705	17	8.2	10.5	11	110.05					
9/4/02	Portage Creek	PC 1	1.21	dry	28.20	533	18.00	8.09	7.70	5	34.49	9.76				
9/20/02	Portage Creek	PC 1	1.21	wet	43.40	507.0	19.90	8.13	6.90	29	103.51					
11/27/01	Consolidated Drain	Garden Ln		wet		577	10	7.5	5.3	3.7	50.08					
12/10/01	Consolidated Drain	Garden Ln		dry		613	7	7.9	6.6	4.2	32.64					
2/25/02	Consolidated Drain	Garden Ln		dry		1022	10	7.5	8.9	3.5	32.90					
3/8/02	Consolidated Drain	Garden Ln		wet						39	100					
5/8/02	Consolidated Drain	Garden Ln		wet		303	13	7.0	7.3	83	307.56	40.9				
6/17/02	Consolidated Drain	Garden Ln		dry		739	19	7.7	9.4	7	25.46					
9/4/02	Consolidated Drain	Garden Ln		dry		575	15.40	7.77	7.96	3	29.79	4.27				
9/20/02	Consolidated Drain	Garden Ln		wet		581.0	17.60	7.82	6.80	7	44.51					
11/30/01	Portage Creek	Gernaat Ct		dry		609	19	7.6	7.2	5.3	23.34		245	86.8	0.01	3.5
12/10/01	Portage Creek	Gernaat Ct		dry		569	20	8.0	8.3	6.6	18.57		245	84.2	0.02	3.0
2/25/02	Portage Creek	Gernaat Ct		dry		615	18	7.6	8.3	6.2	35.96		258	57.4	0.01	6.3
3/8/02	Portage Creek	Gernaat Ct		wet		1293	10	6.2	10.4	26.8	88.15		130	46.0	0.02	42.2
4/4/02	Portage Creek	Gernaat Ct		dry		633	16	8.0	8.9	3.8	30.39		254	77.2	0.01	7.7
5/8/02	Portage Creek	Gernaat Ct		wet		645	20	6.9	5.5	8.0	37.01	1.3	226	80.8	0.01	1.6
5/15/02	Portage Creek	Gernaat Ct		dry		657	19	7.9	8.5	3.3	23.09		255	89.8	0.01	2.9
6/3/02	Portage Creek	Gernaat Ct		wet			18	8.0	7.7	7.0	55.60		238	80.5	0.01	12.3
6/17/02	Portage Creek	Gernaat Ct		dry		732	20	7.8	8.9	3.0	34.46		268	91.0	0.01	1.0
7/16/02	Portage Creek	Gernaat Ct		dry		753	24	7.9	7.8	4.0			268	87.4	0.01	3.5
8/12/02	Portage Creek	Gernaat Ct		dry		699	22	7.7	8.2	4.0			260	85.8	0.01	3.0
8/26/02	Portage Creek	Gernaat Ct		dry		669	18	7.9	8.5	4.0	26.56		260	84.3	0.01	3.9
9/4/02	Portage Creek	Gernaat Ct		dry		578	21	7.8	7.9	2.0	31.13	23.7	255	80.2	0.01	4.4
9/20/02	Portage Creek	Gernaat Ct		wet		606	20	7.8	7.1	1.0	32.56		261	86.3	0.01	5.3



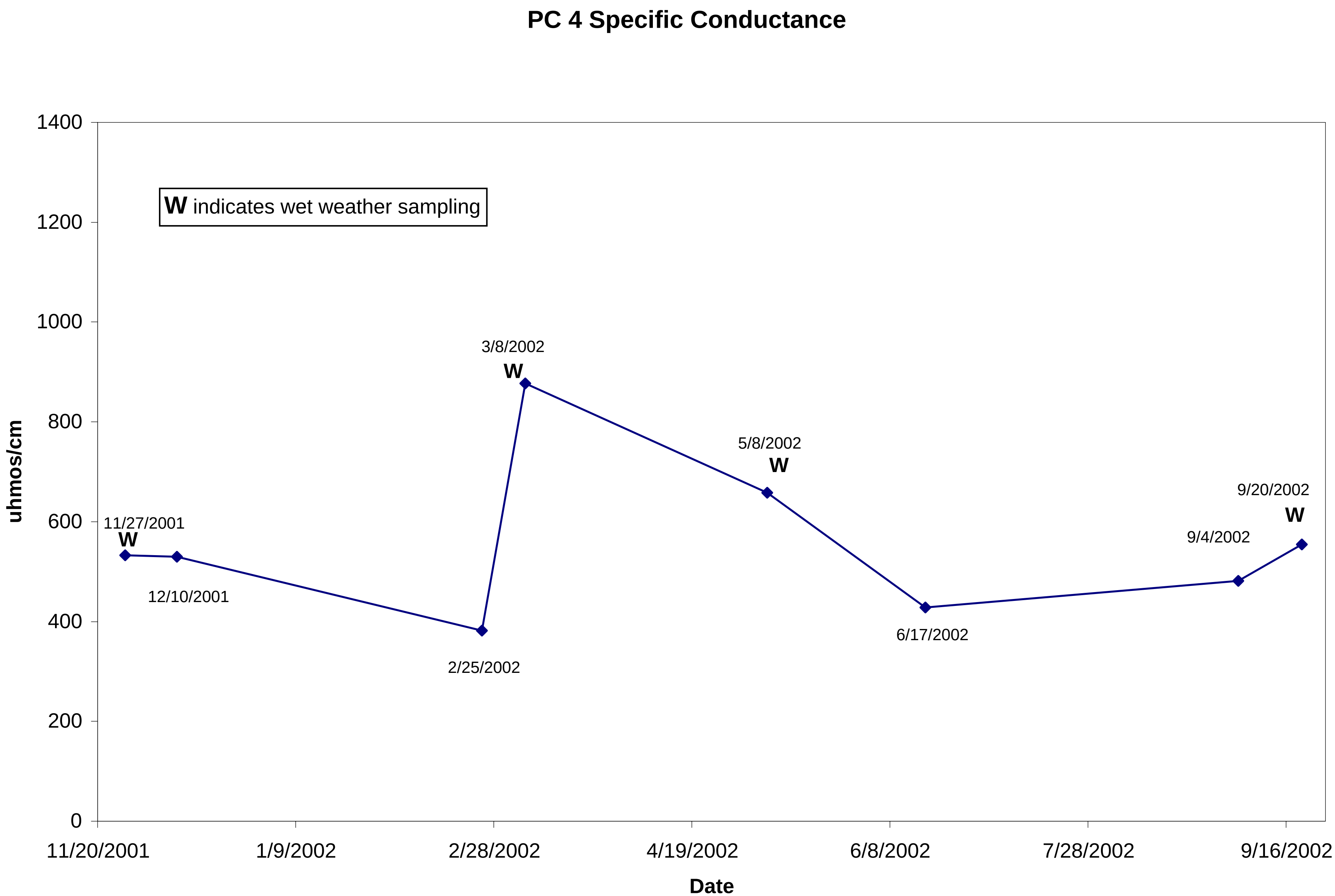
KIESER & ASSOCIATES



KEISER & ASSOCIATES



KIESER & ASSOCIATES



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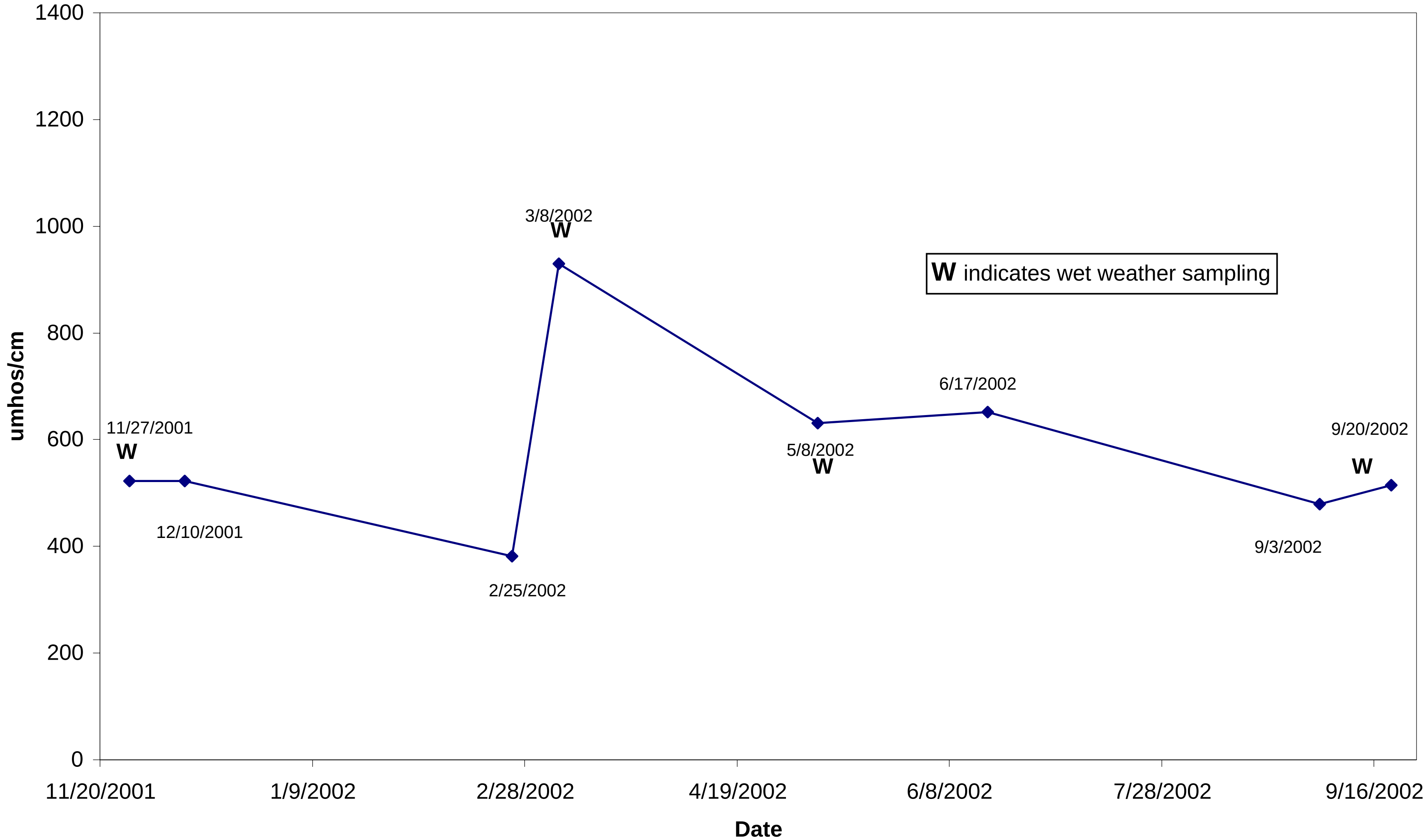
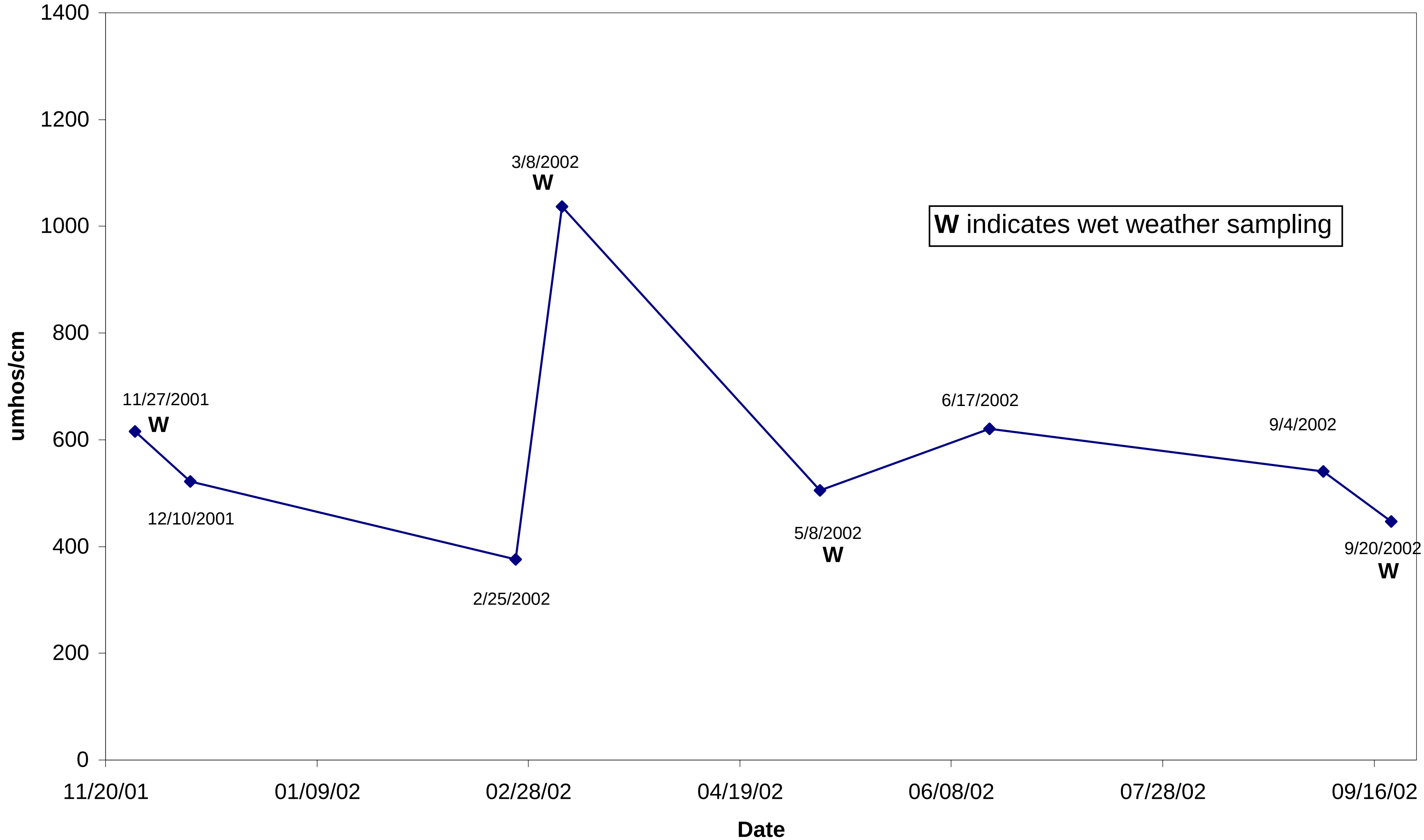
PC 5 Specific Conductance



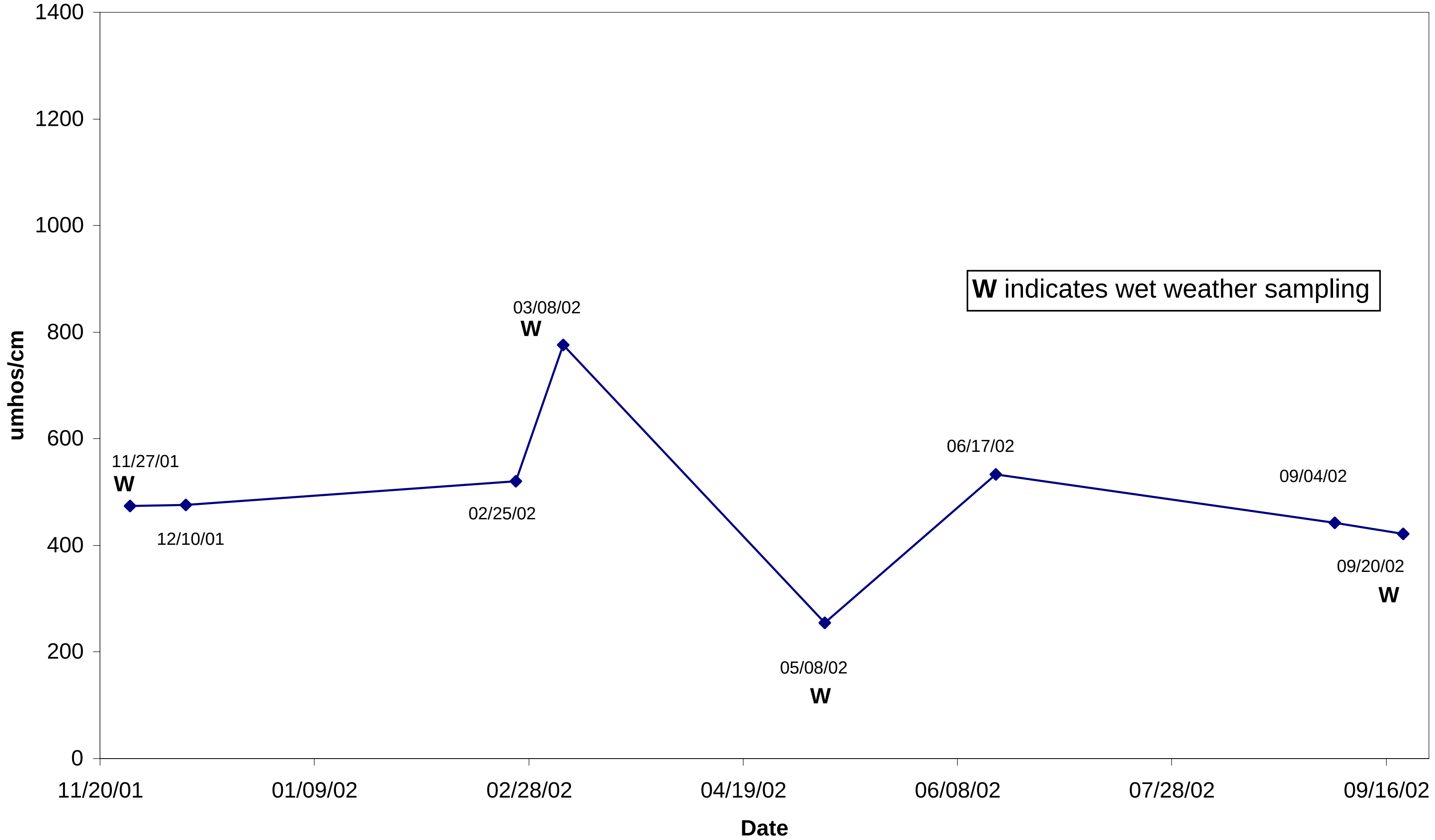
KIESER & ASSOCIATES

PC 6 Specific Conductance

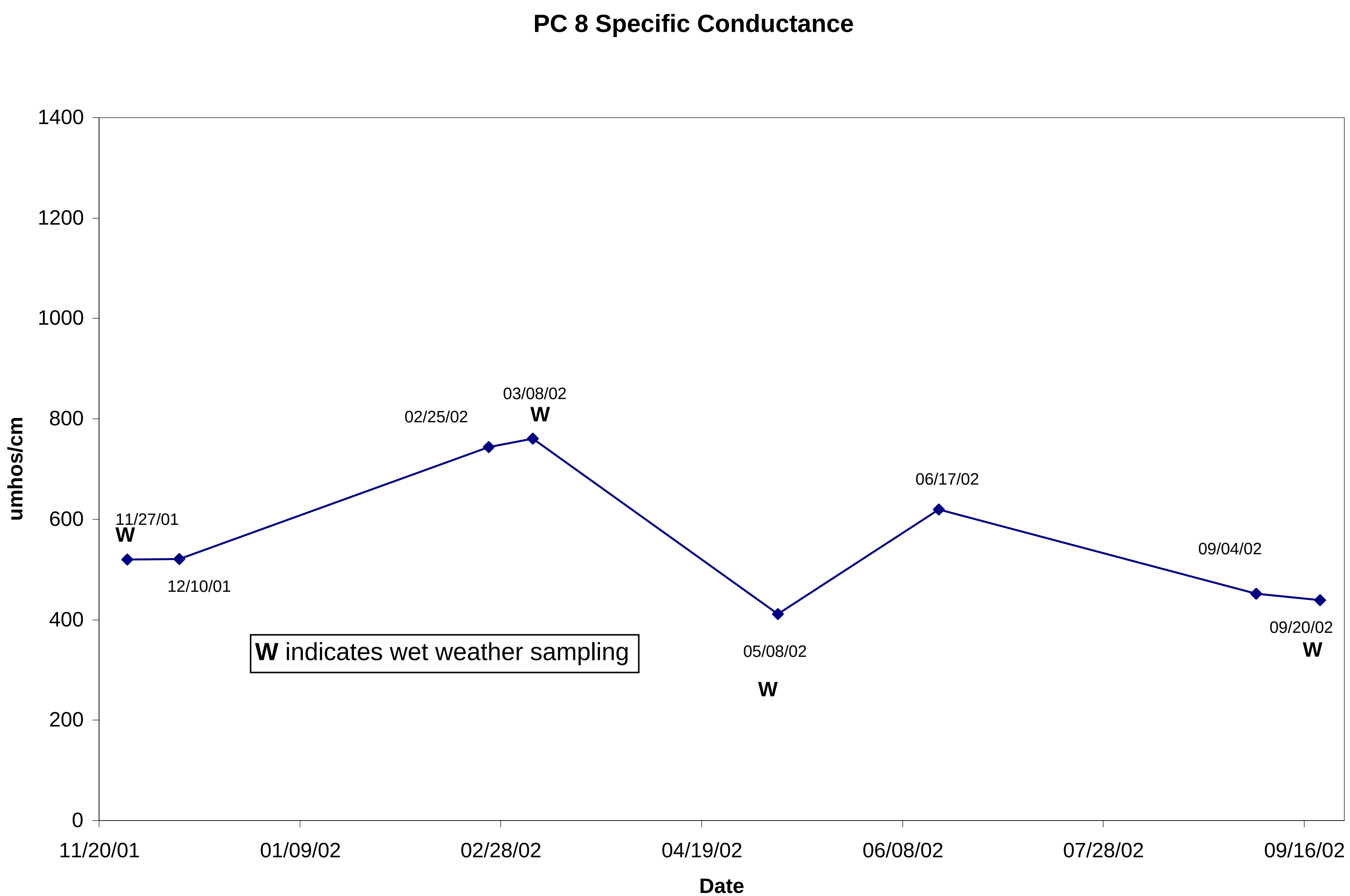


KIESER & ASSOCIATES

PC 7 Specific Conductance

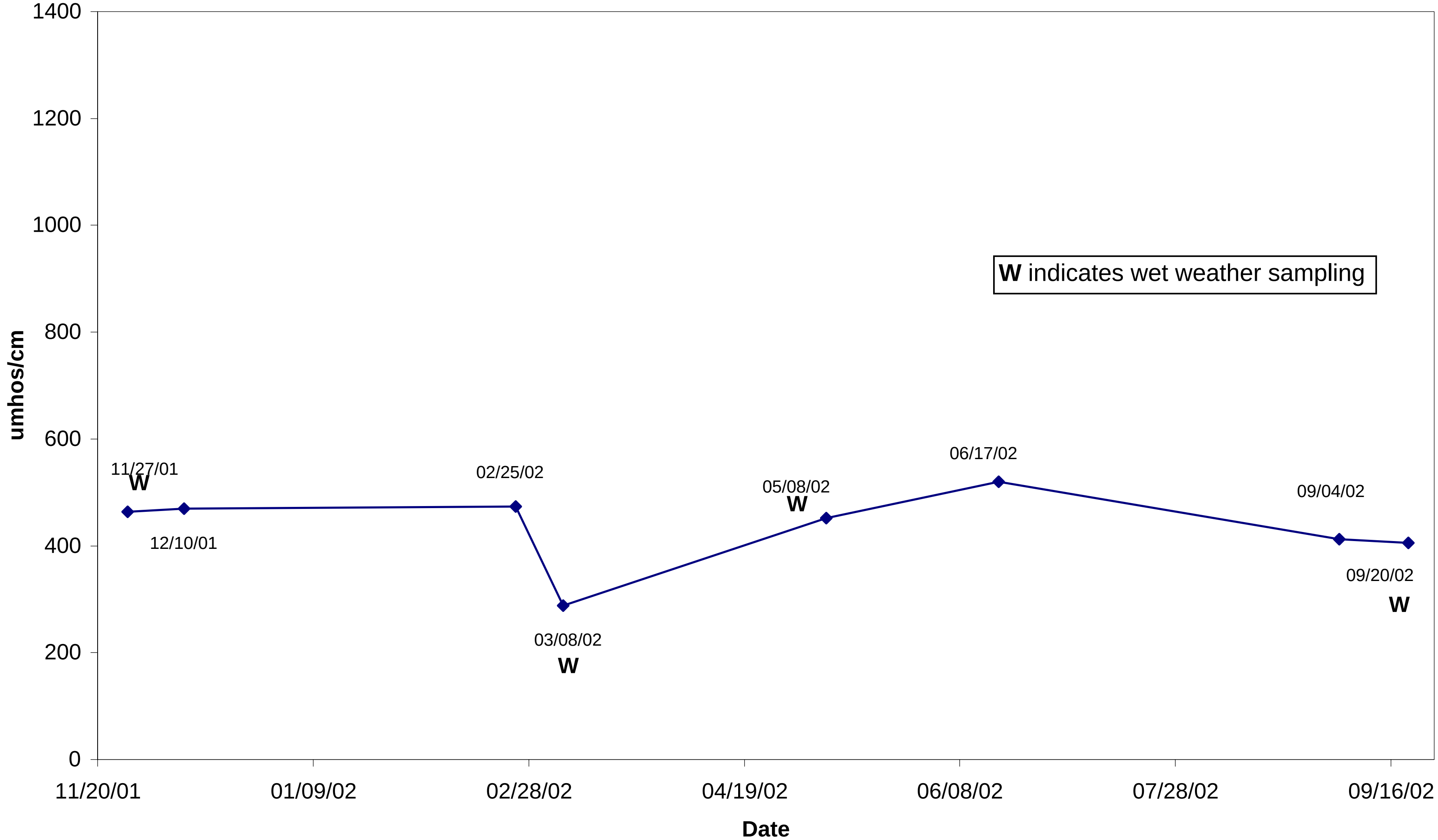


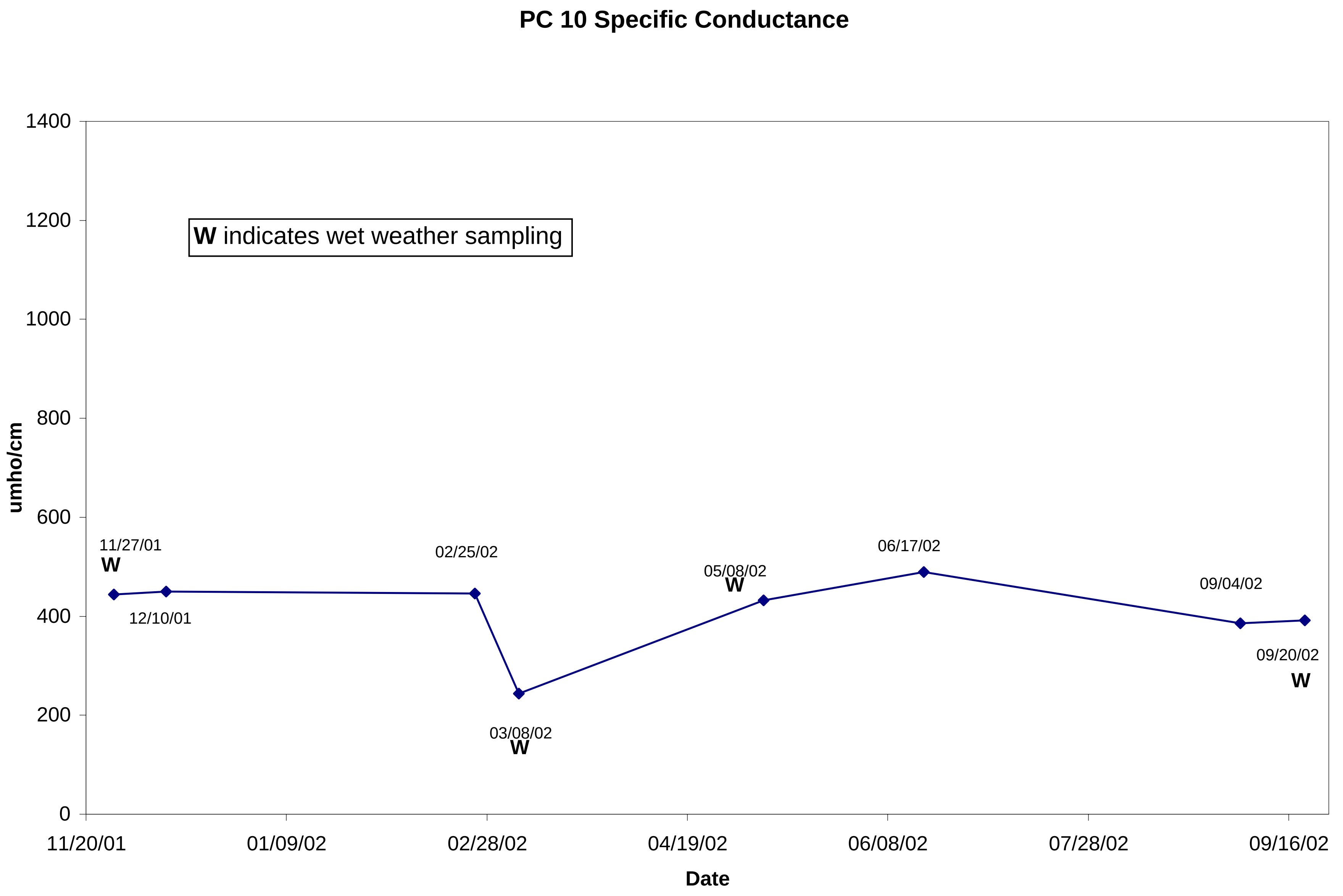
KIESER & ASSOCIATES



KIESER & ASSOCIATES

PC 9 Specific Conductance





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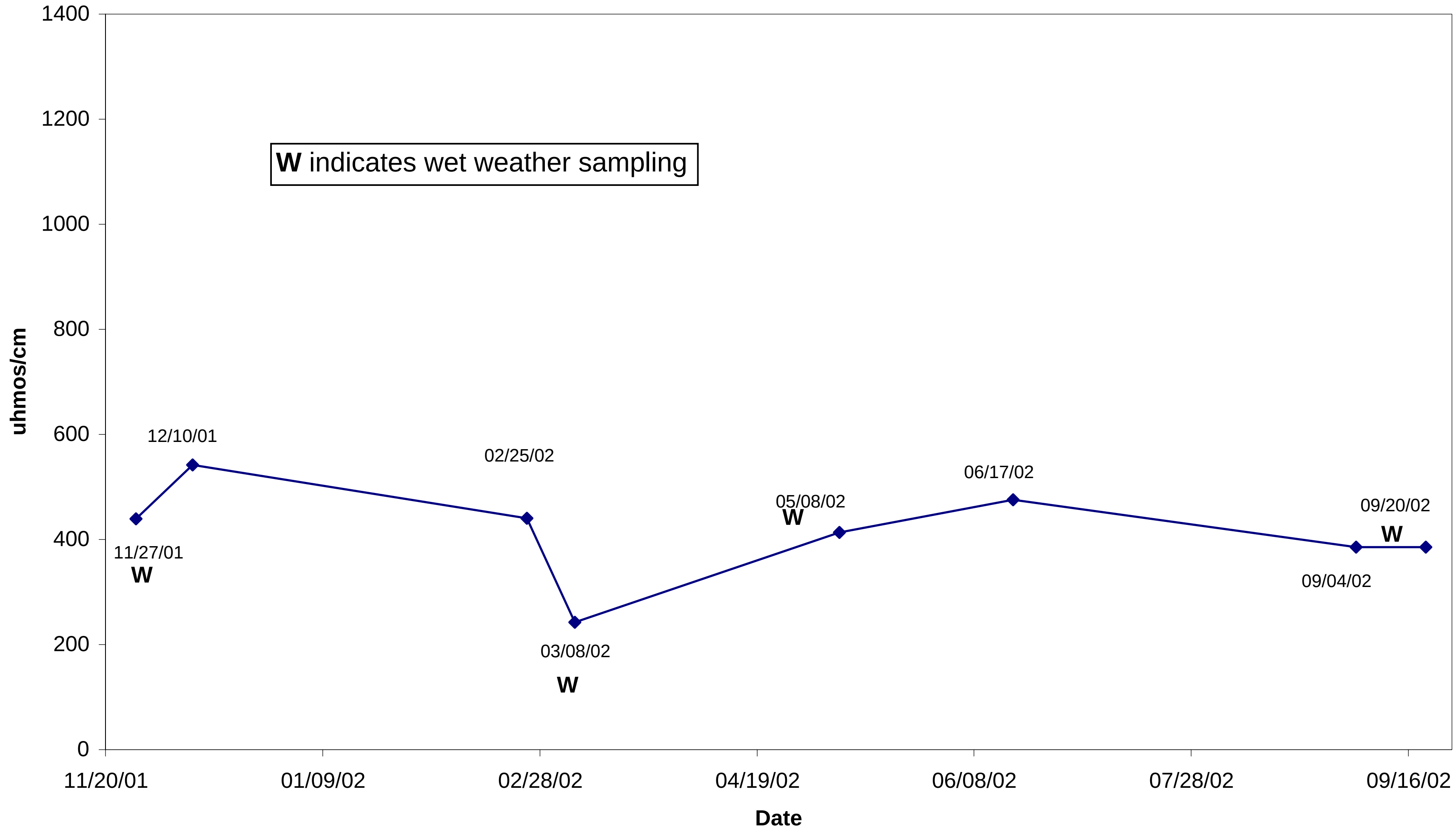
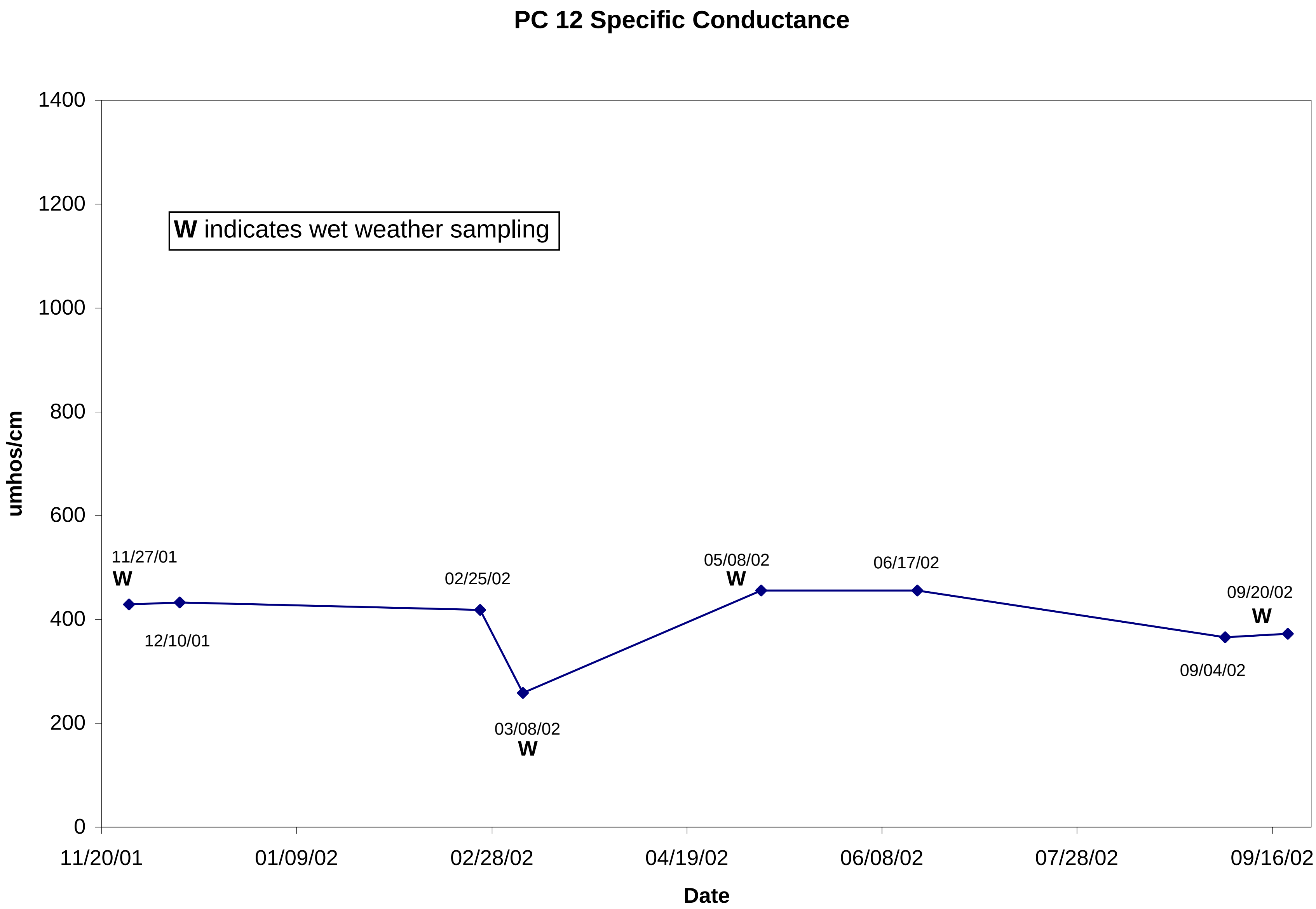
PC 11 Specific Conductance

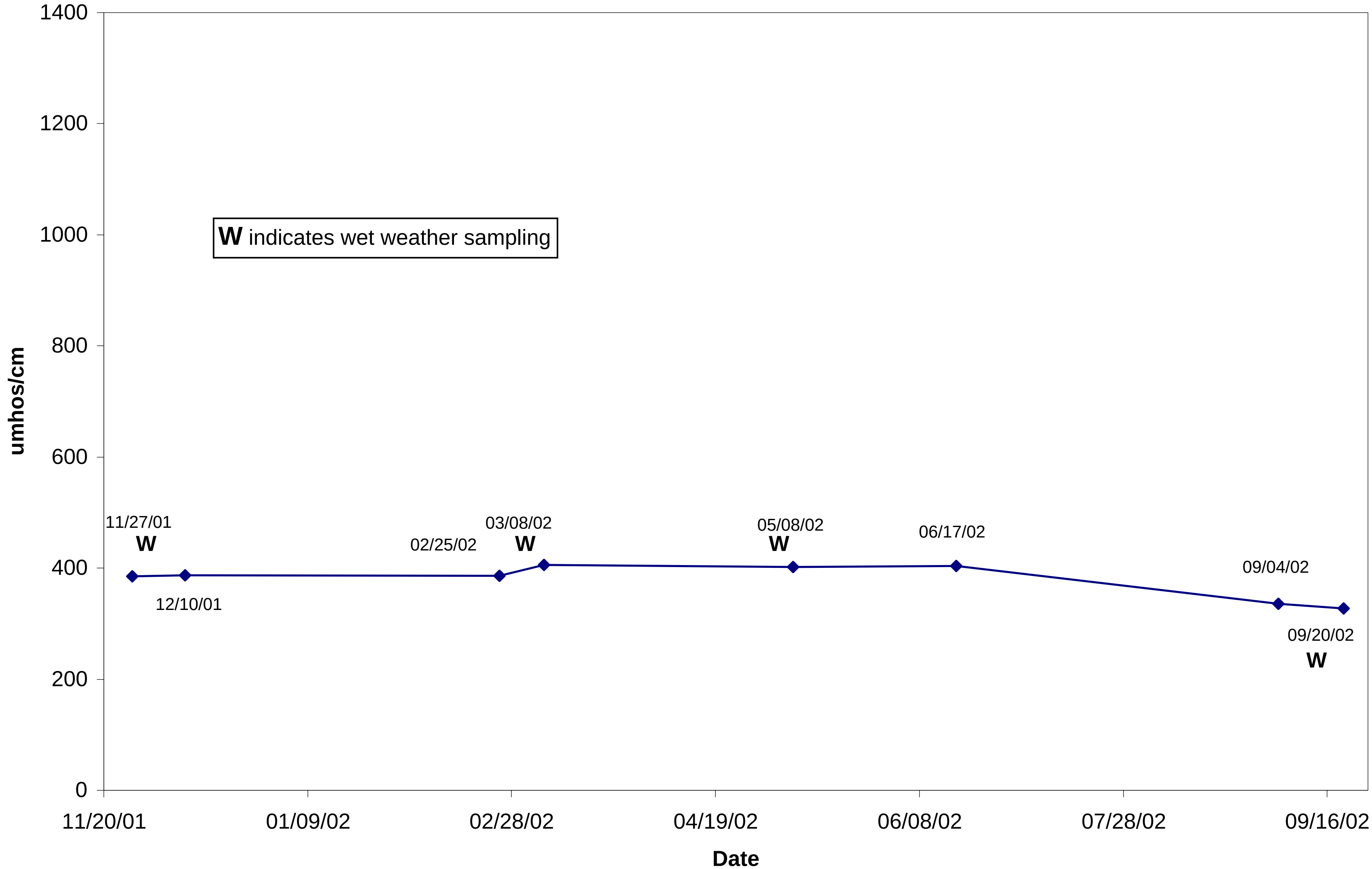


KIESER & ASSOCIATES



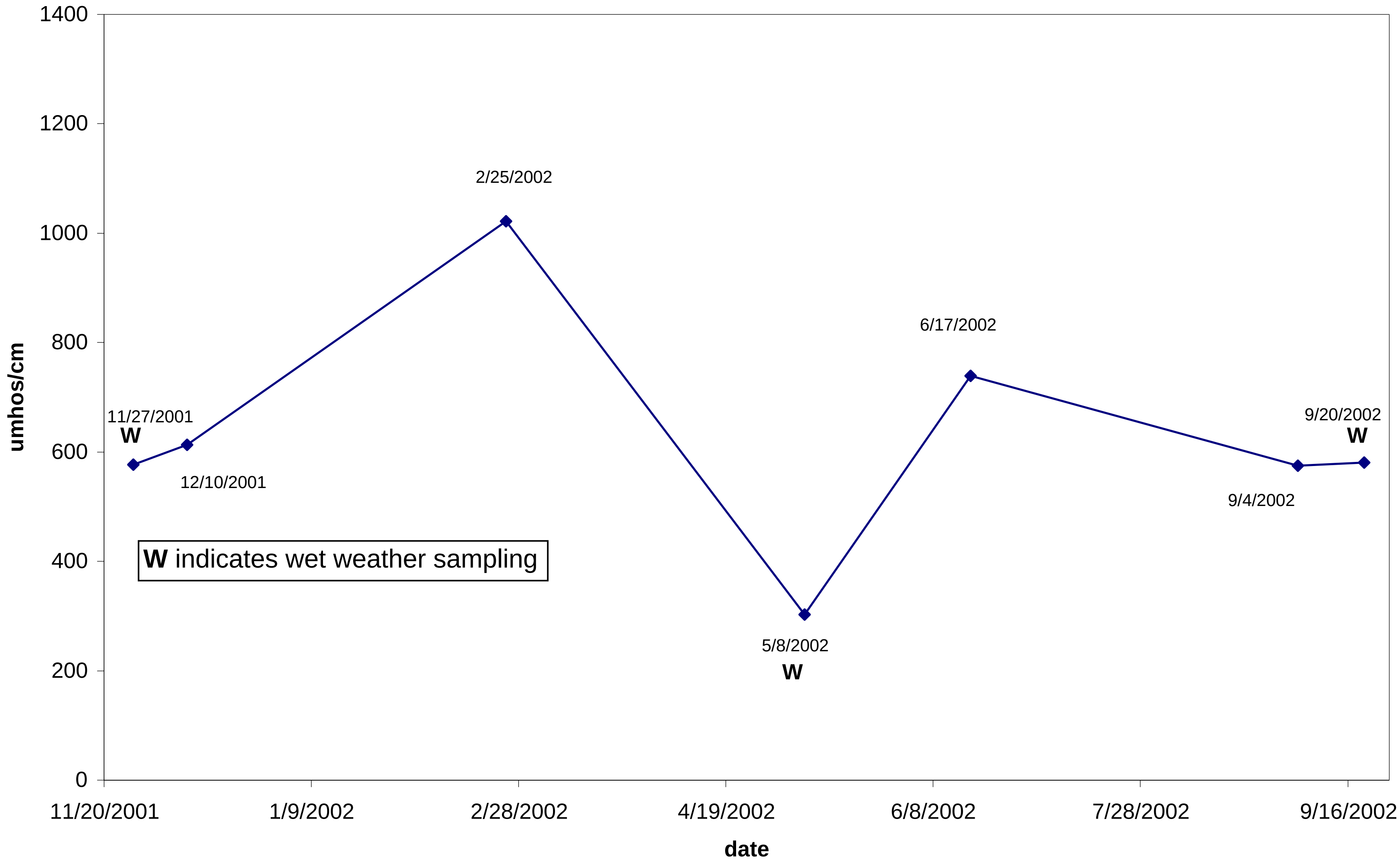
KIESER & ASSOCIATES

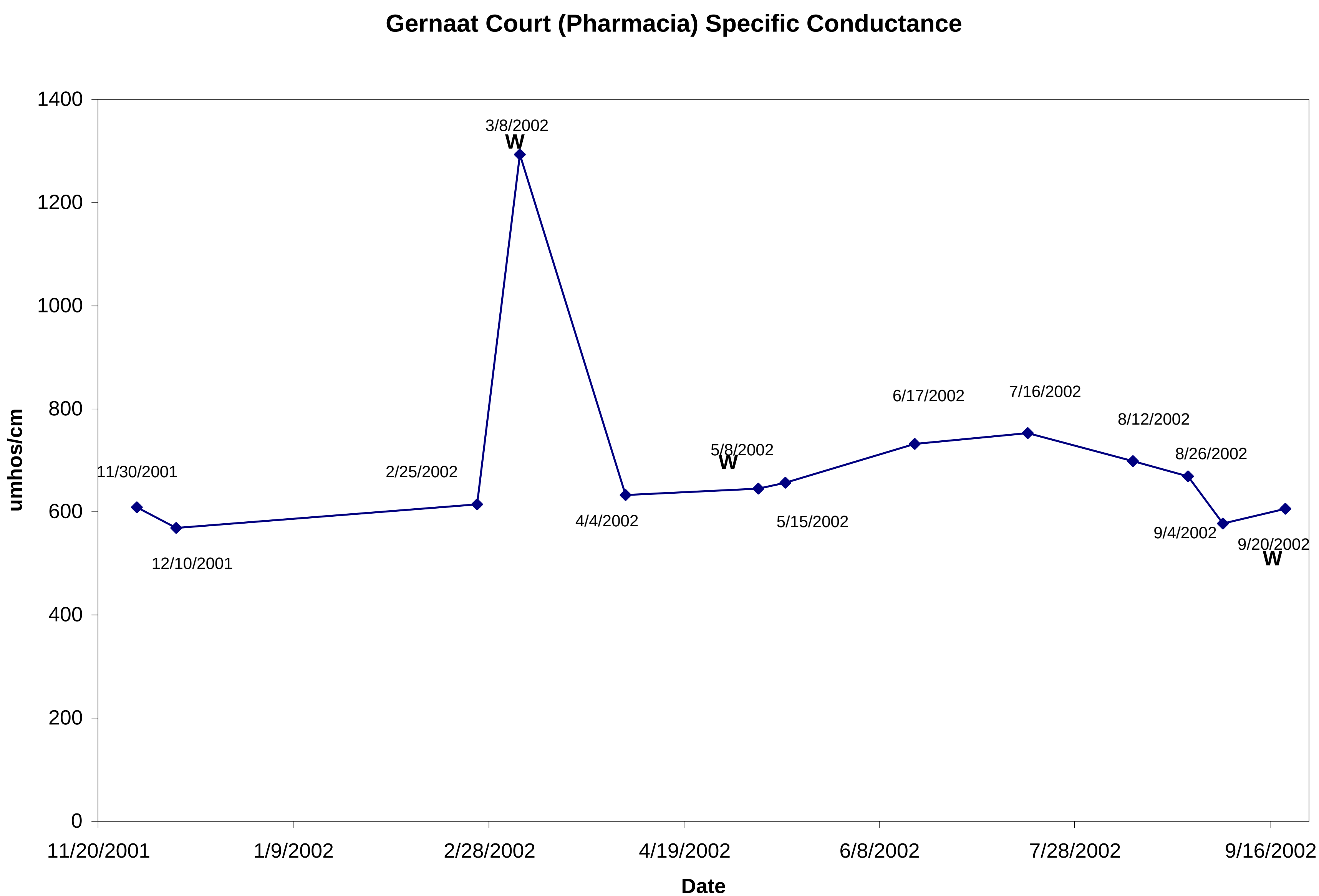
PC 13 Specific conductance



KIESER & ASSOCIATES

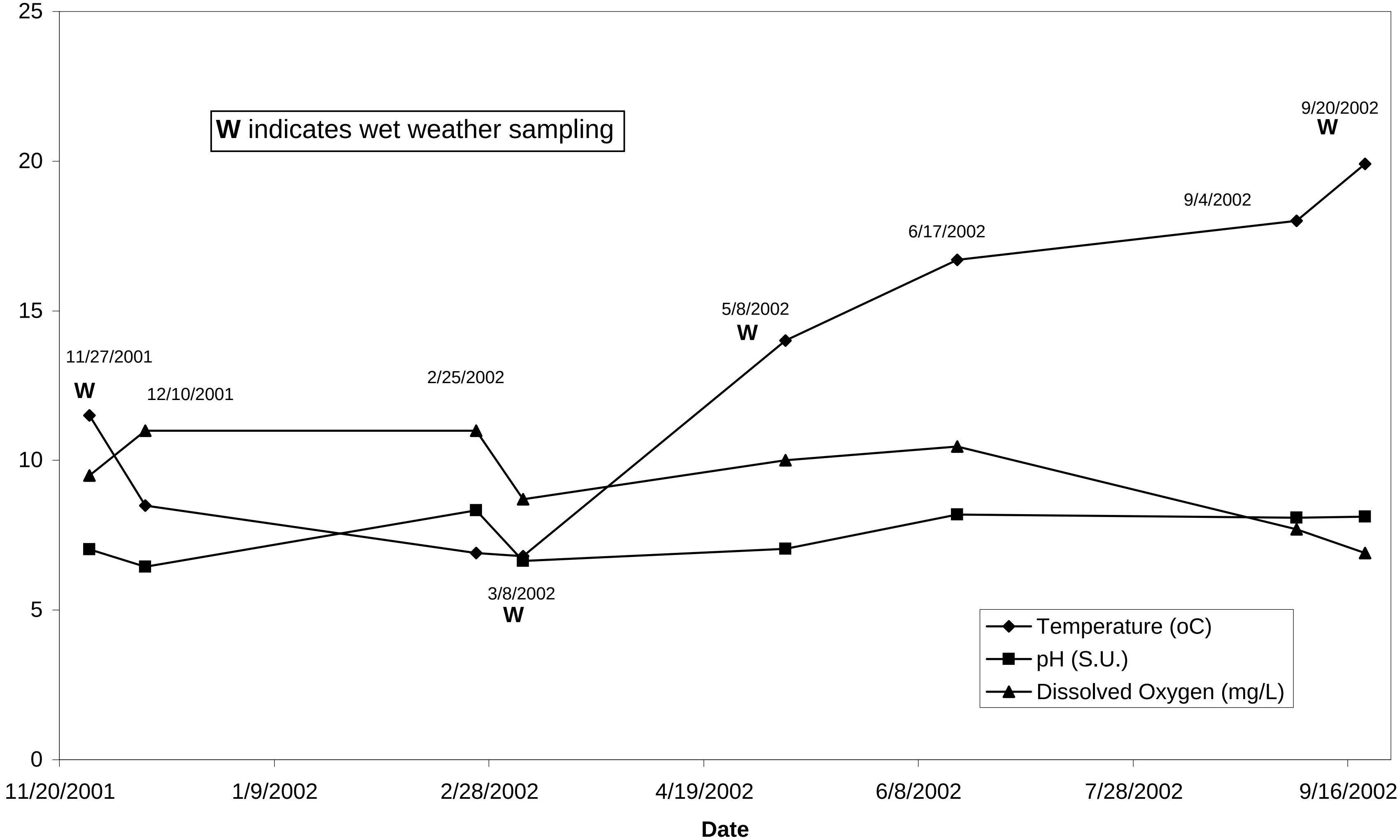
Consolidated Drain Specific Conductance





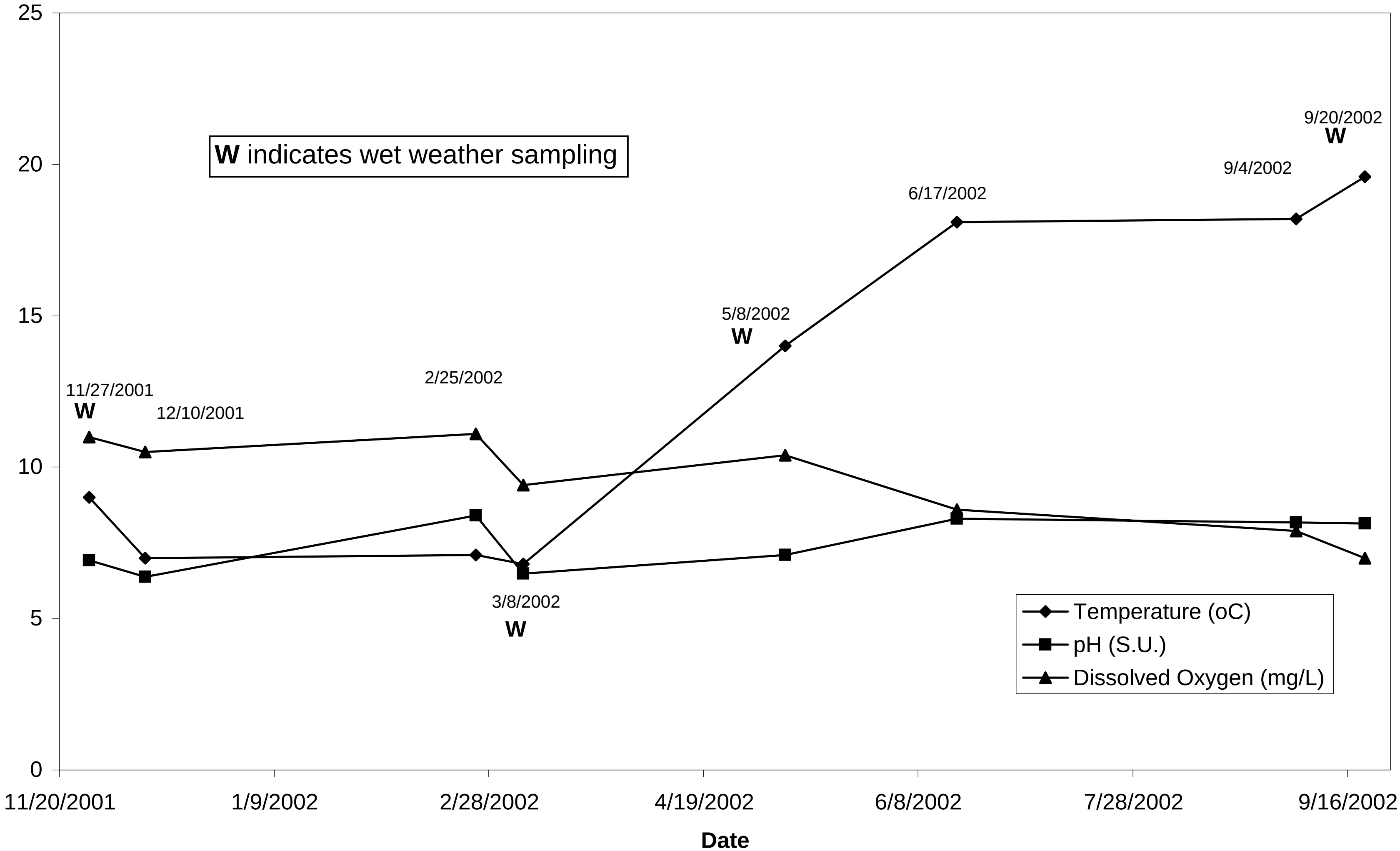
Gernaat Court (Pharmacia) Specific Conductance
1400
1200
1000
800
600
400
200
0
umhos/cm
3/8/2002
W
11/30/2001
12/10/2001
2/25/2002
4/4/2002
5/8/2002
W
5/15/2002
6/17/2002
7/16/2002
8/12/2002
8/26/2002
9/4/2002
9/20/2002
W
11/20/2001
1/9/2002
2/28/2002
4/19/2002
6/8/2002
7/28/2002
9/16/2002
Date

PC 1 Temperature, pH and Dissolved Oxygen



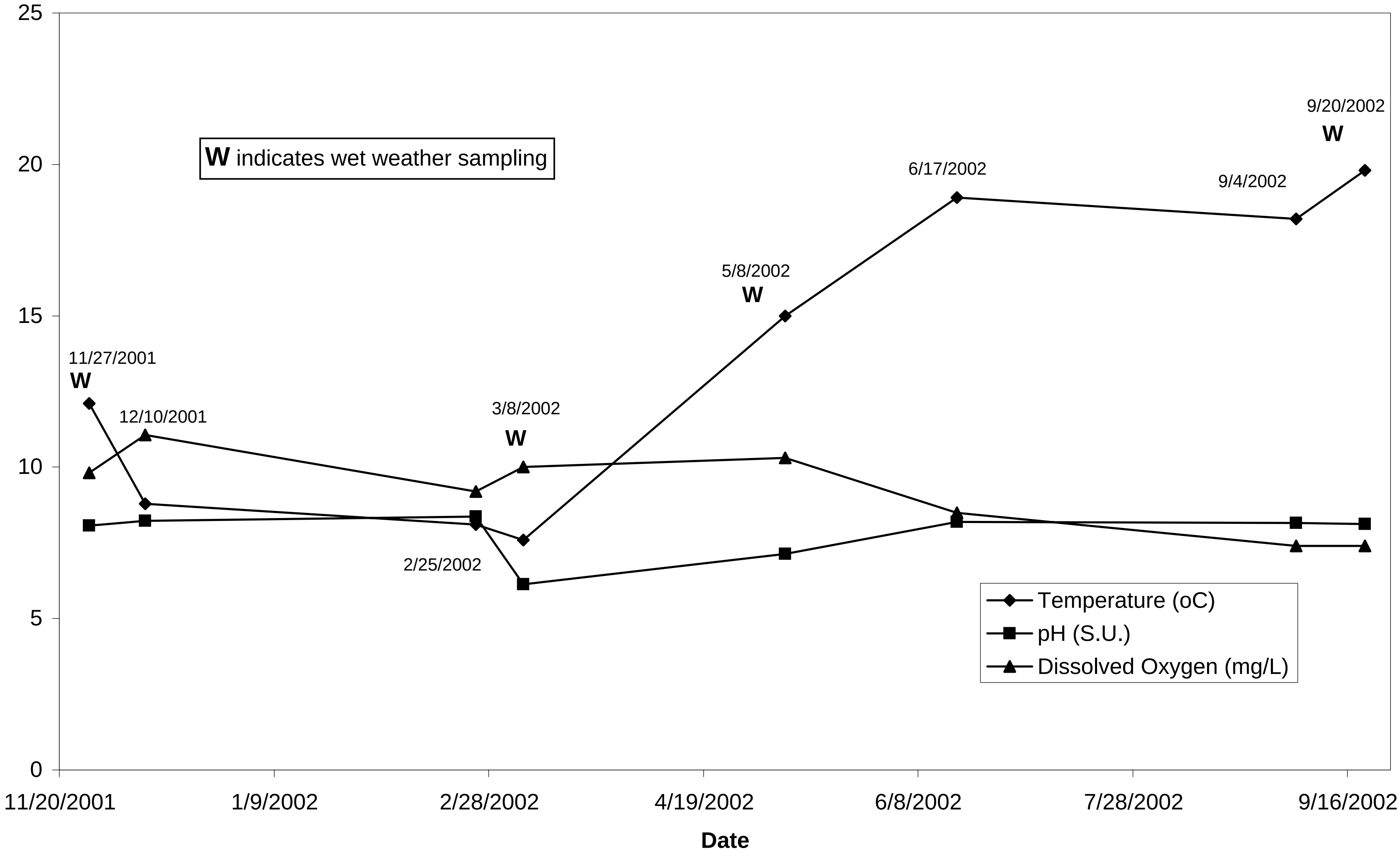
KIESER & ASSOCIATES

PC 2 Temperature, pH and Dissolved Oxygen

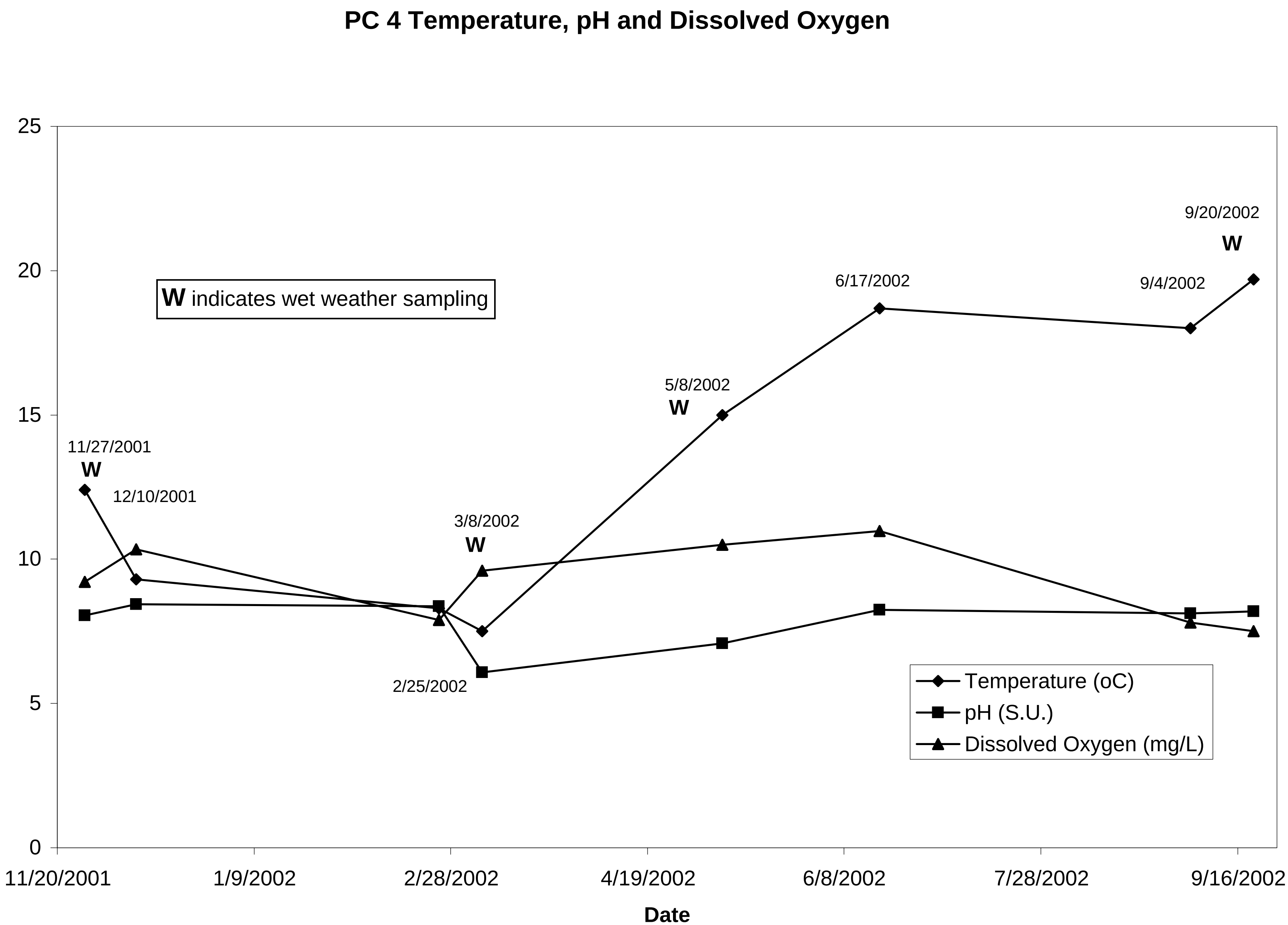


KIESER & ASSOCIATES

PC 3 Temperature, pH and Dissolved Oxygen

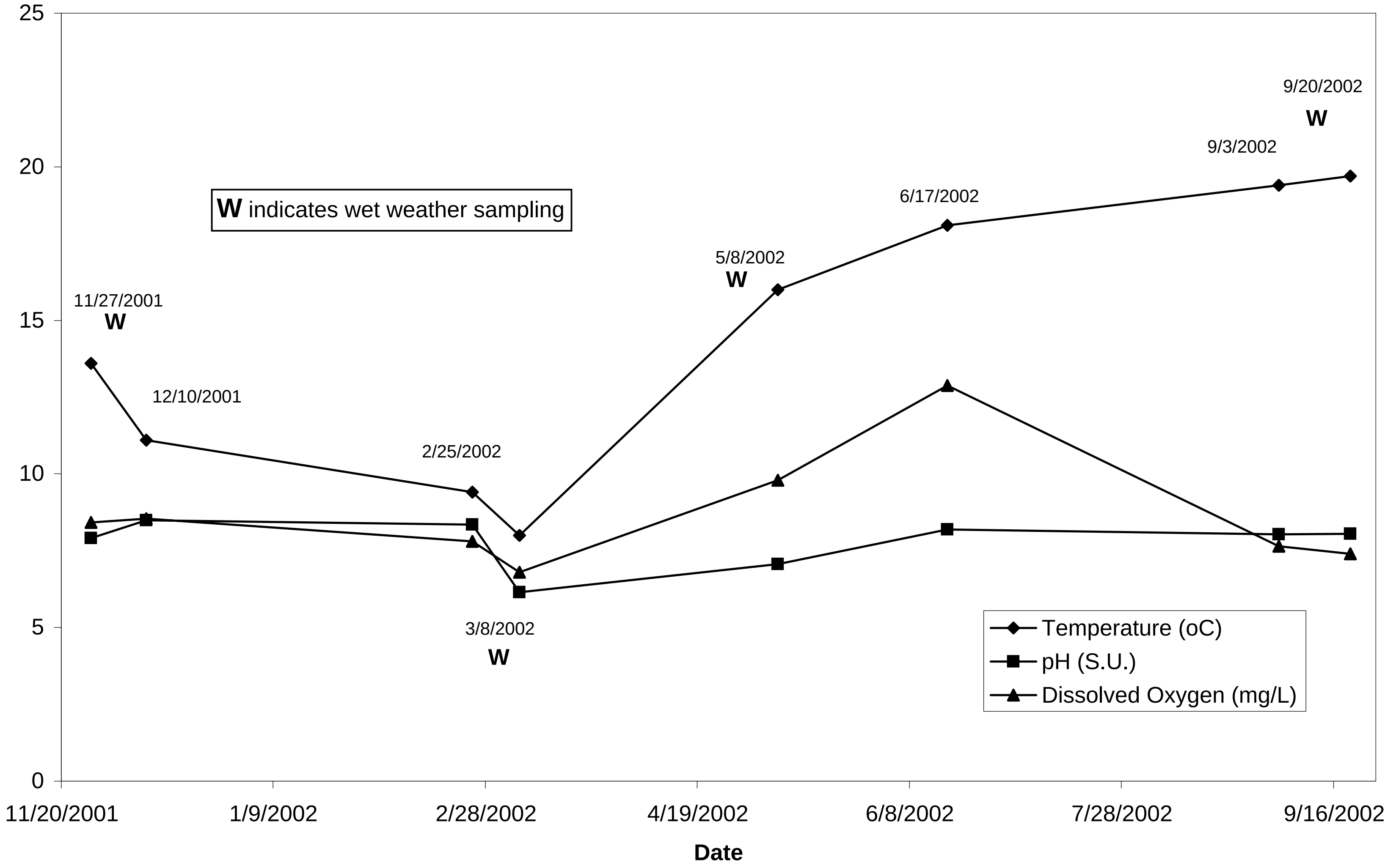


KIESER & ASSOCIATES

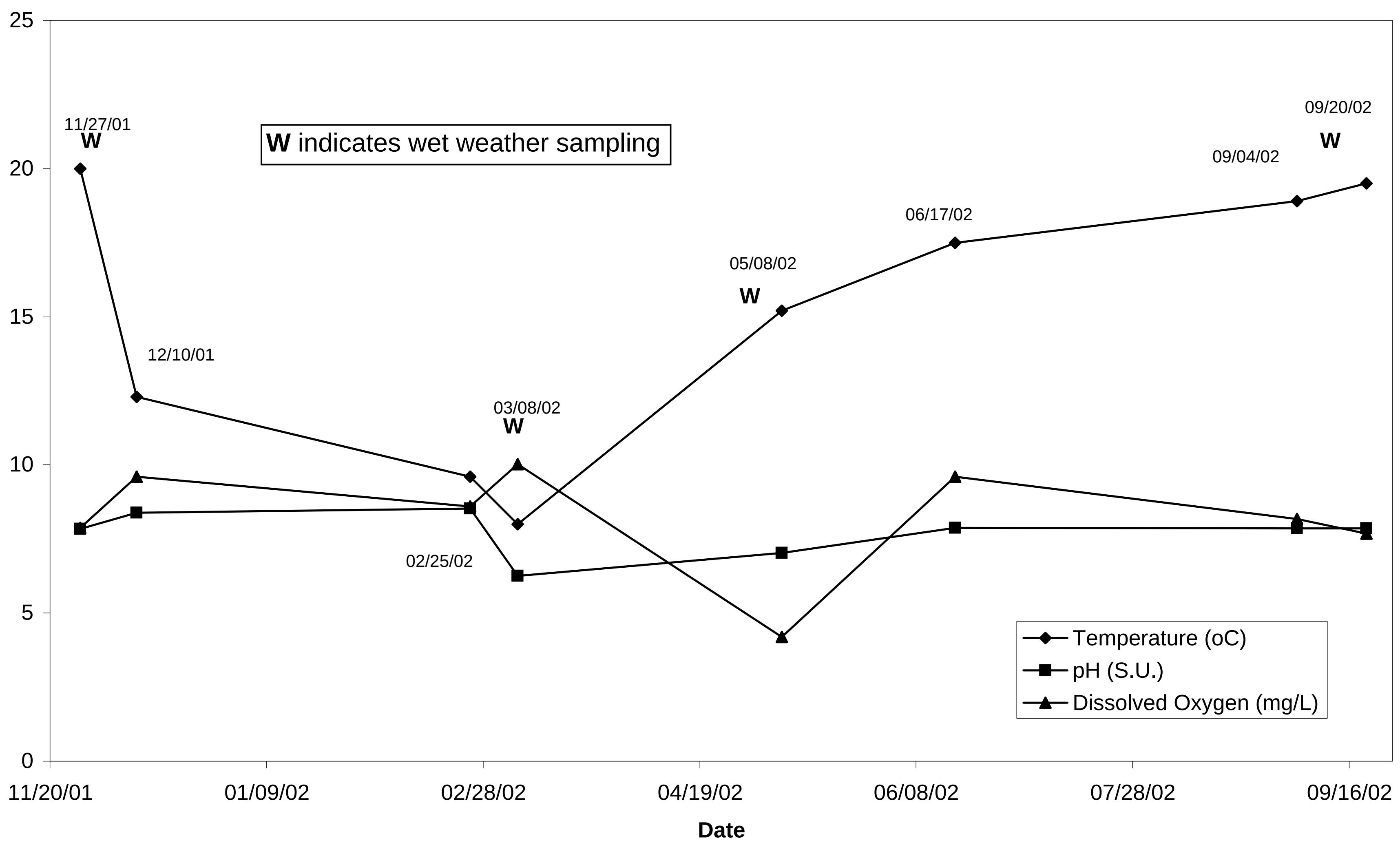


KIESER & ASSOCIATES

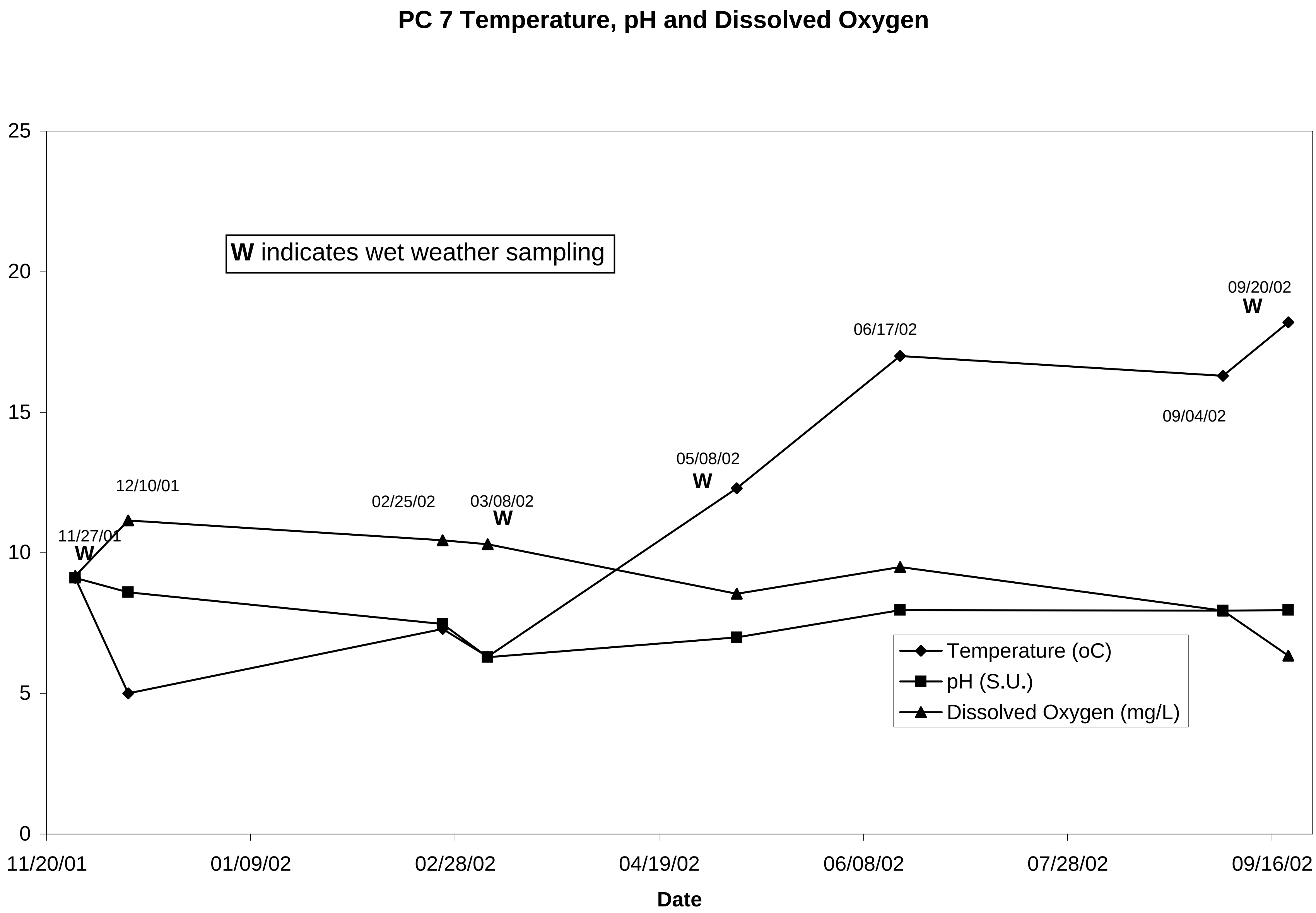
PC 5 Temperature, pH and Dissolved Oxygen



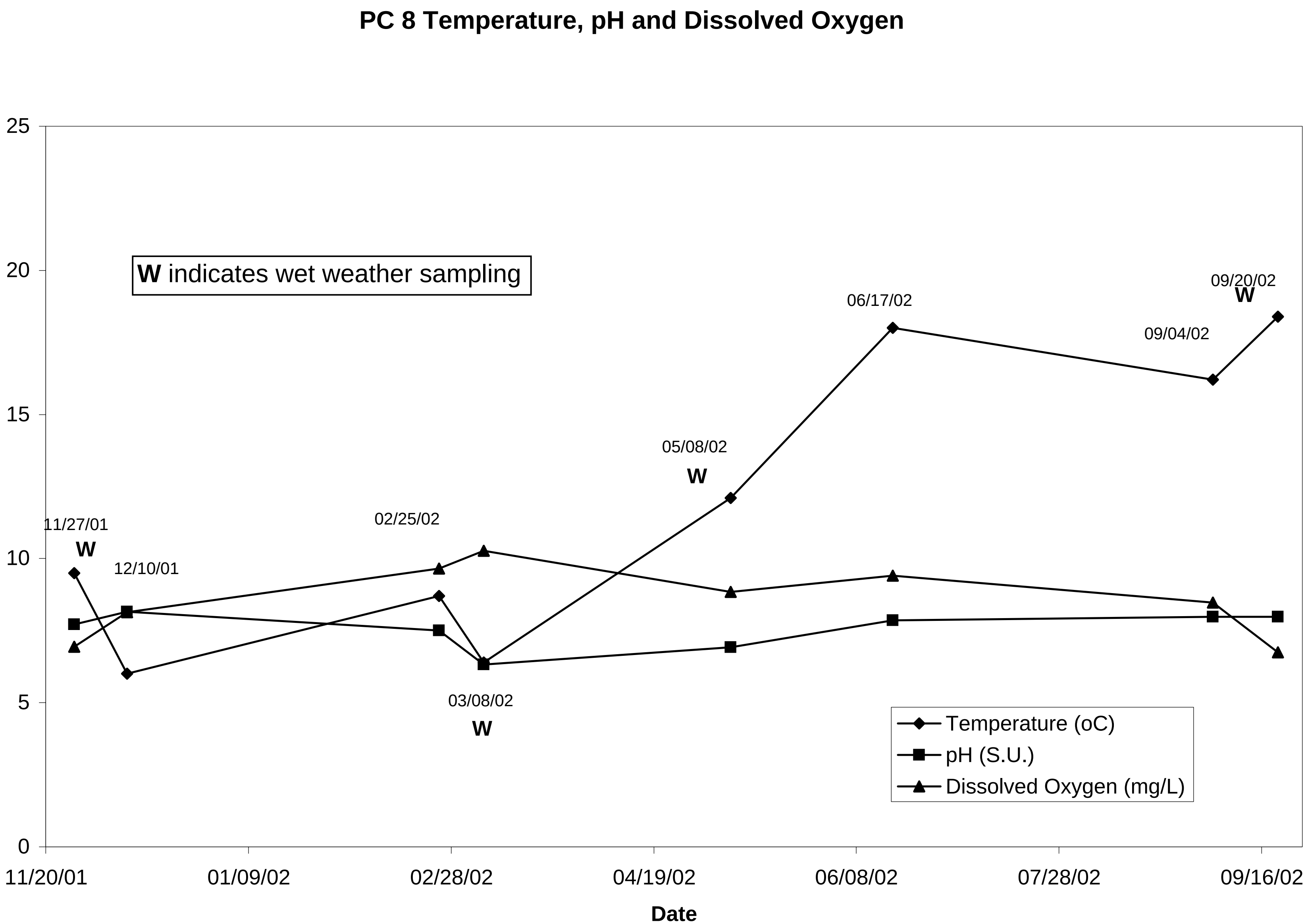
PC 6 Temperature, pH and Dissolved Oxygen



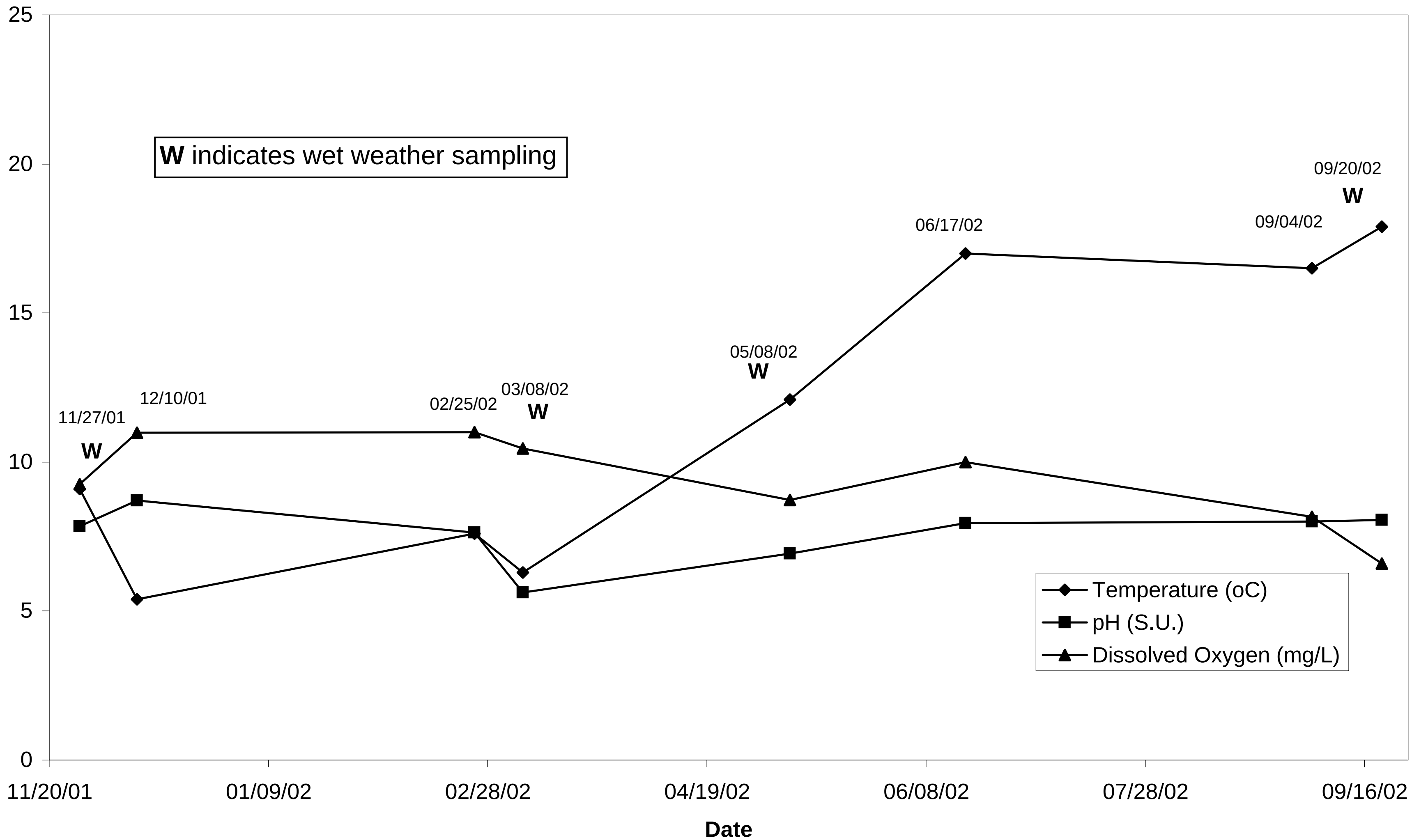
KIESER & ASSOCIATES



KIESER & ASSOCIATES


PC 8 Temperature, pH and Dissolved Oxygen
25
20
15
10
5
0
W indicates wet weather sampling
11/27/01
W
12/10/01
02/25/02
03/08/02
W
05/08/02
W
06/17/02
09/04/02
09/20/02
W
Temperature (oC)
pH (S.U.)
Dissolved Oxygen (mg/L)
11/20/01
01/09/02
02/28/02
04/19/02
06/08/02
07/28/02
09/16/02
Date

PC 9 Temperature, pH and Dissolved Oxygen



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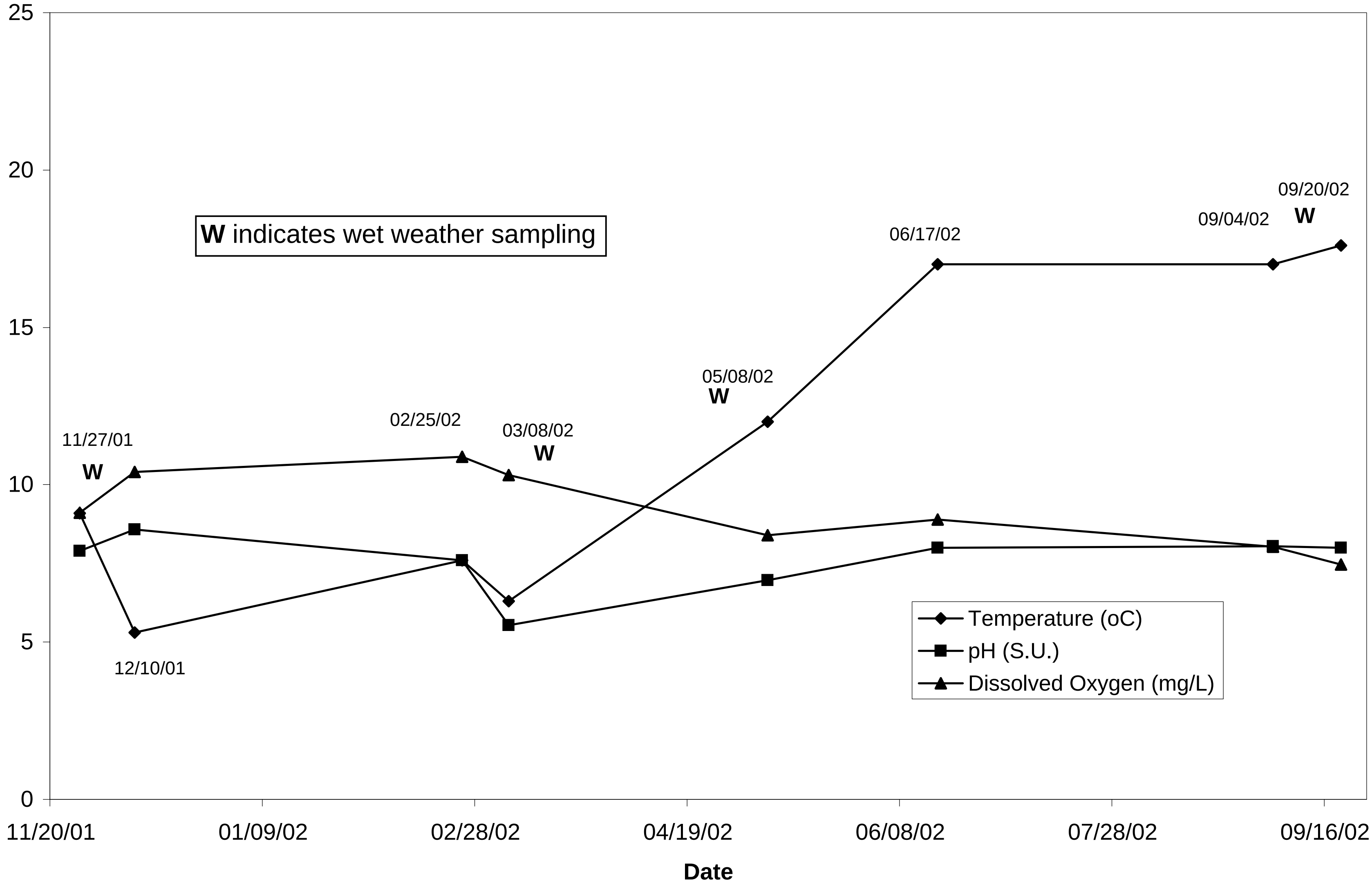
PC 10 Temperature, pH and Dissolved Oxygen



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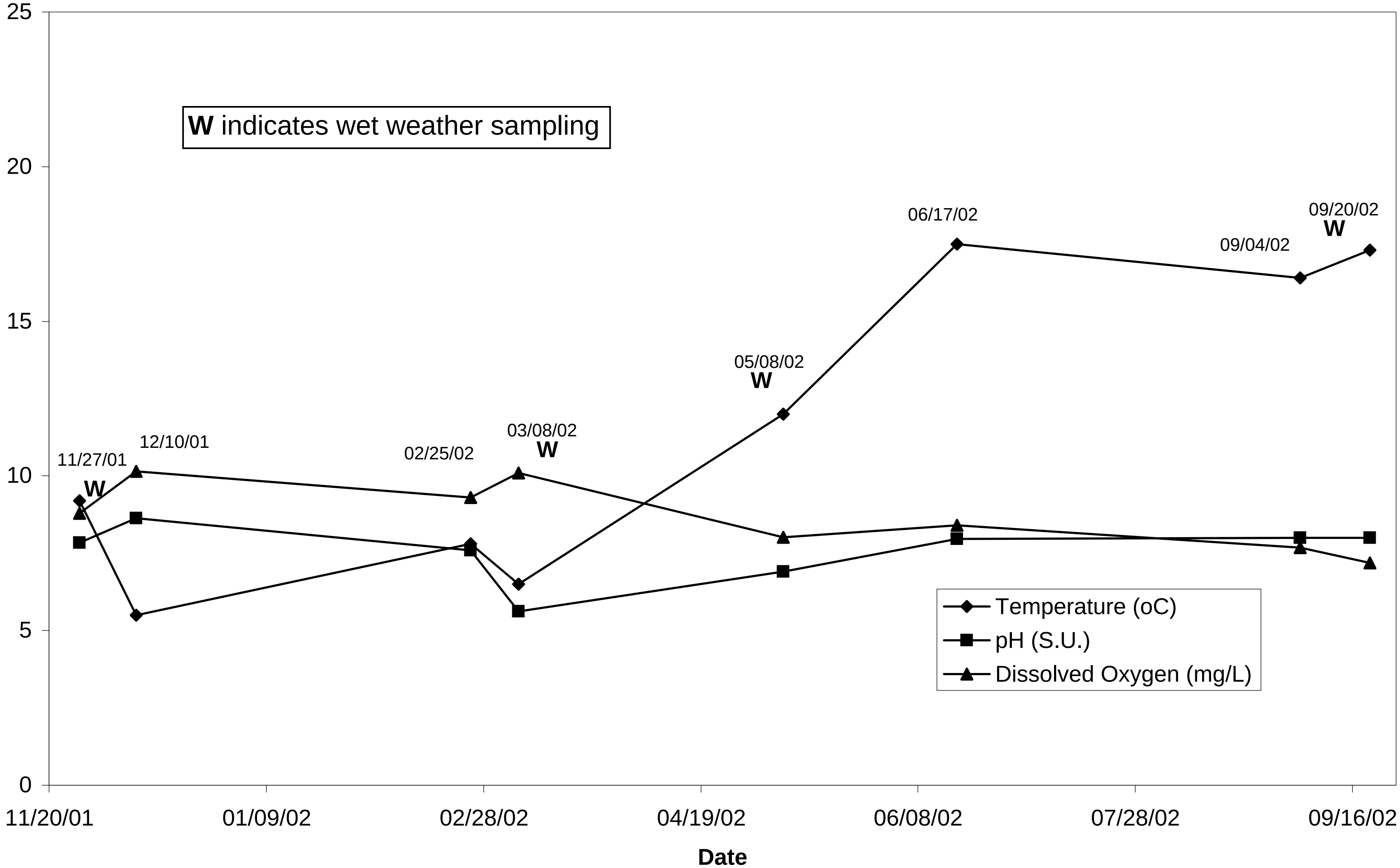
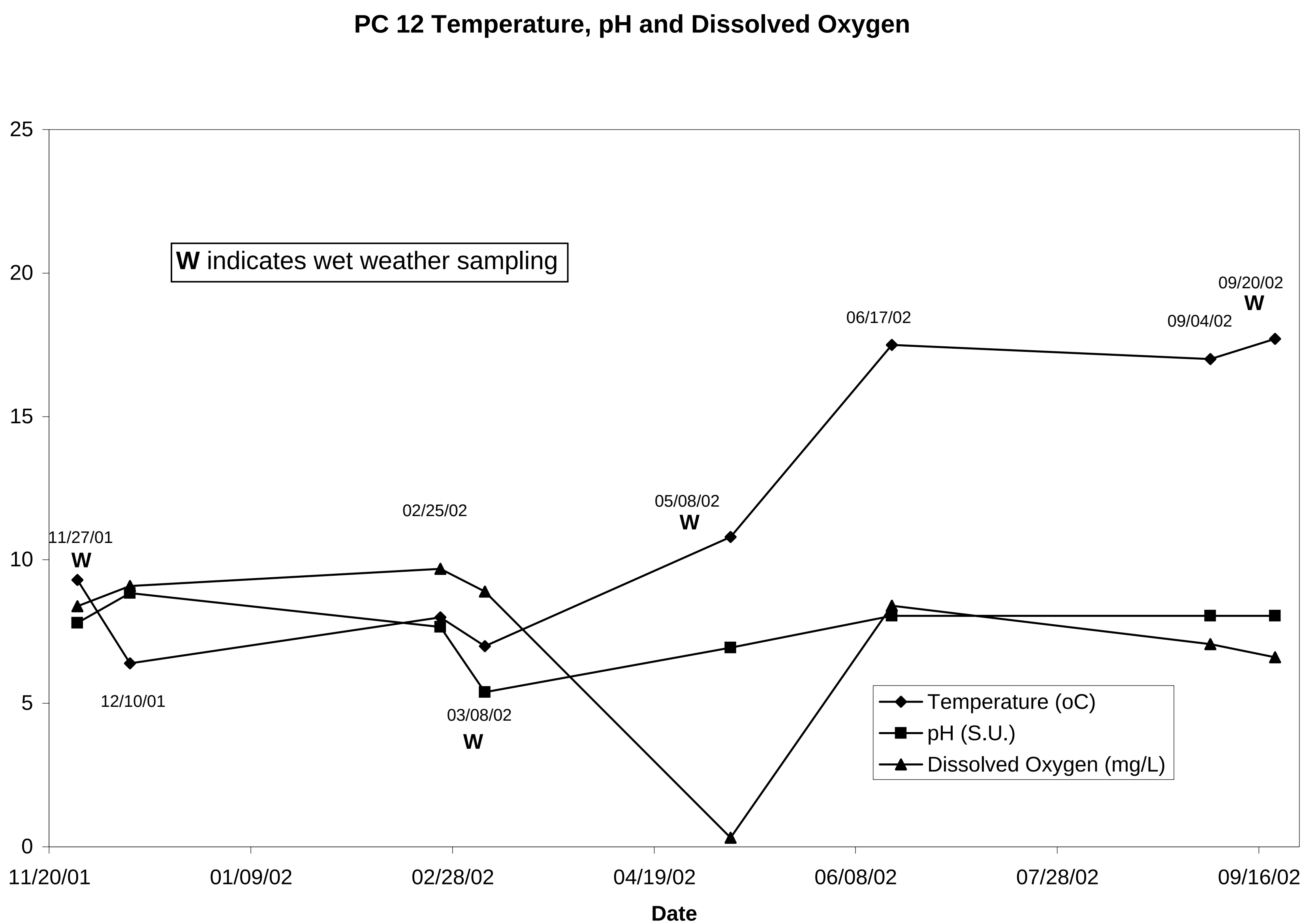
PC 11 Temperature, pH and Dissolved Oxygen

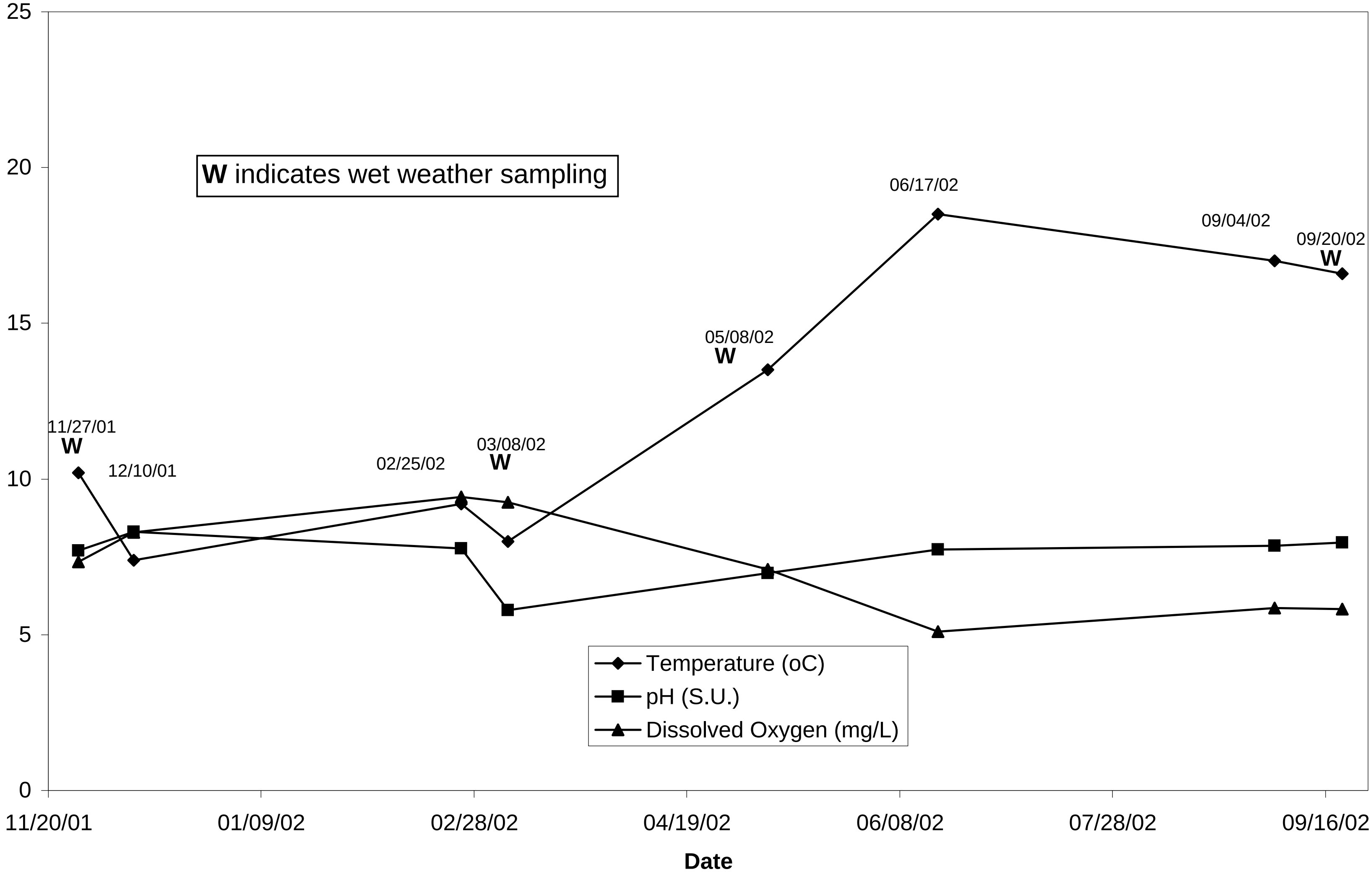


KIESER & ASSOCIATES



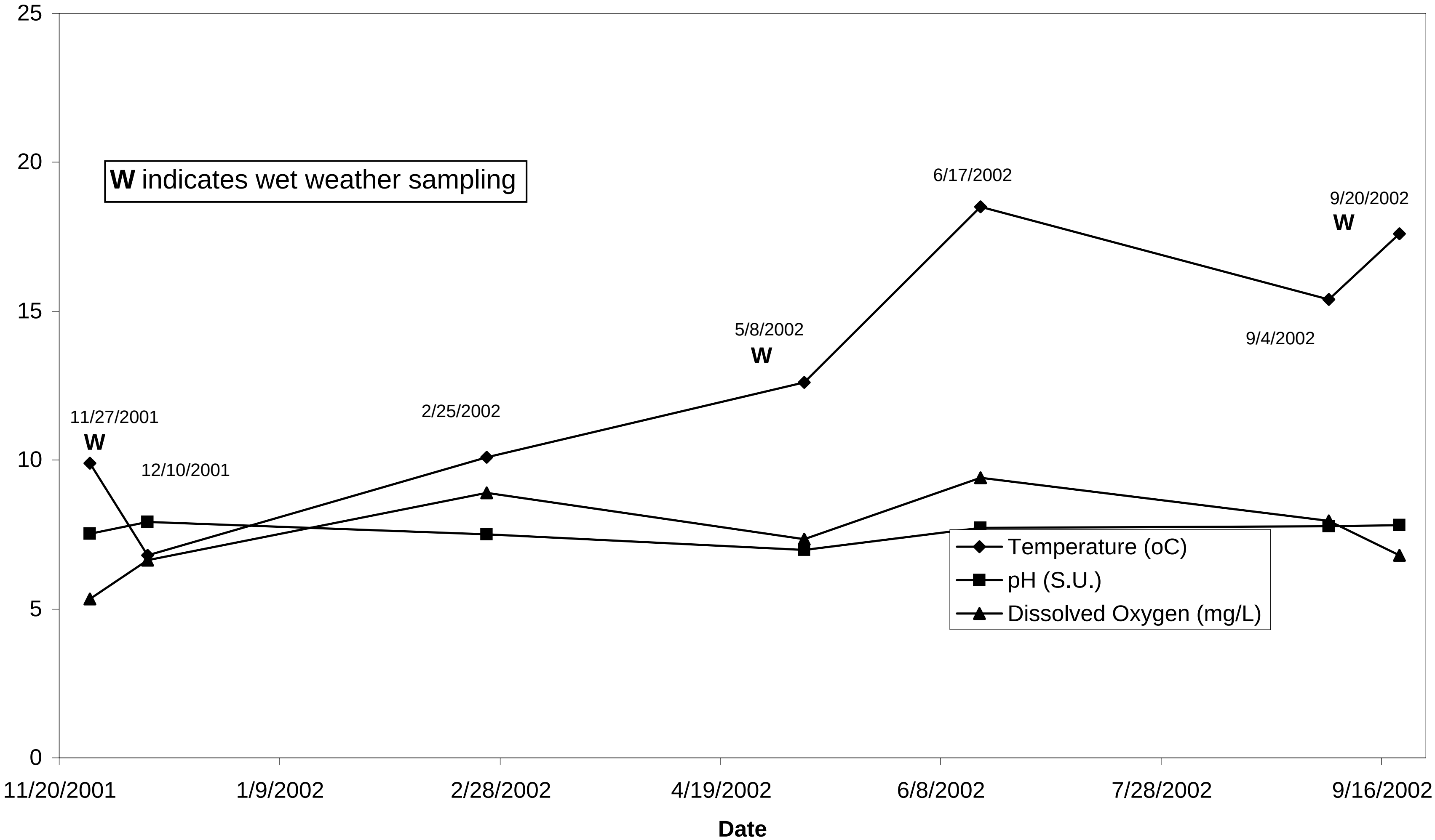
KIESER & ASSOCIATES

PC 13 Temperature, pH and Dissolved Oxygen



KIESER & ASSOCIATES

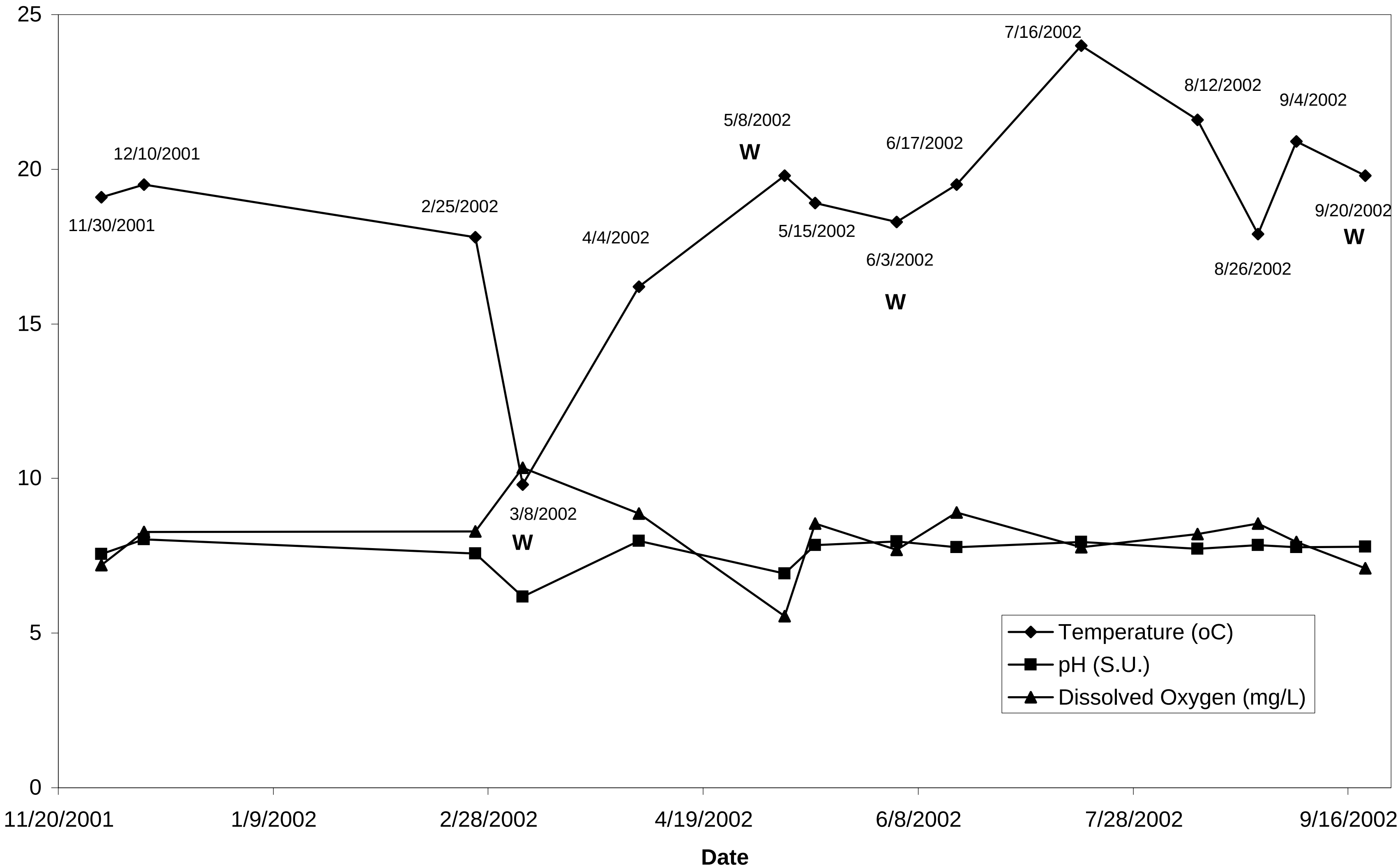
Consolidated Drain Temperature, pH and Dissolved Oxygen



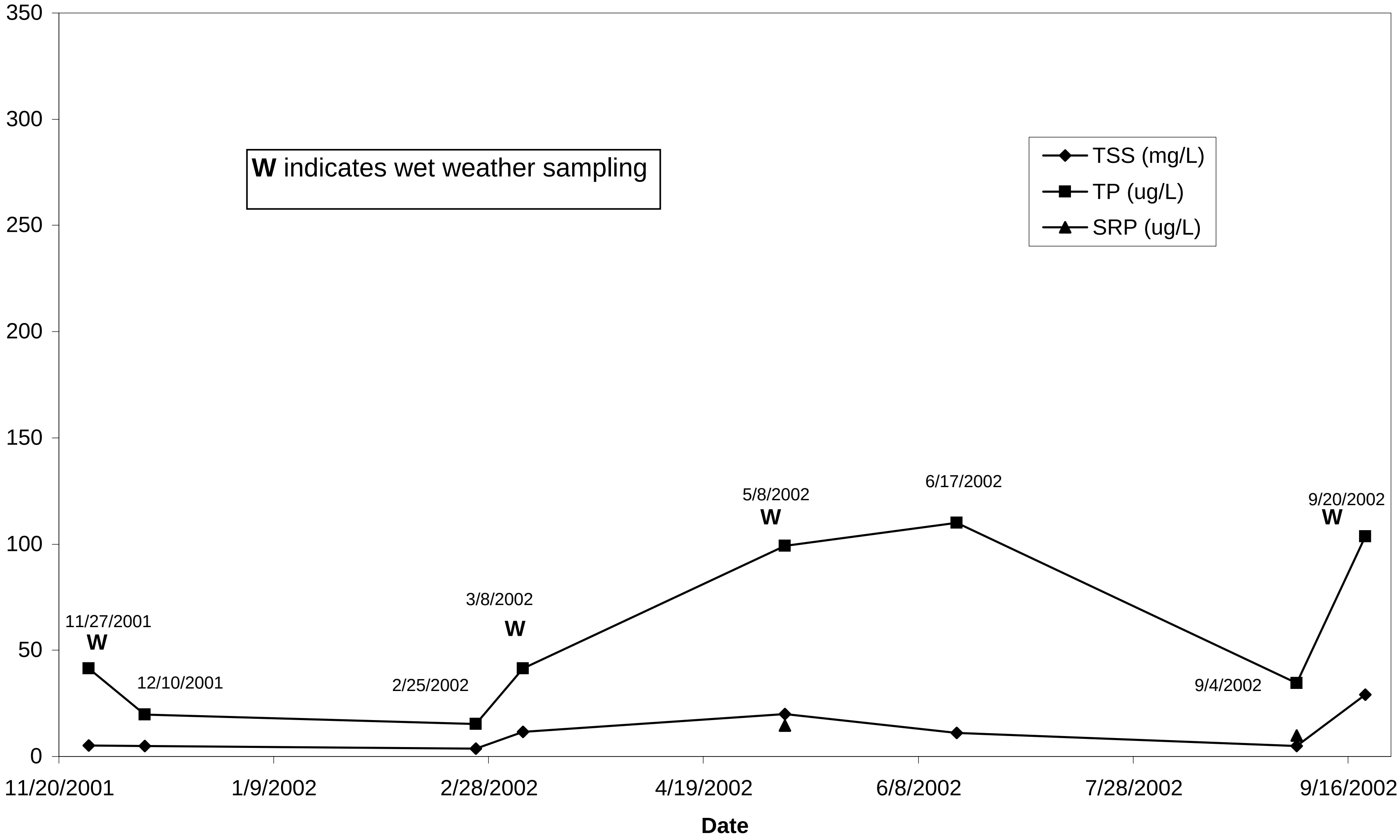
City of Portage

KIESER & ASSOCIATES

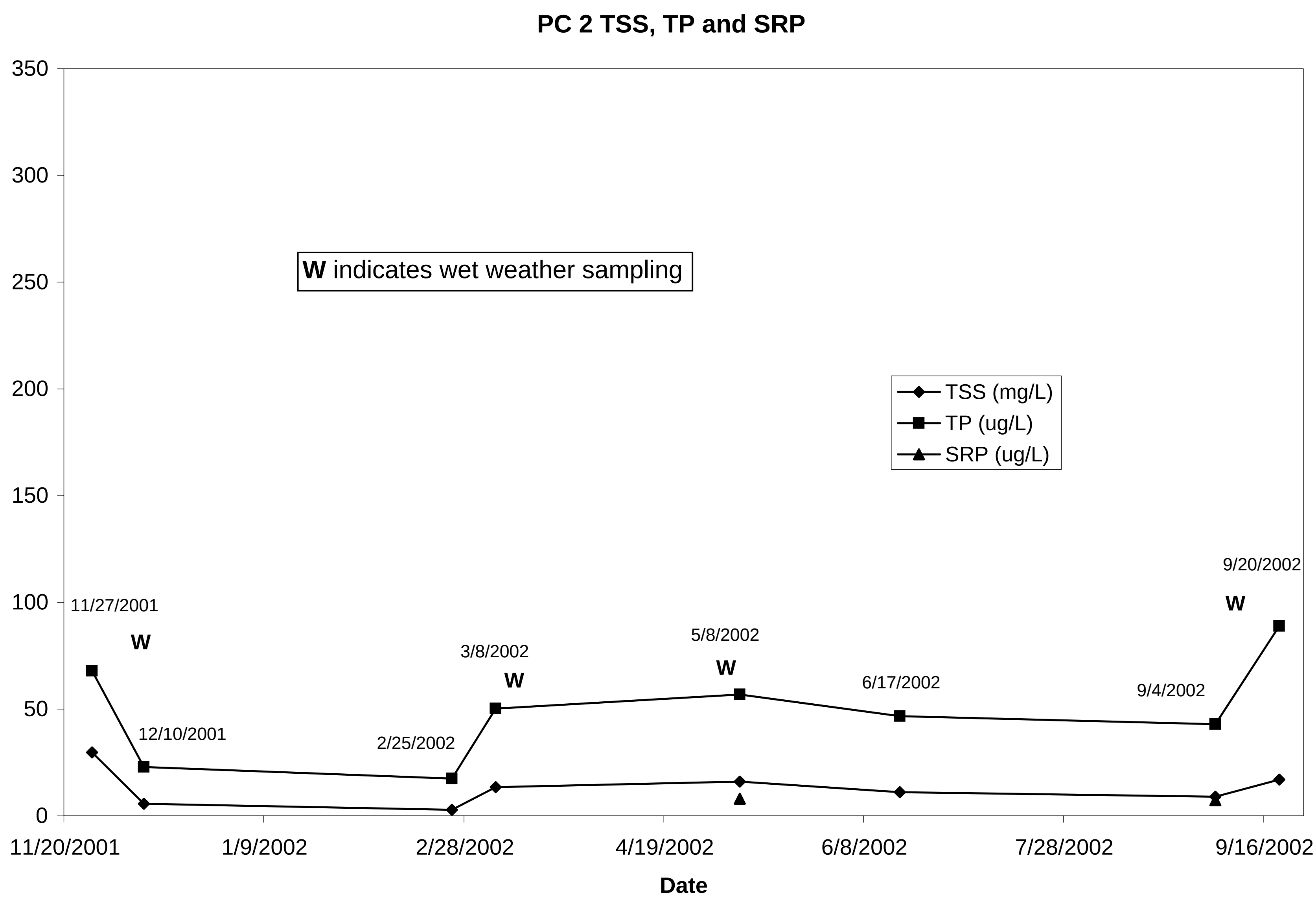
Gernaat Court (Pharmacia) Temperature, pH and Dissolved Oxygen



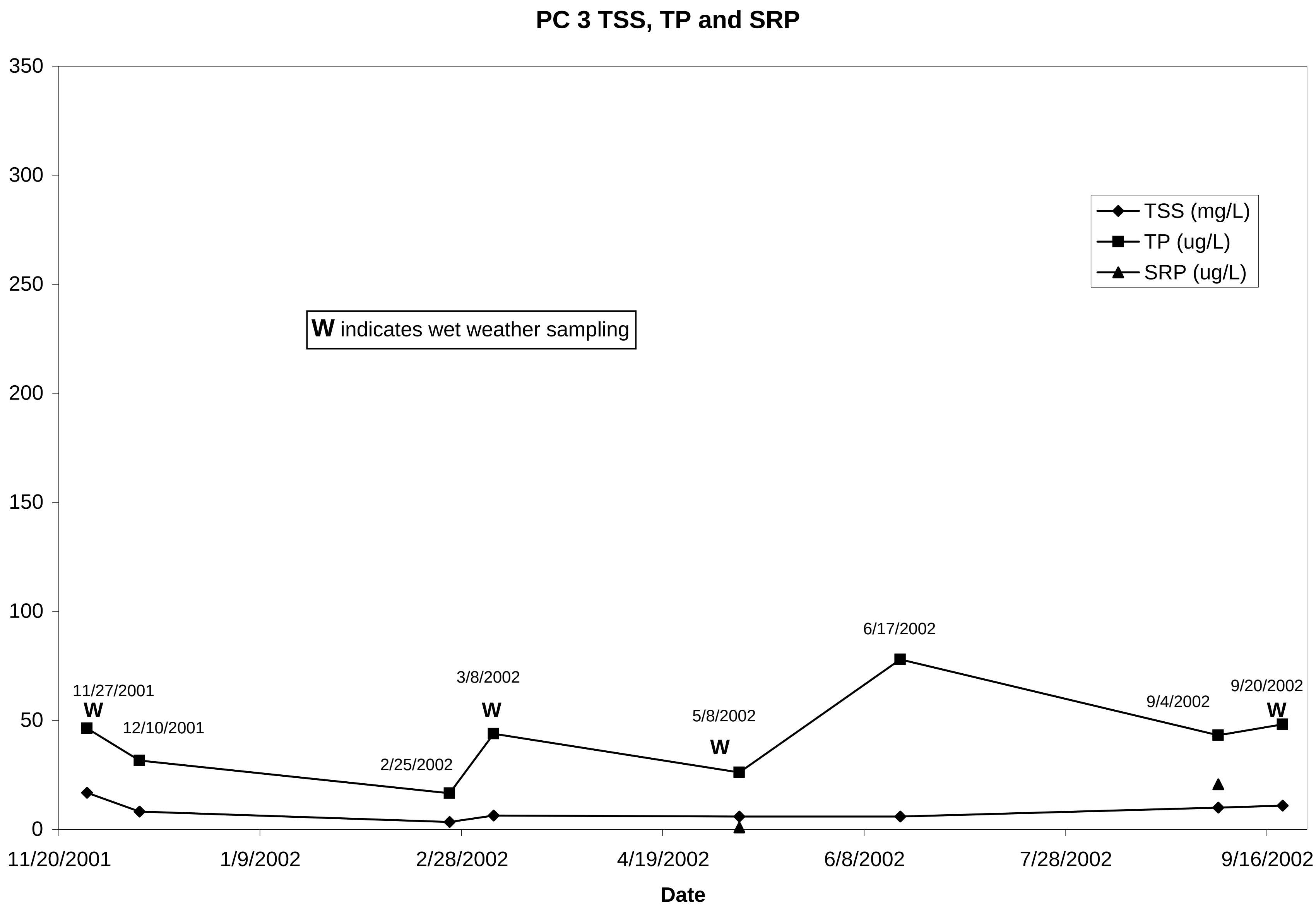
PC 1 TSS, TP and SRP



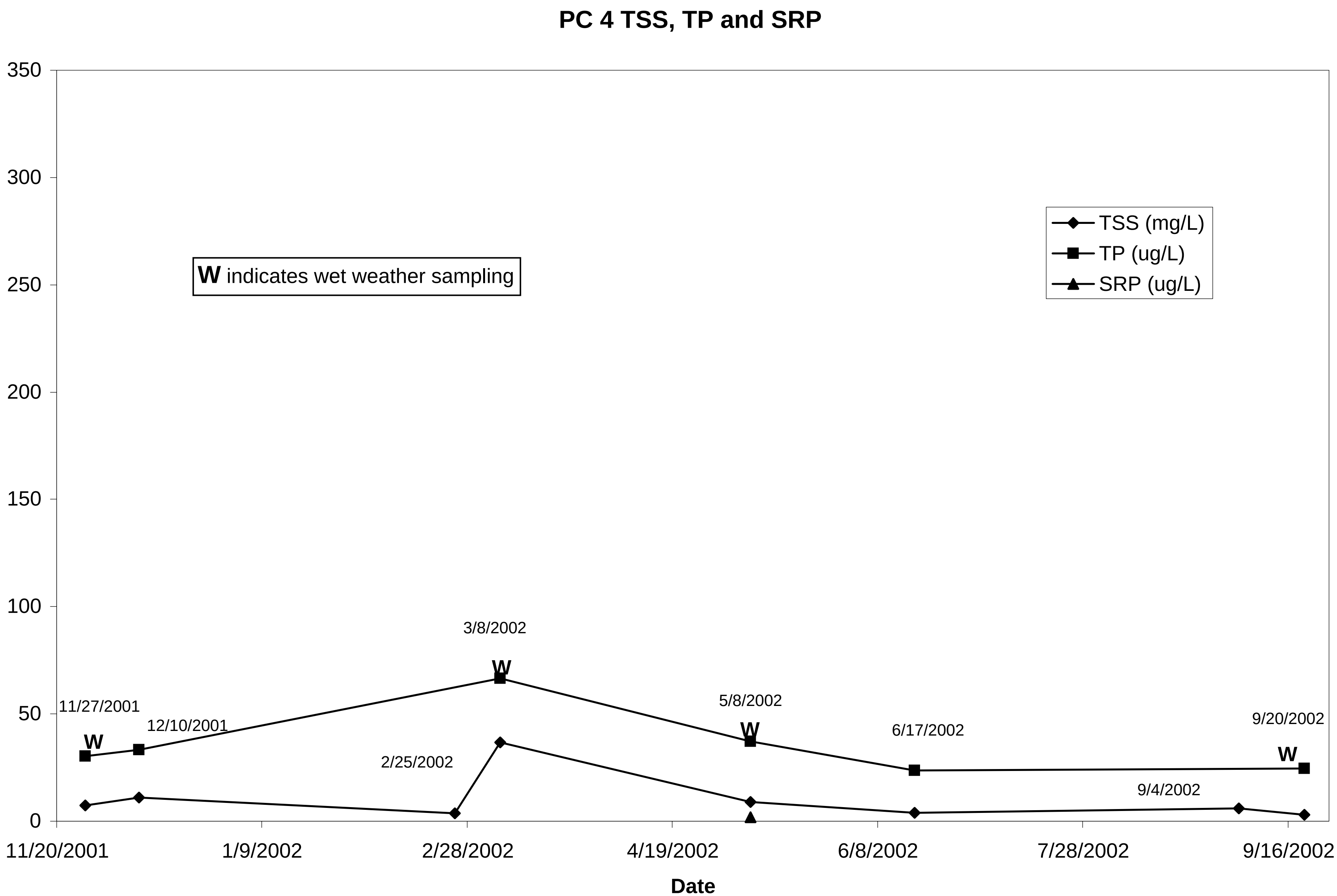
KIESER & ASSOCIATES



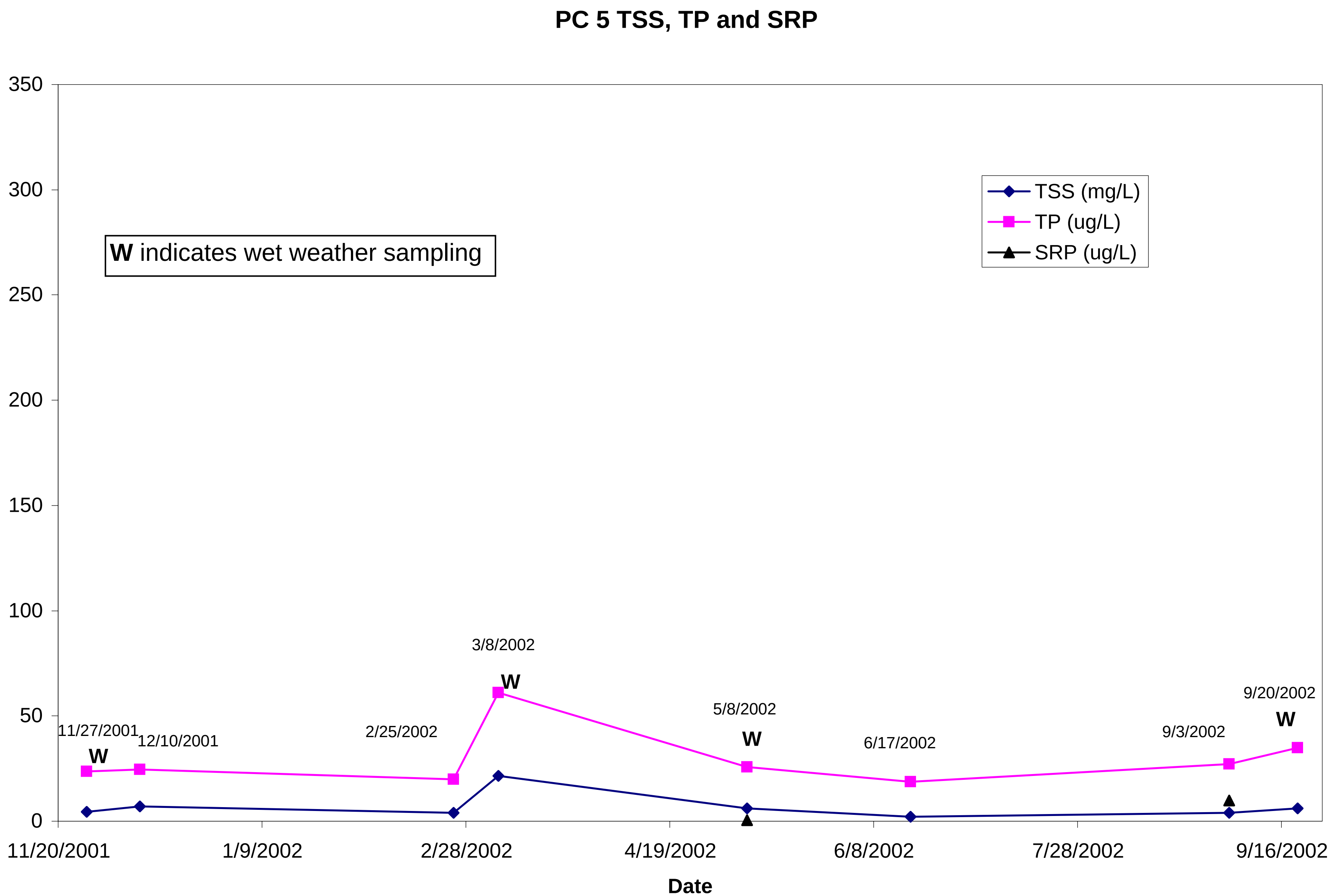
KIESER & ASSOCIATES



KIESER & ASSOCIATES

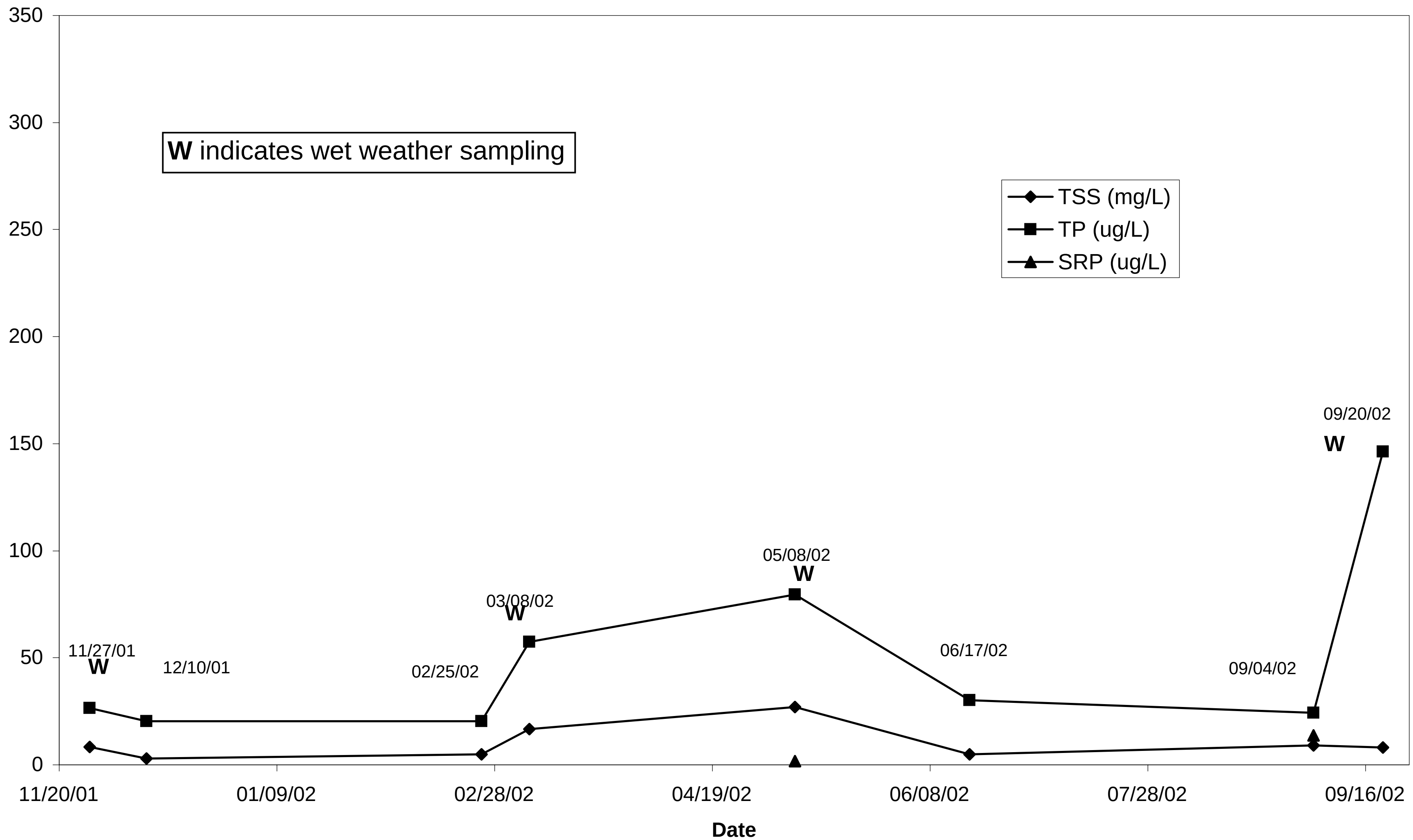


KIESER & ASSOCIATES

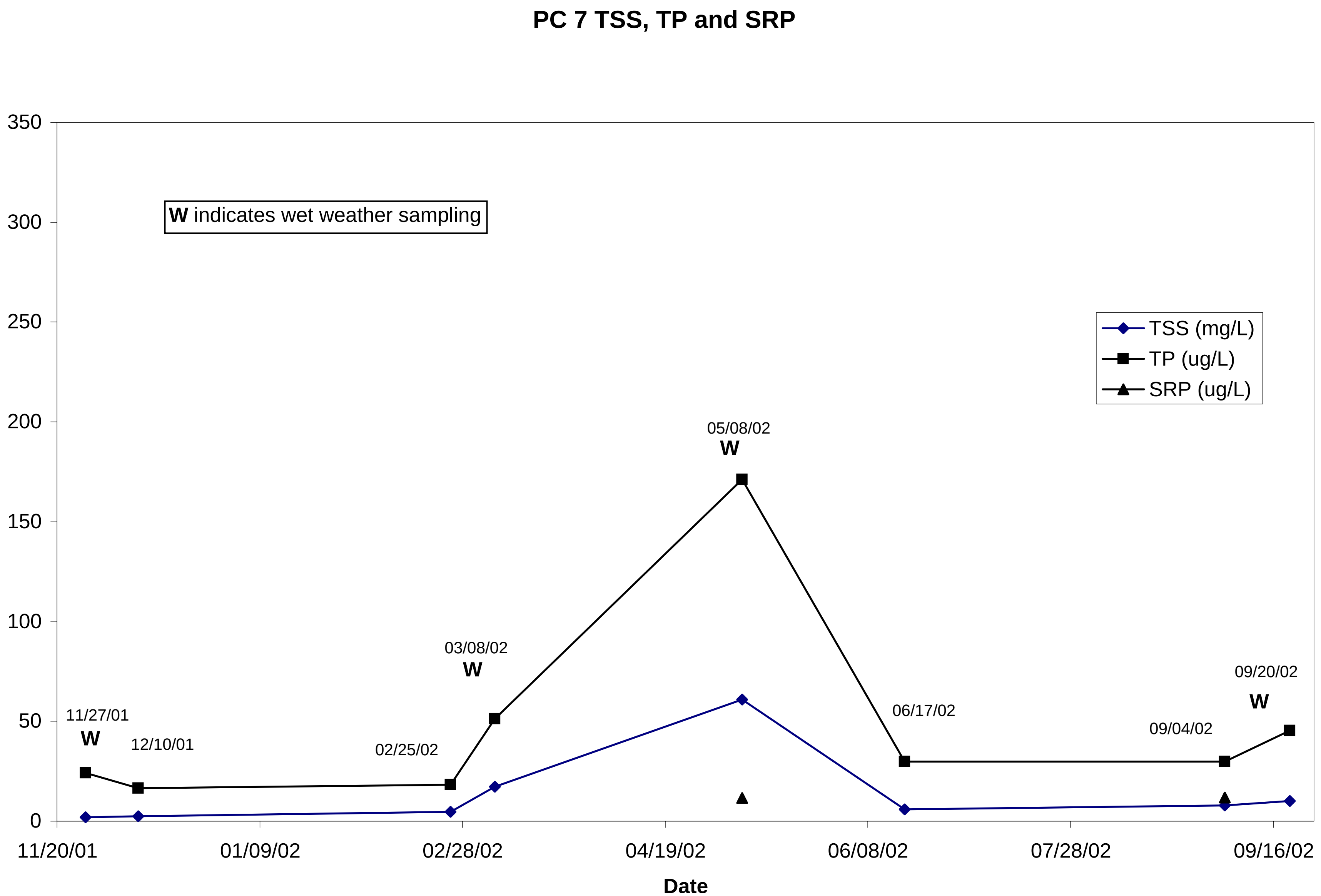


KIESER & ASSOCIATES

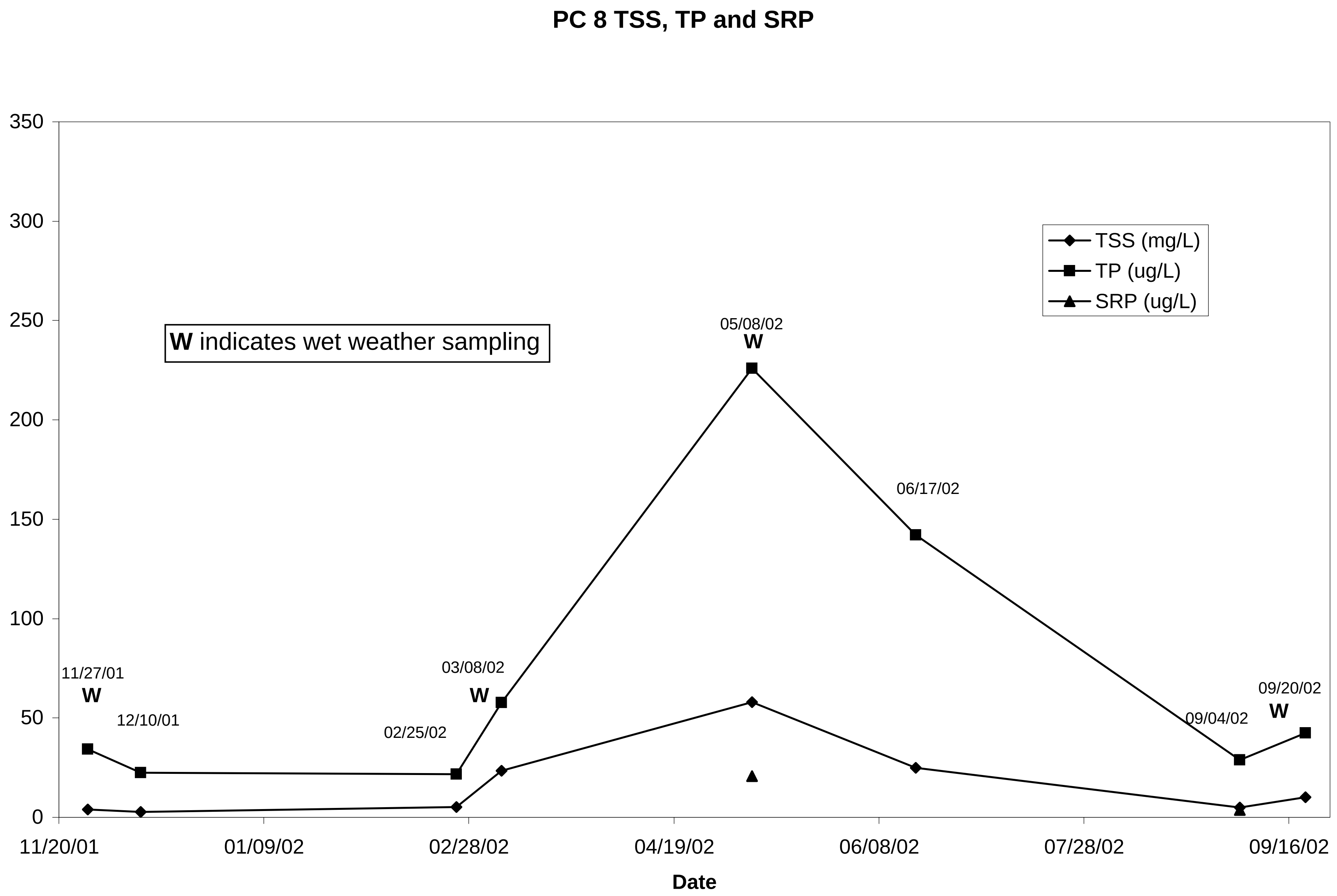
PC 6 TSS, TP and SRP



KIESER & ASSOCIATES

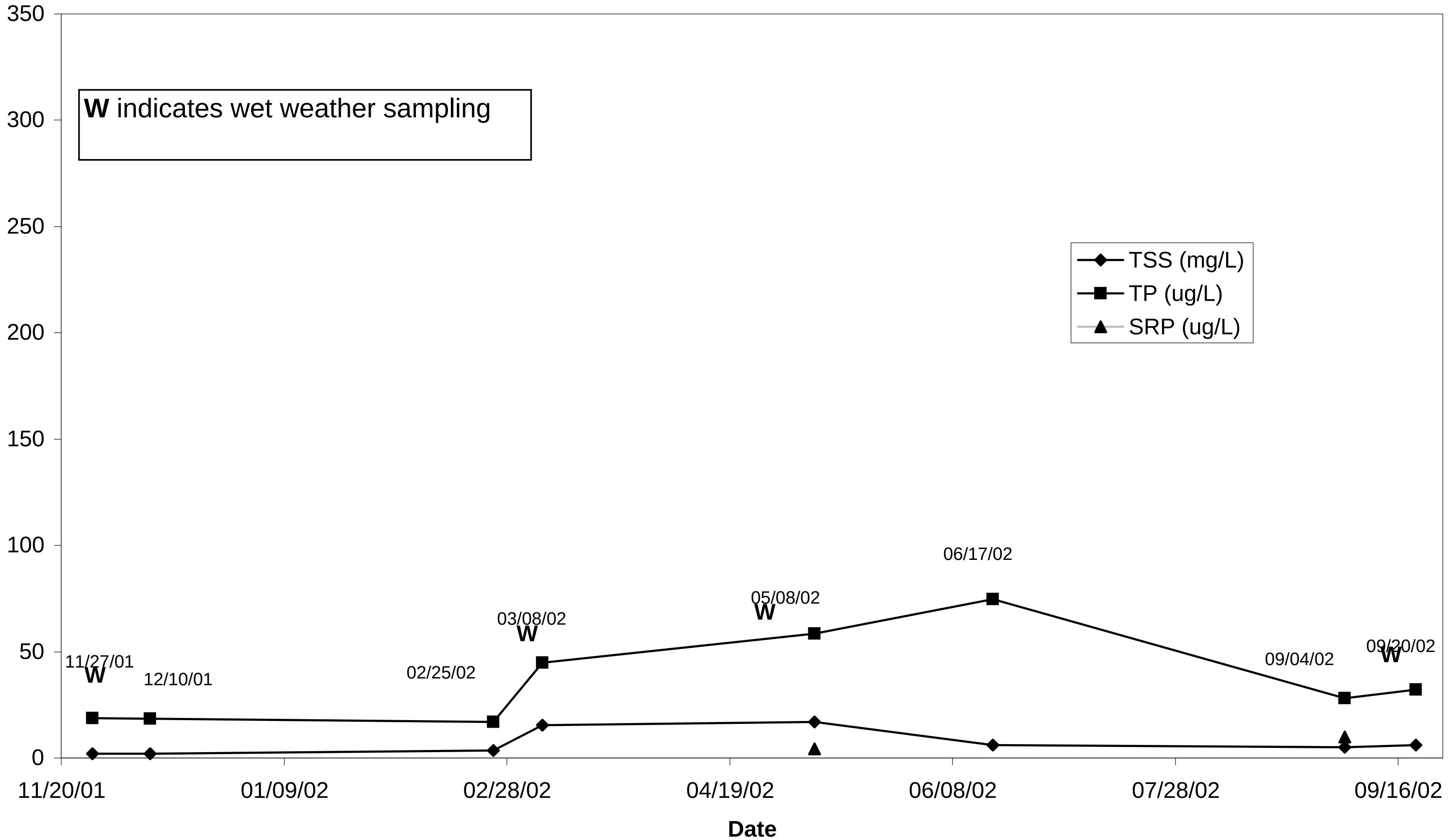


KIESER & ASSOCIATES

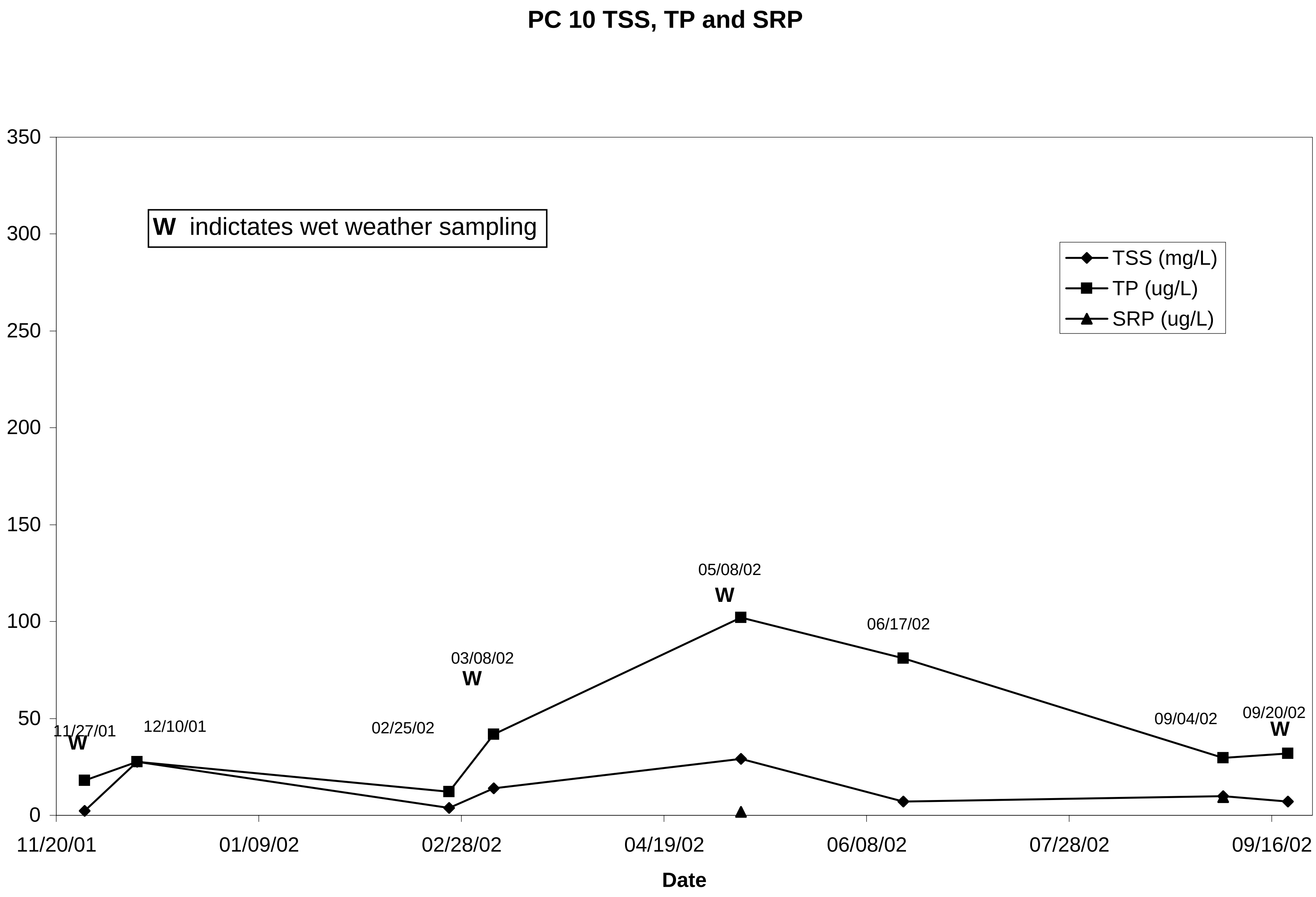


KIESER & ASSOCIATES

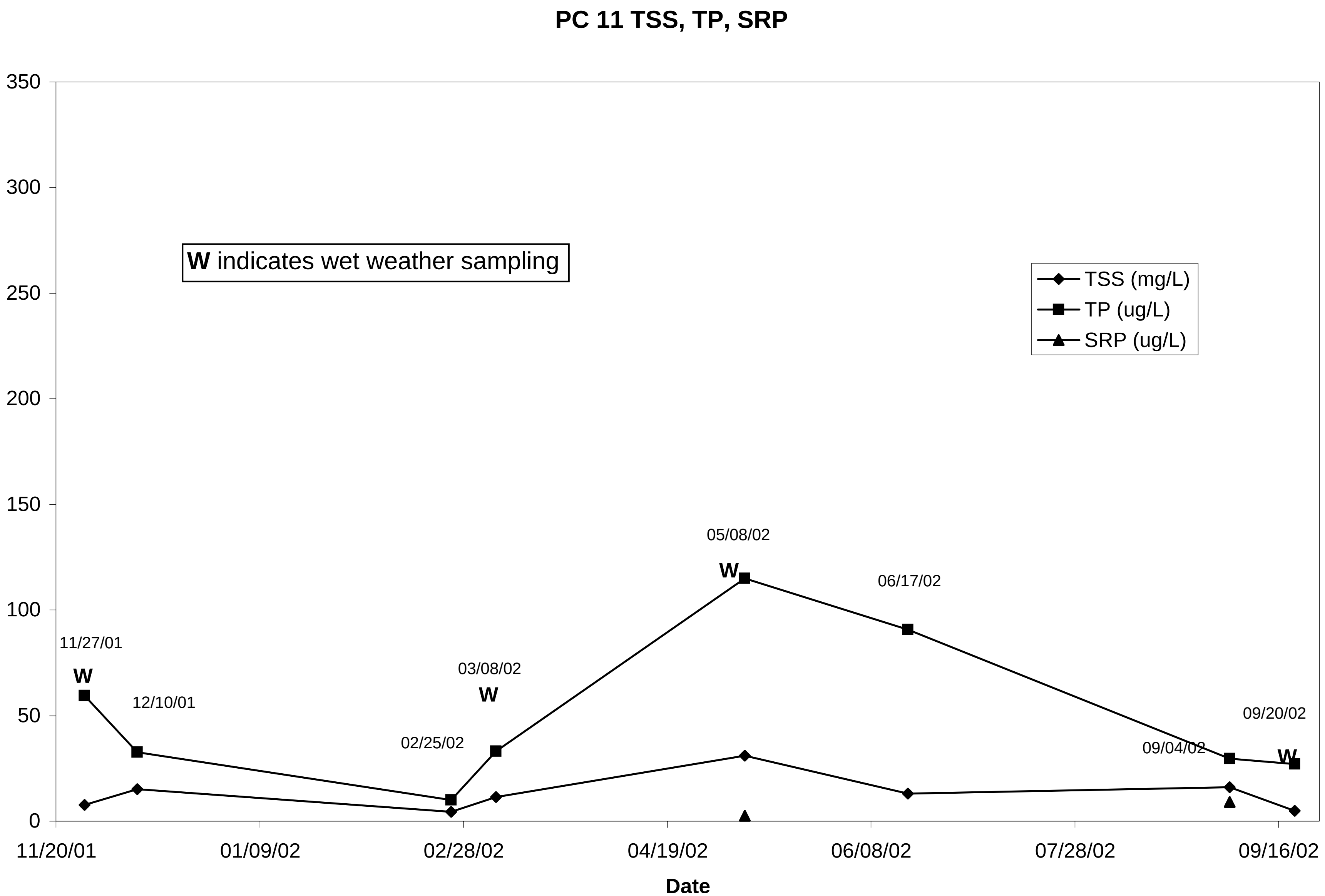
PC 9 TSS, TP and SRP



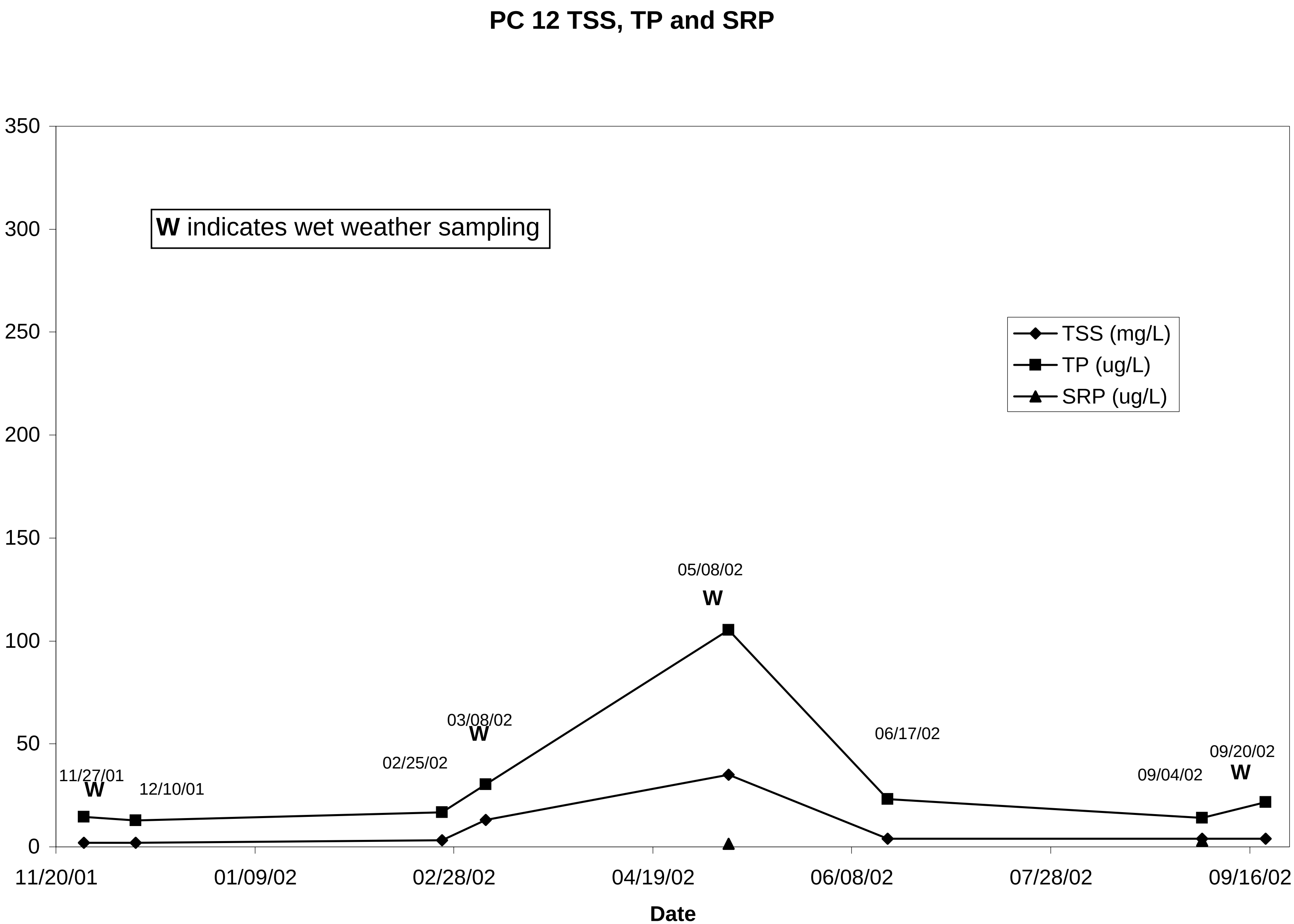
KIESER & ASSOCIATES

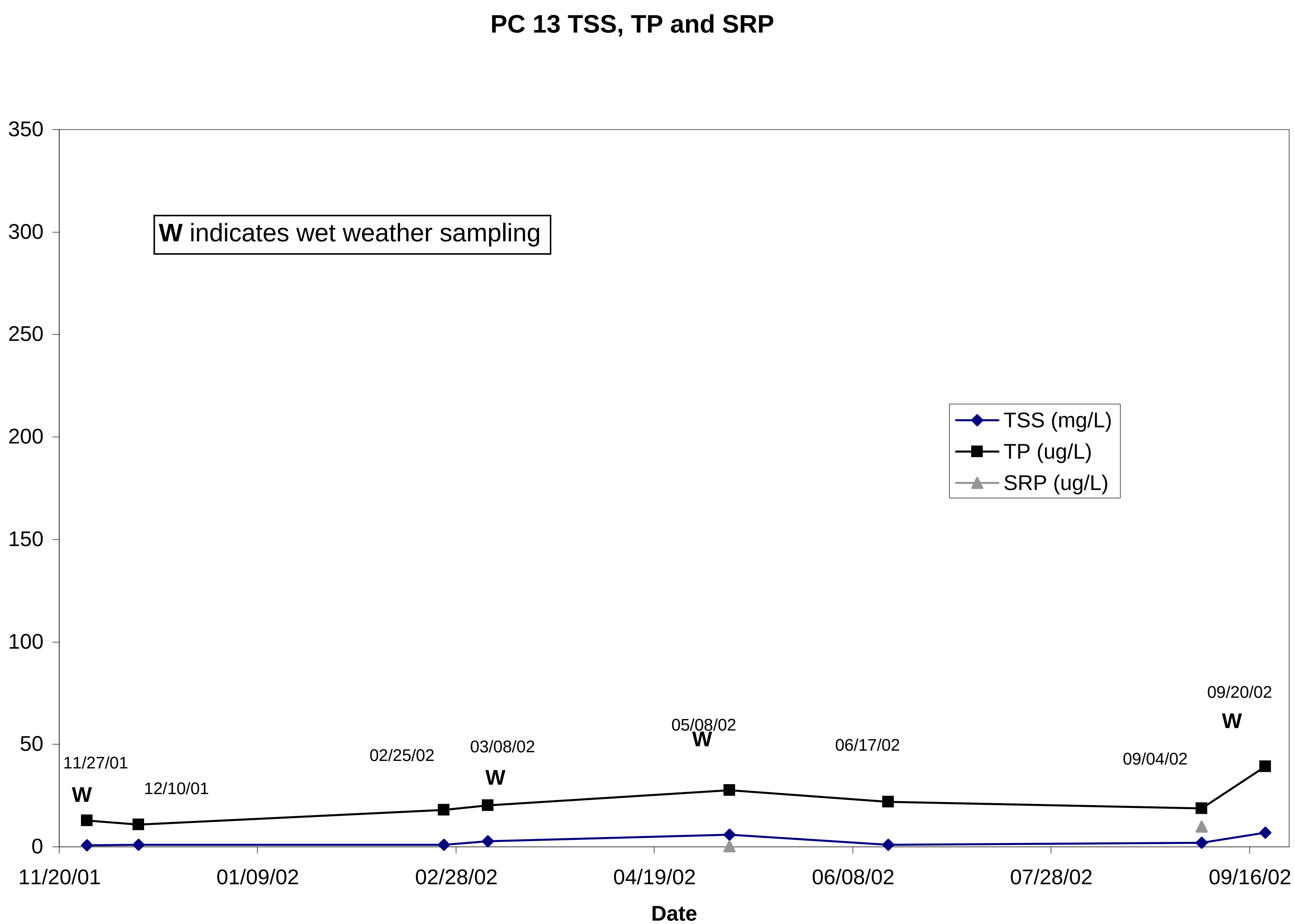


KIESER & ASSOCIATES

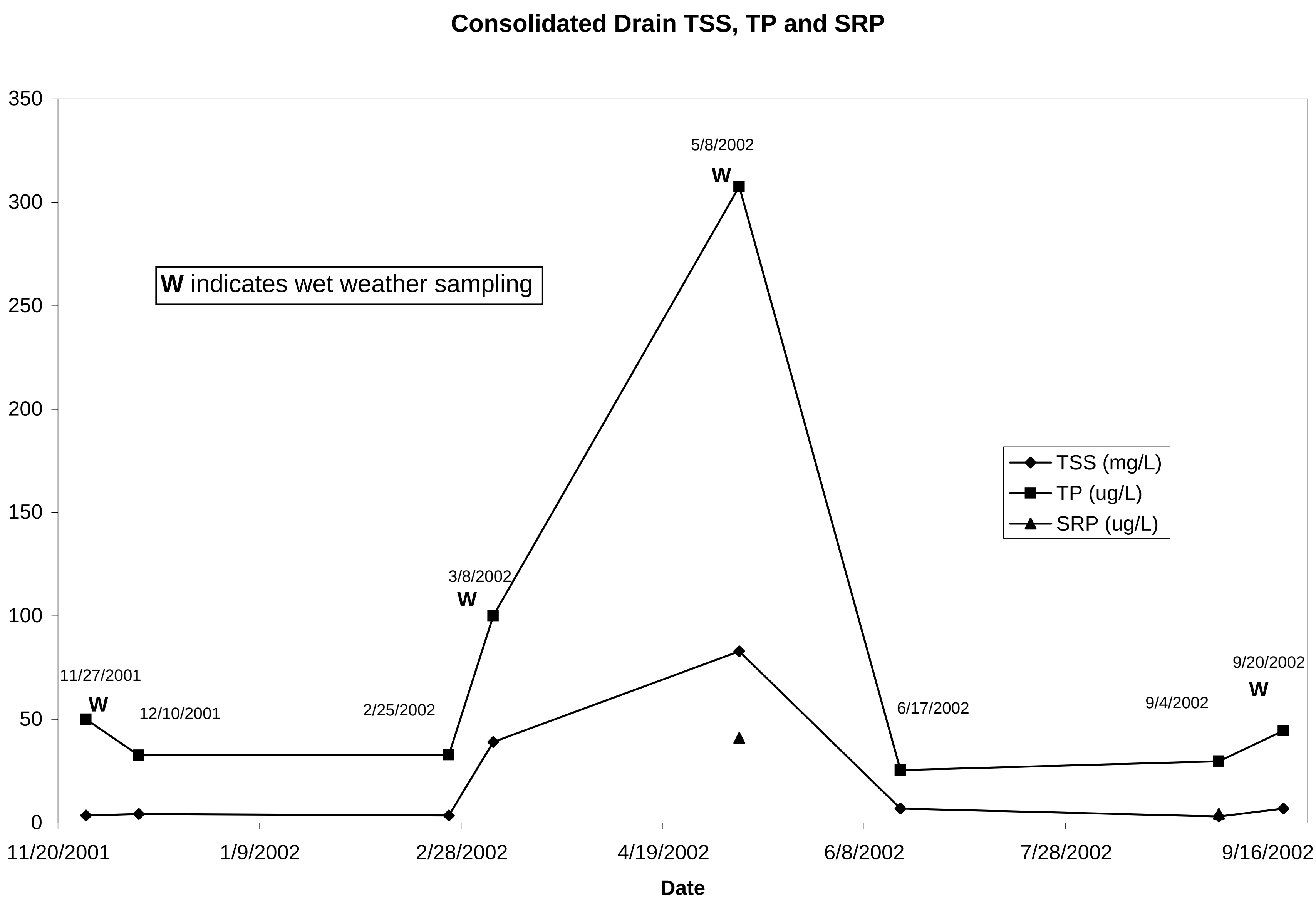


KIESER & ASSOCIATES

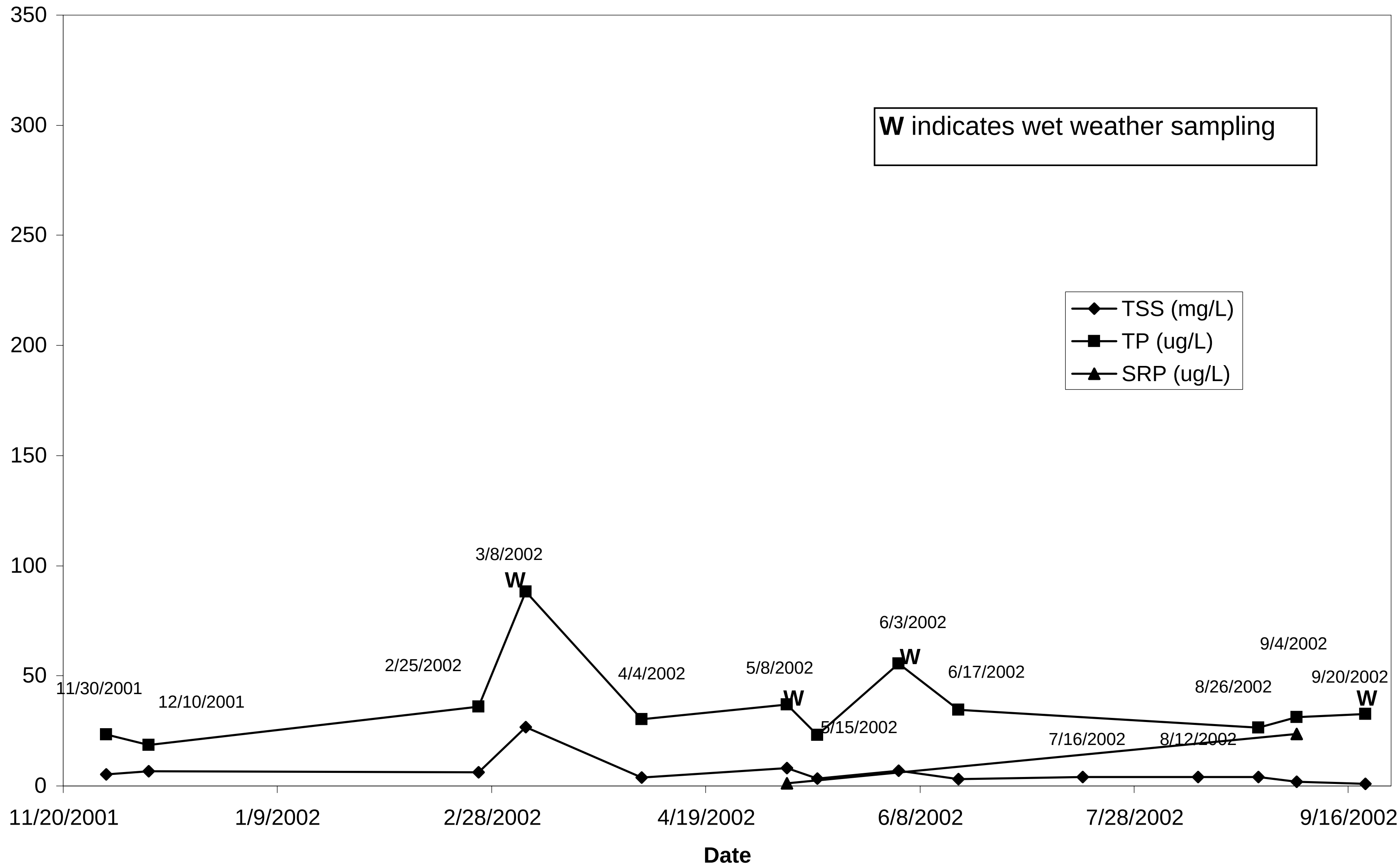

PC 12 TSS, TP and SRP
W indicates wet weather sampling
TSS (mg/L)
TP (ug/L)
SRP (ug/L)
350
300
250
200
150
100
50
0
11/27/01
W
12/10/01
02/25/02
03/08/02
W
05/08/02
W
06/17/02
09/04/02
09/20/02
W
11/20/01
01/09/02
02/28/02
04/19/02
06/08/02
07/28/02
09/16/02
Date



KIESER & ASSOCIATES


Consolidated Drain TSS, TP and SRP
350
300
250
200
150
100
50
0
W indicates wet weather sampling
5/8/2002
W
3/8/2002
W
11/27/2001
W
12/10/2001
2/25/2002
6/17/2002
9/4/2002
9/20/2002
W
TSS (mg/L)
TP (ug/L)
SRP (ug/L)
11/20/2001
1/9/2002
2/28/2002
4/19/2002
6/8/2002
7/28/2002
9/16/2002
Date

Gernaat Court (Pharmacia) TSS, TP and SRP



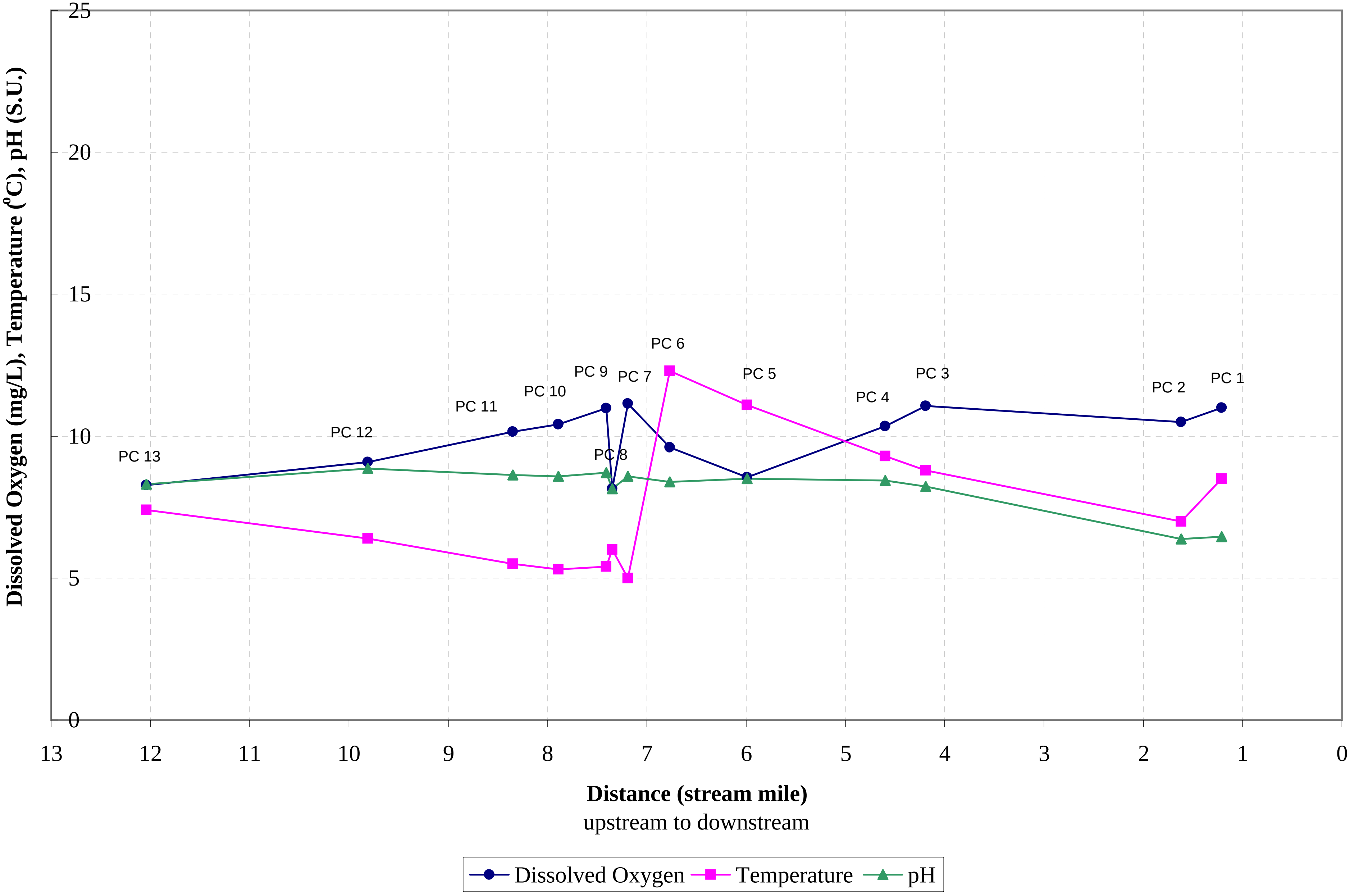
Attachment B

Subwatershed Sampling Station Water Quality Measurements during Wet and Dry Sampling Events

Portage Creek

Dissolved Oxygen, Temperature and pH

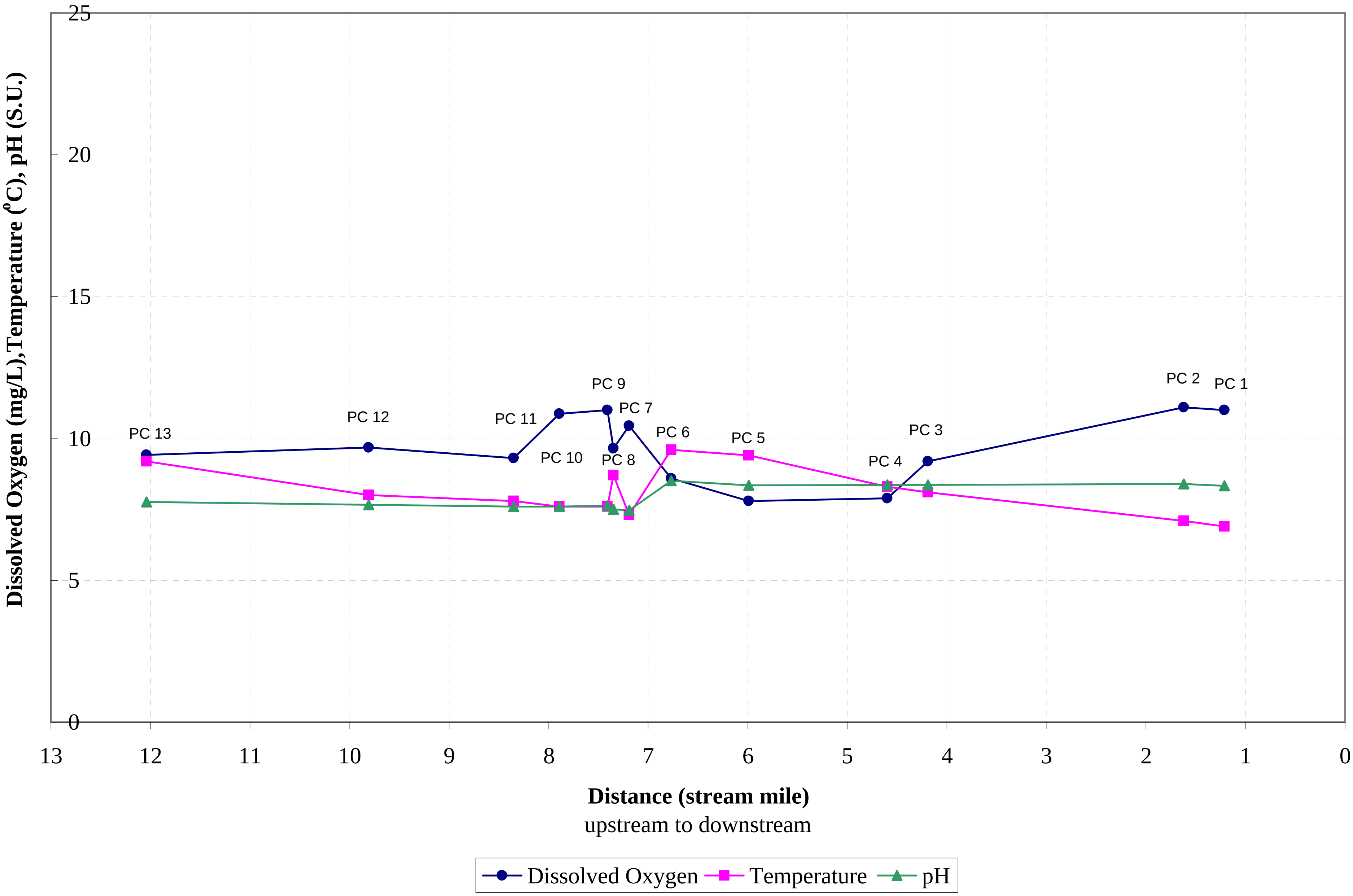
Dry weather sampling event, December 10, 2001



Portage Creek

Dissolved Oxygen, Temperature and pH

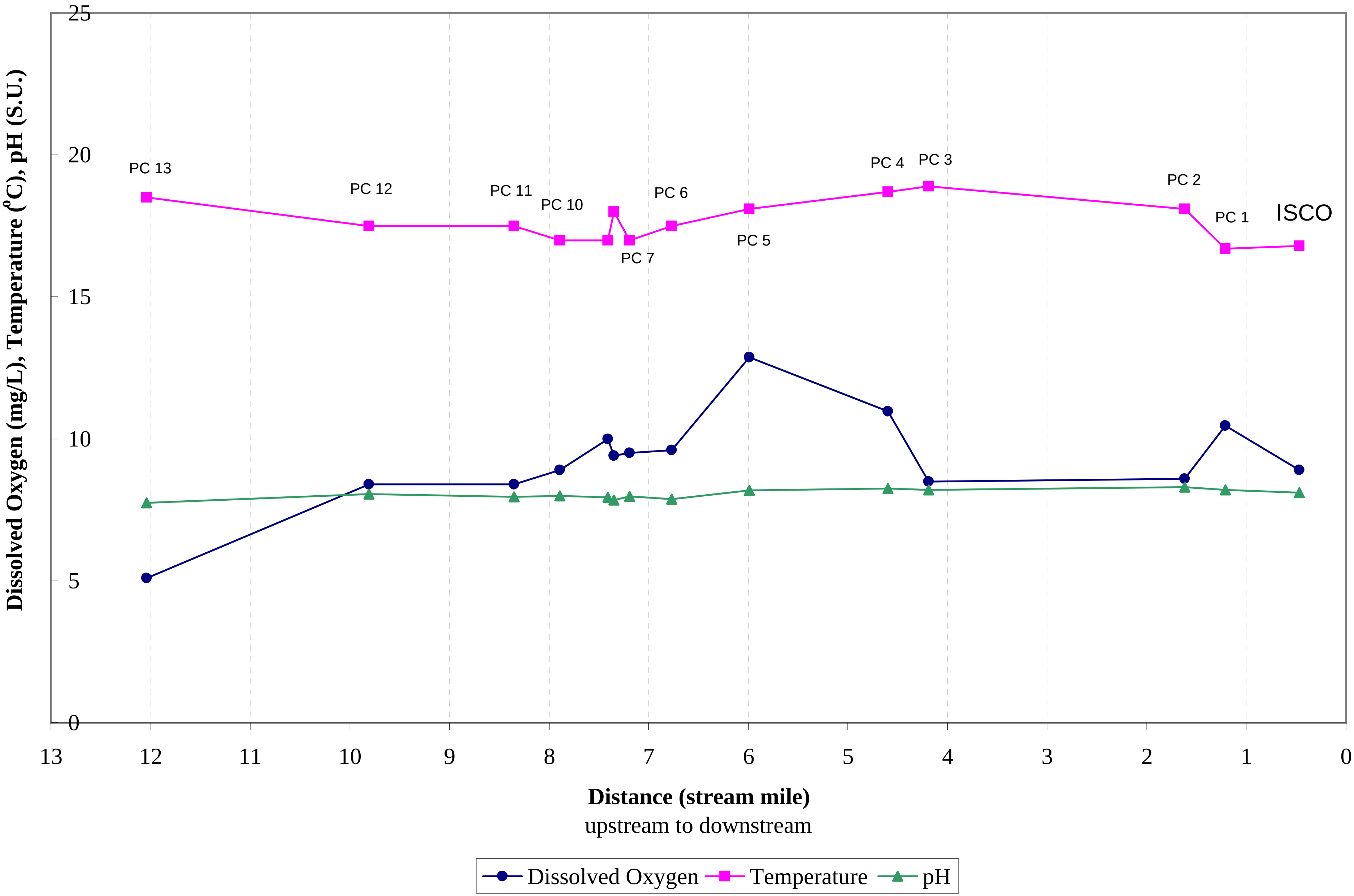
Dry weather sampling event, February 25, 2002



Portage Creek

Dissolved Oxygen, Temperature and pH

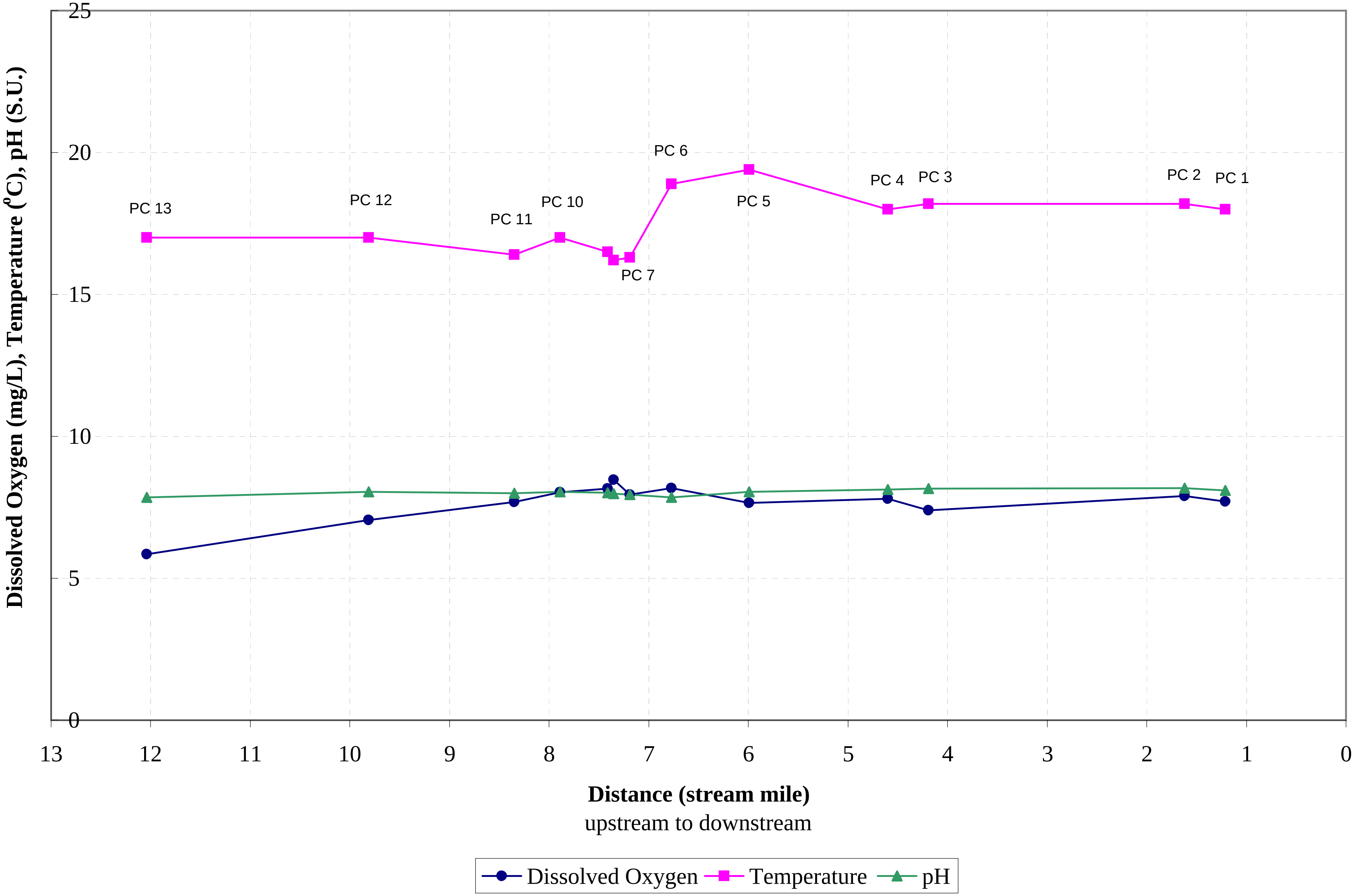
Dry weather sampling event, June 17, 2002

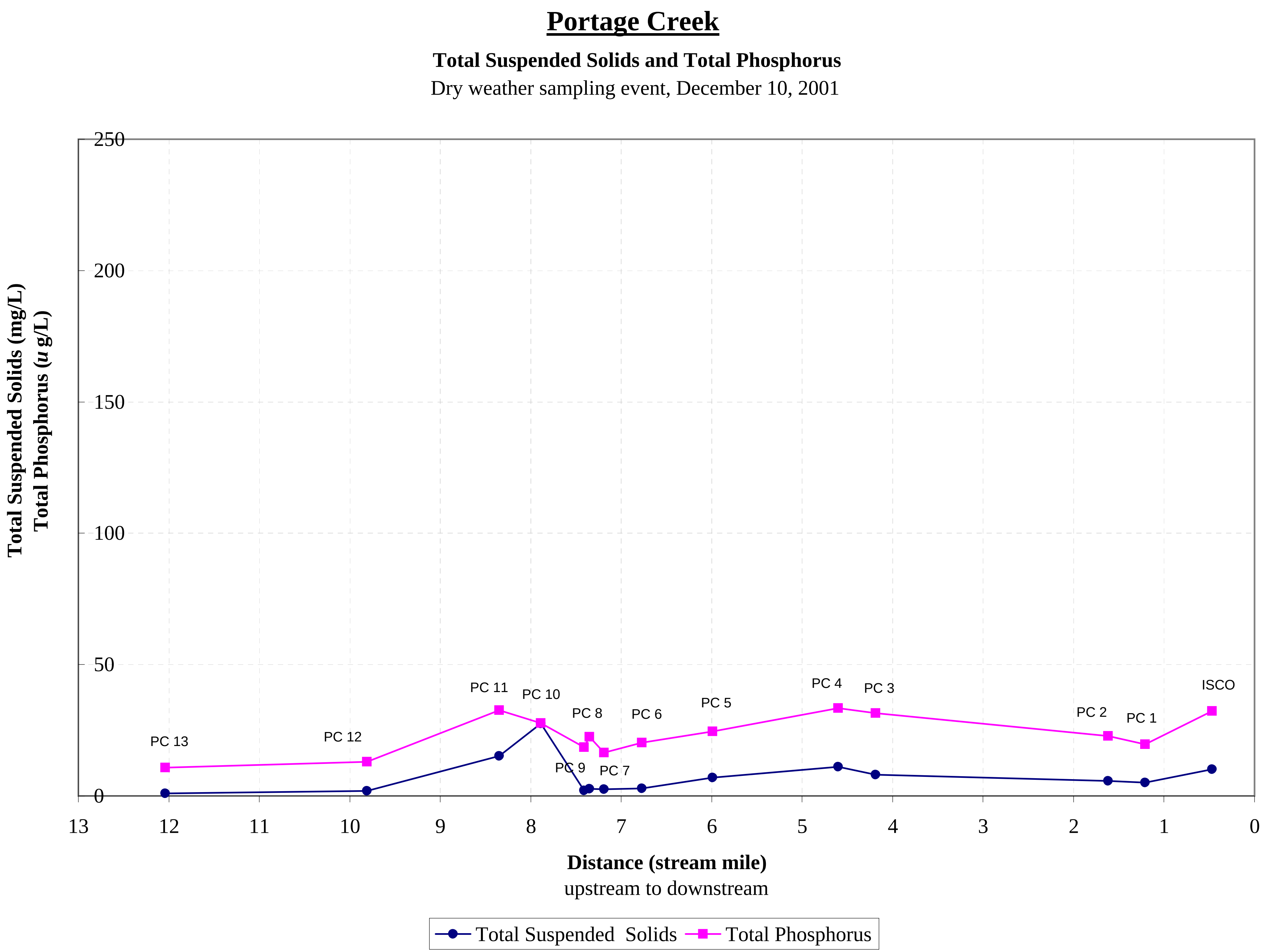


Portage Creek

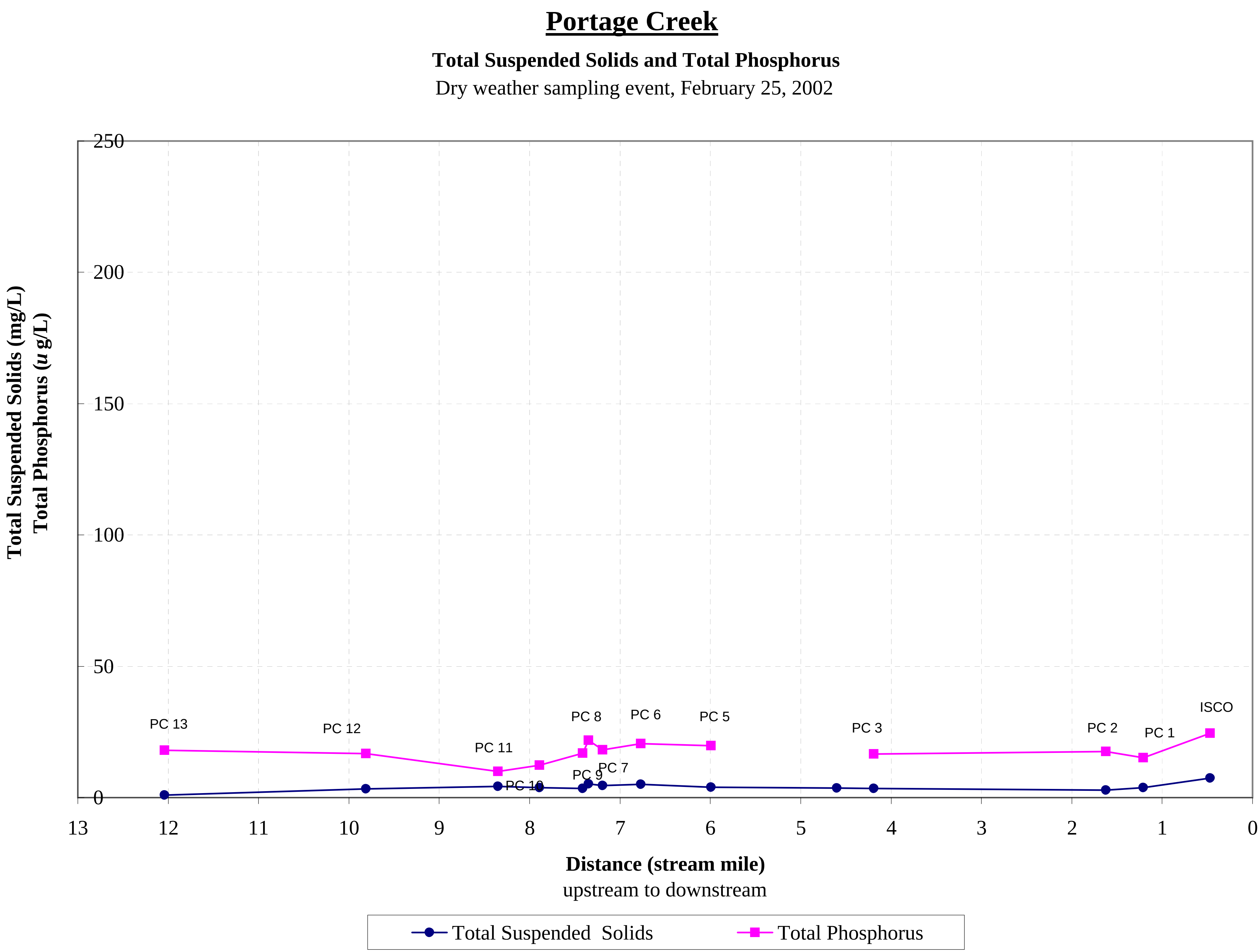
Dissolved Oxygen, Temperature and pH

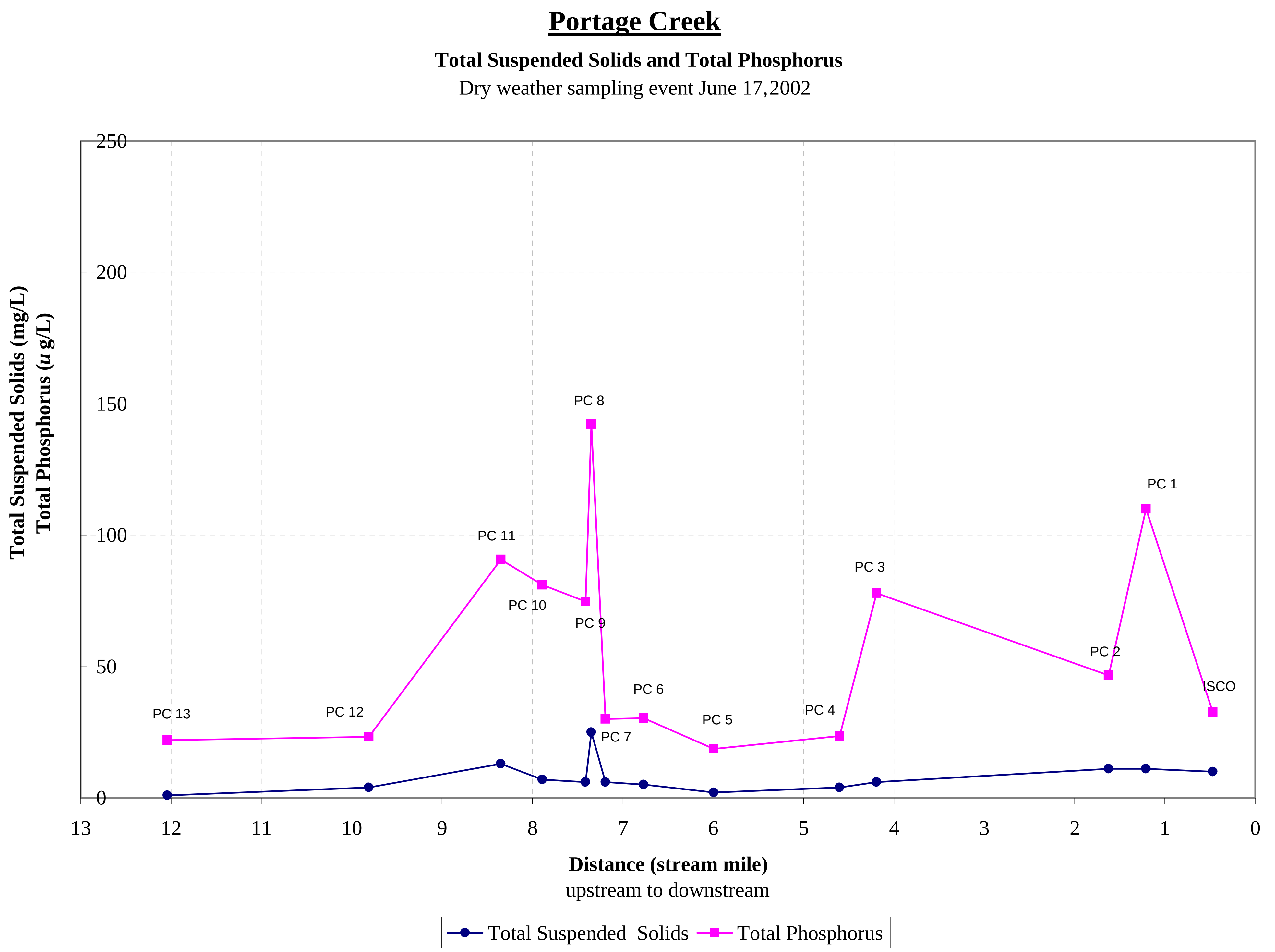
Dry weather sampling event, September 4, 2002





Portage Creek
Total Suspended Solids and Total Phosphorus
Dry weather sampling event, December 10, 2001
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
250
200
150
100
50
0
PC 13
PC 12
PC 11
PC 10
PC 9
PC 8
PC 7
PC 6
PC 5
PC 4
PC 3
PC 2
PC 1
ISCO
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

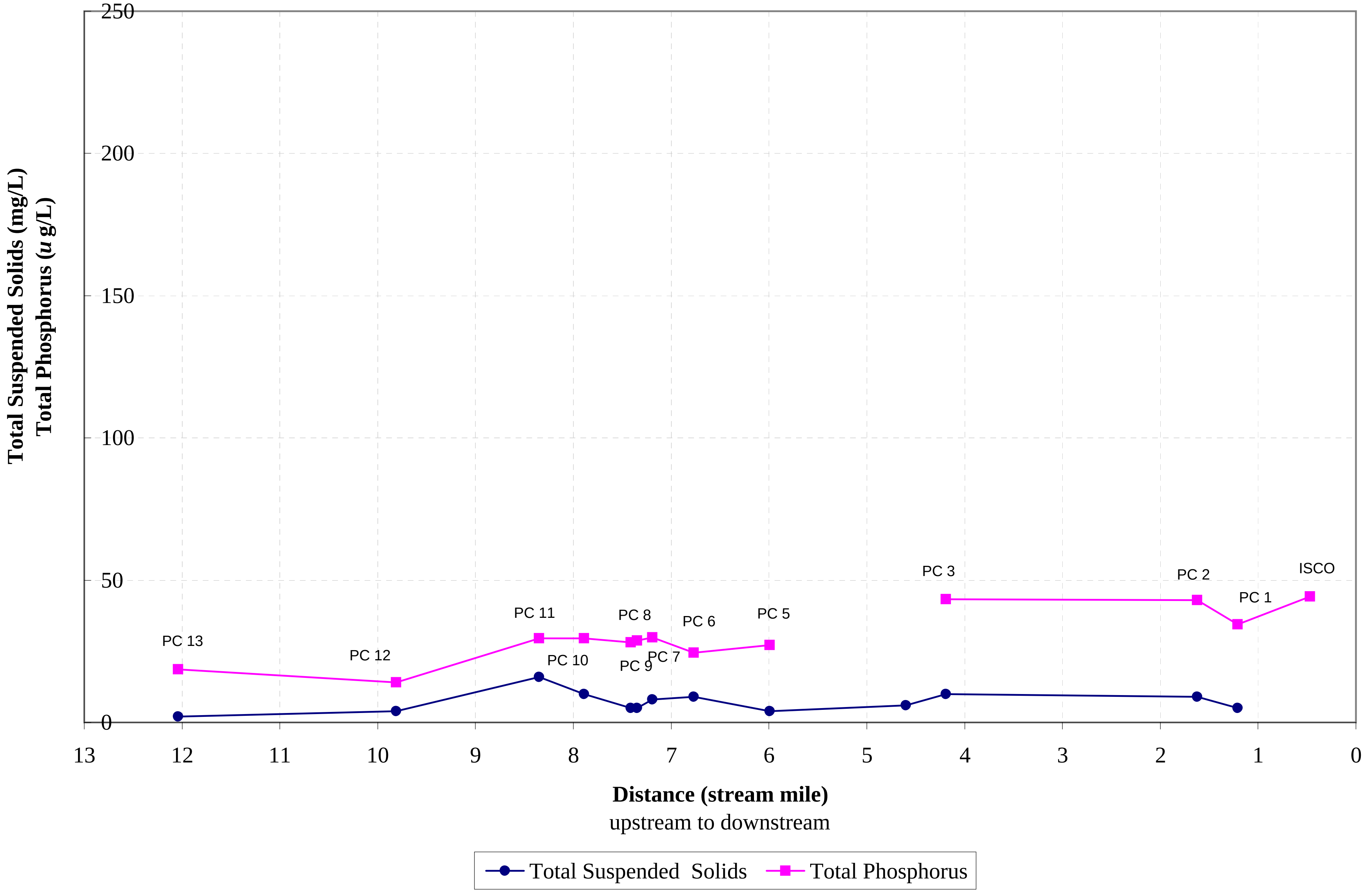

Portage Creek
Total Suspended Solids and Total Phosphorus
Dry weather sampling event, February 25, 2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
250
200
150
100
50
0
PC 13
PC 12
PC 11
PC 10
PC 9
PC 8
PC 7
PC 6
PC 5
PC 3
PC 2
PC 1
ISCO
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

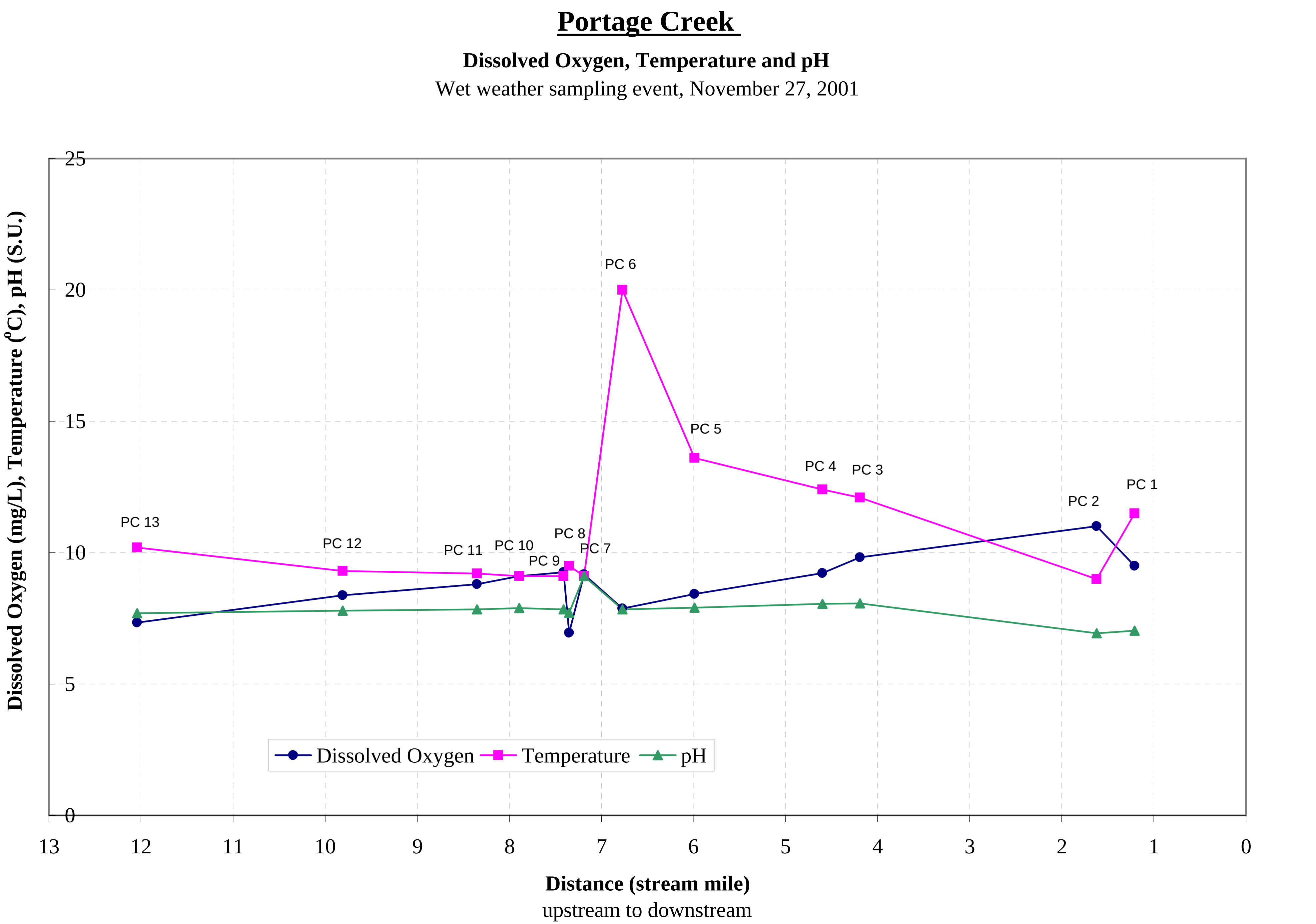

Portage Creek
Total Suspended Solids and Total Phosphorus
Dry weather sampling event June 17,2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
250
200
150
100
50
0
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
PC 13
PC 12
PC 11
PC 10
PC 9
PC 8
PC 7
PC 6
PC 5
PC 4
PC 3
PC 2
PC 1
ISCO
Total Suspended Solids
Total Phosphorus

Portage Creek

Total Suspended Solids and Total Phosphorus

Dry weather sampling event, September 4,2002



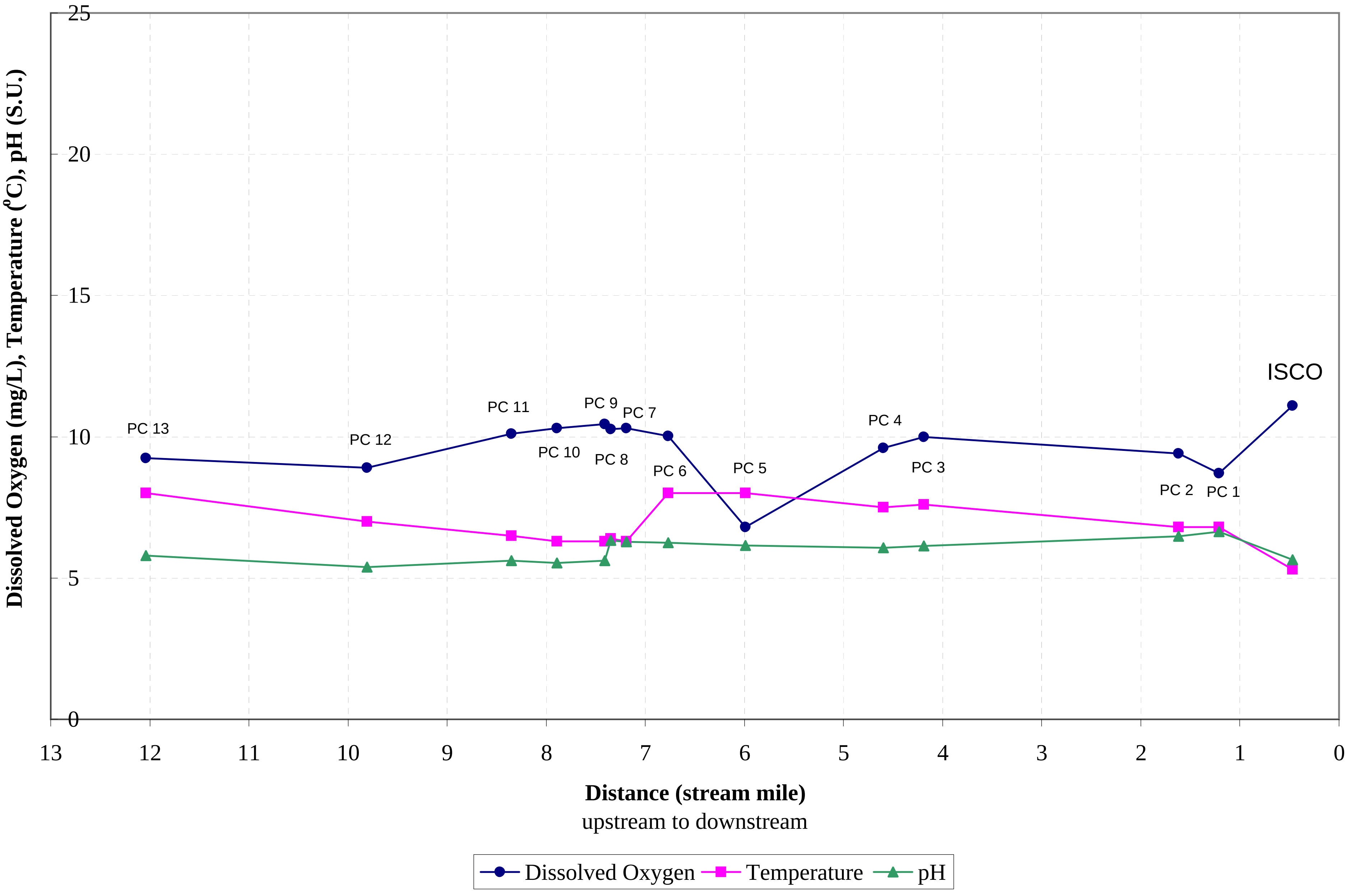


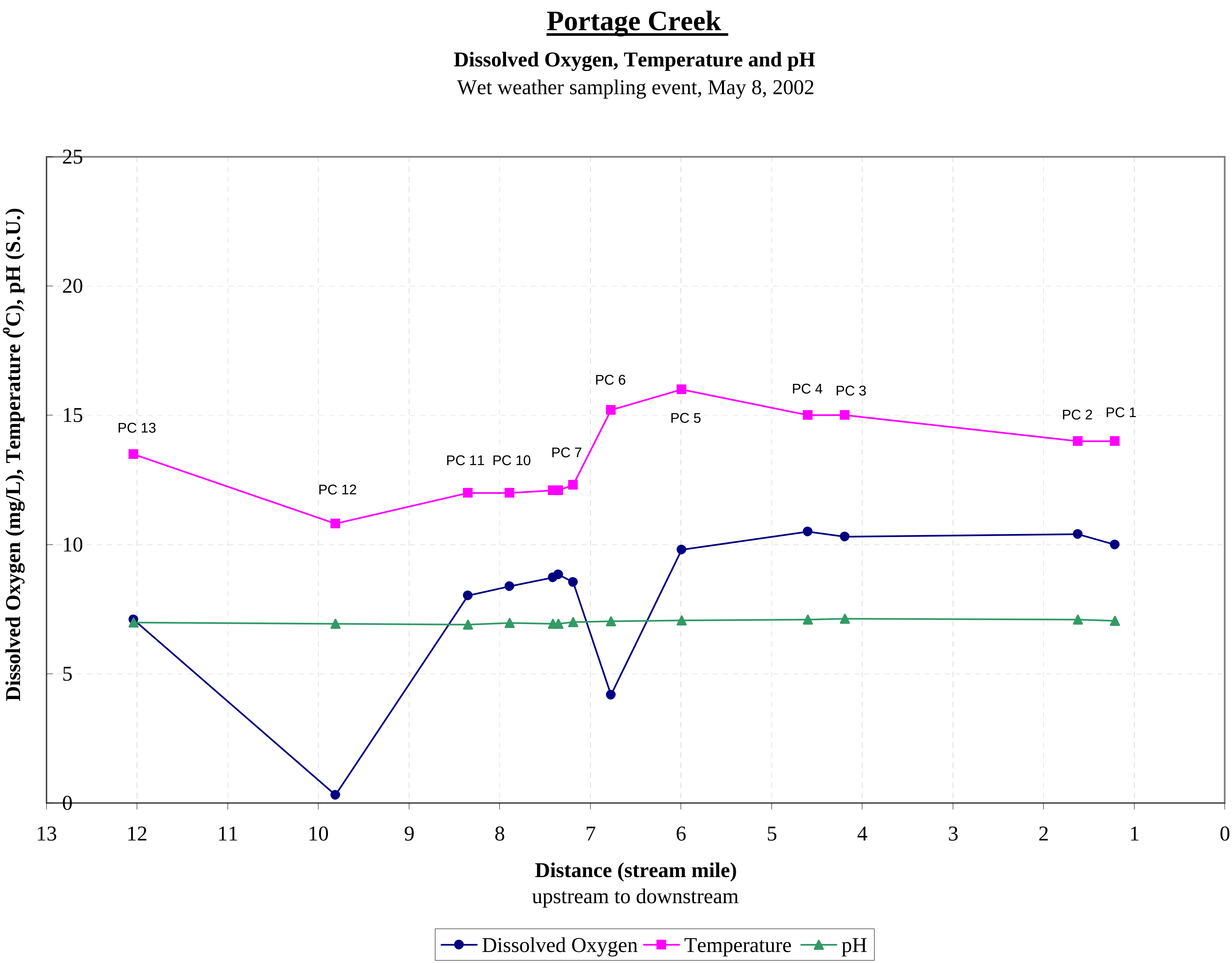
Portage Creek
Dissolved Oxygen, Temperature and pH
Wet weather sampling event, November 27, 2001
Dissolved Oxygen (mg/L), Temperature (°C), pH (S.U.)
Distance (stream mile)
upstream to downstream
PC 13
PC 12
PC 11
PC 10
PC 9
PC 8
PC 7
PC 6
PC 5
PC 4
PC 3
PC 2
PC 1
Dissolved Oxygen
Temperature
pH
0
5
10
15
20
25
13
12
11
10
9
8
7
6
5
4
3
2
1
0

Portage Creek

Dissolved Oxygen, Temperature and pH

Wet weather sampling event, March 8, 2002

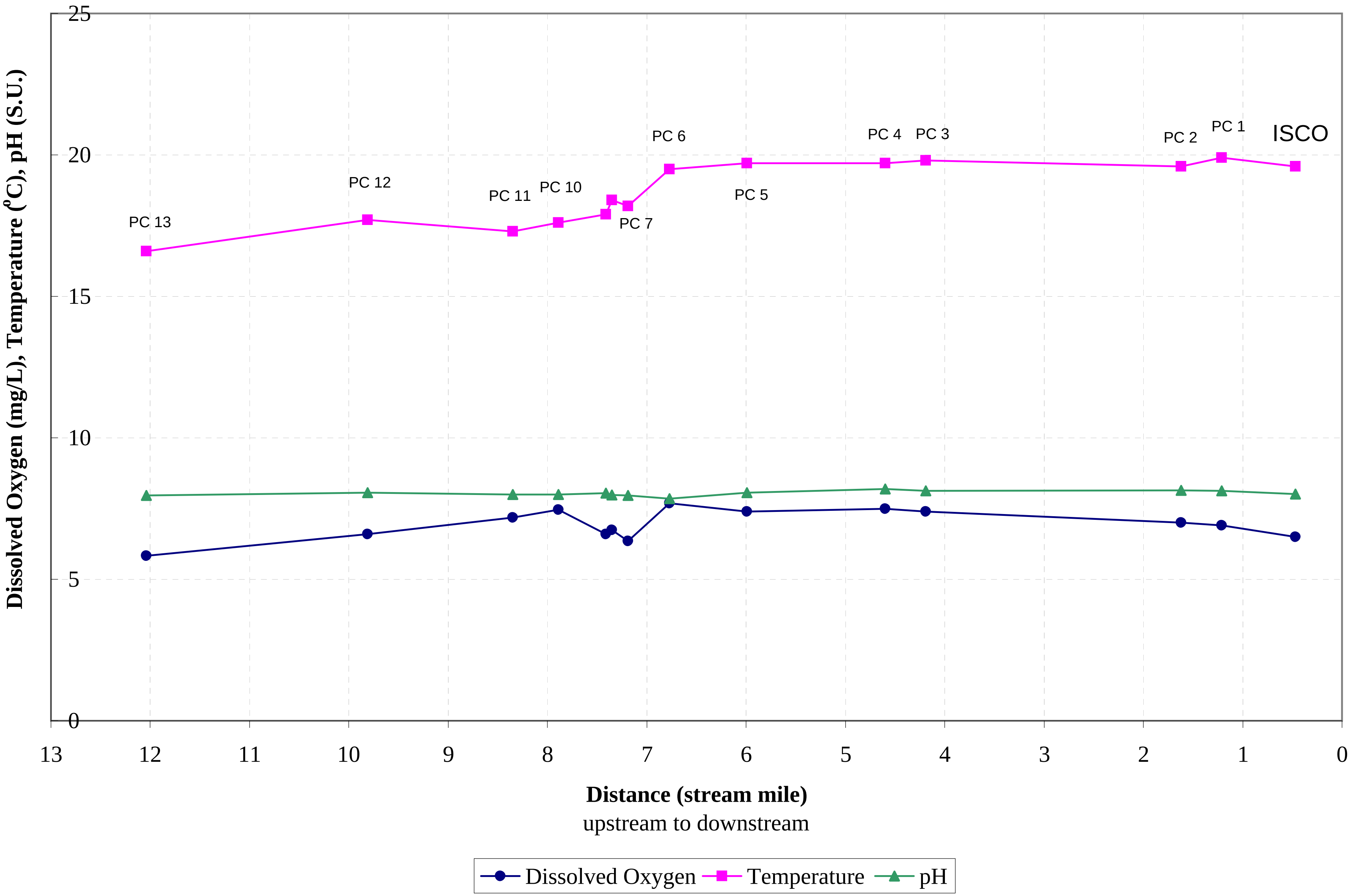


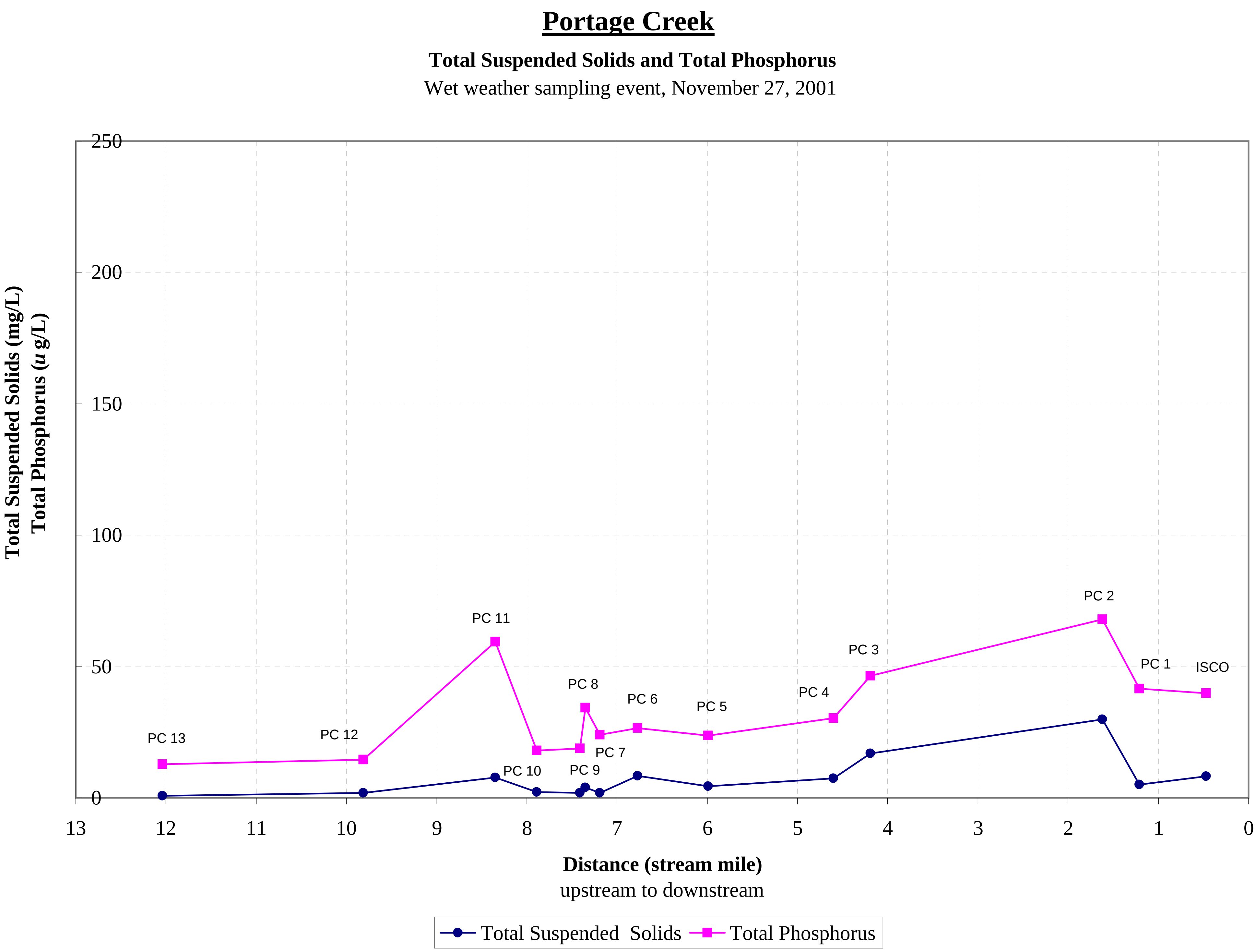

Portage Creek
Dissolved Oxygen, Temperature and pH
Wet weather sampling event, May 8, 2002
Dissolved Oxygen (mg/L), Temperature (°C), pH (S.U.)
25
20
15
10
5
0
PC 13
PC 12
PC 11
PC 10
PC 7
PC 6
PC 5
PC 4
PC 3
PC 2
PC 1
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Dissolved Oxygen
Temperature
pH

Portage Creek

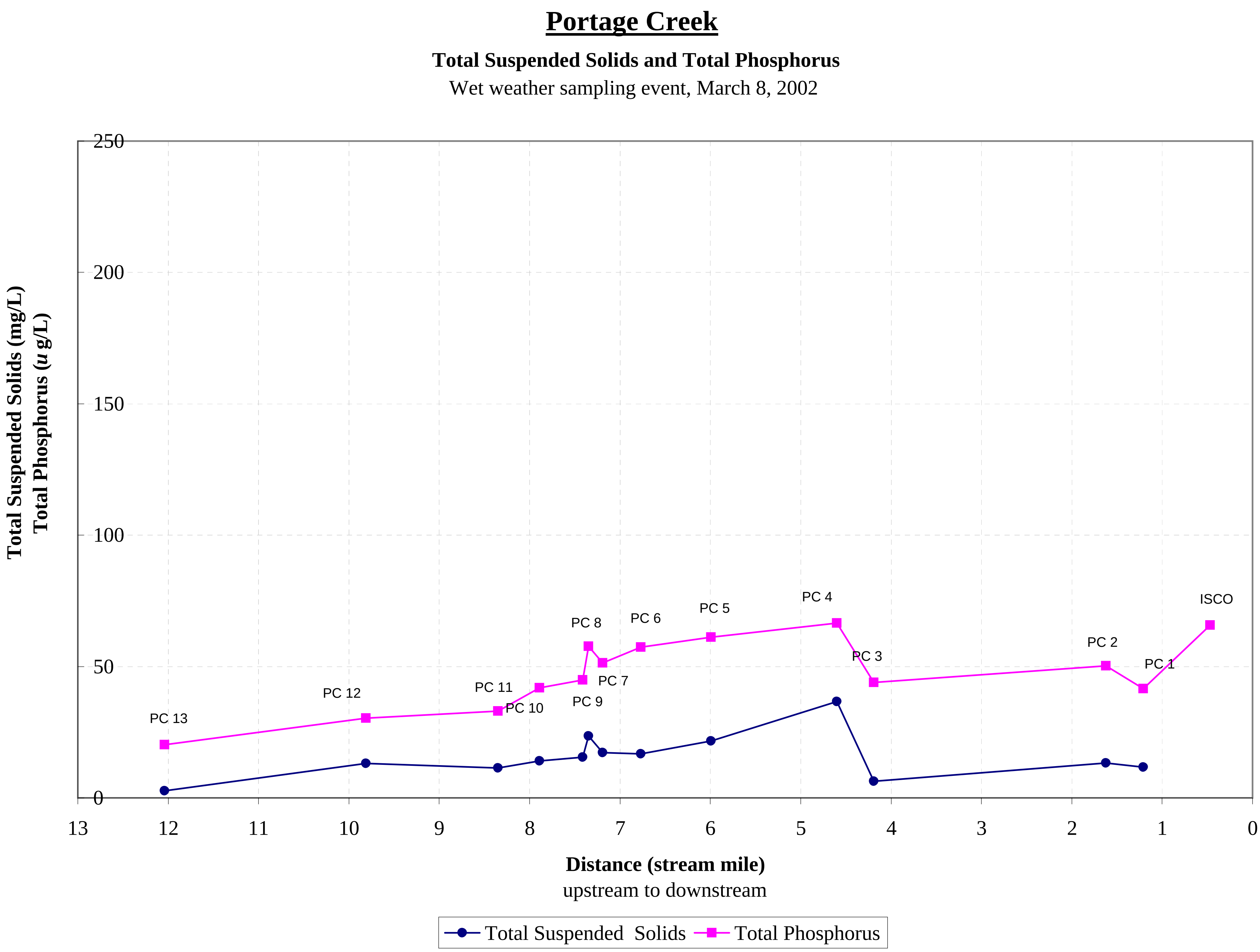
Dissolved Oxygen, Temperature and pH

Wet weather sampling event, September 20, 2002





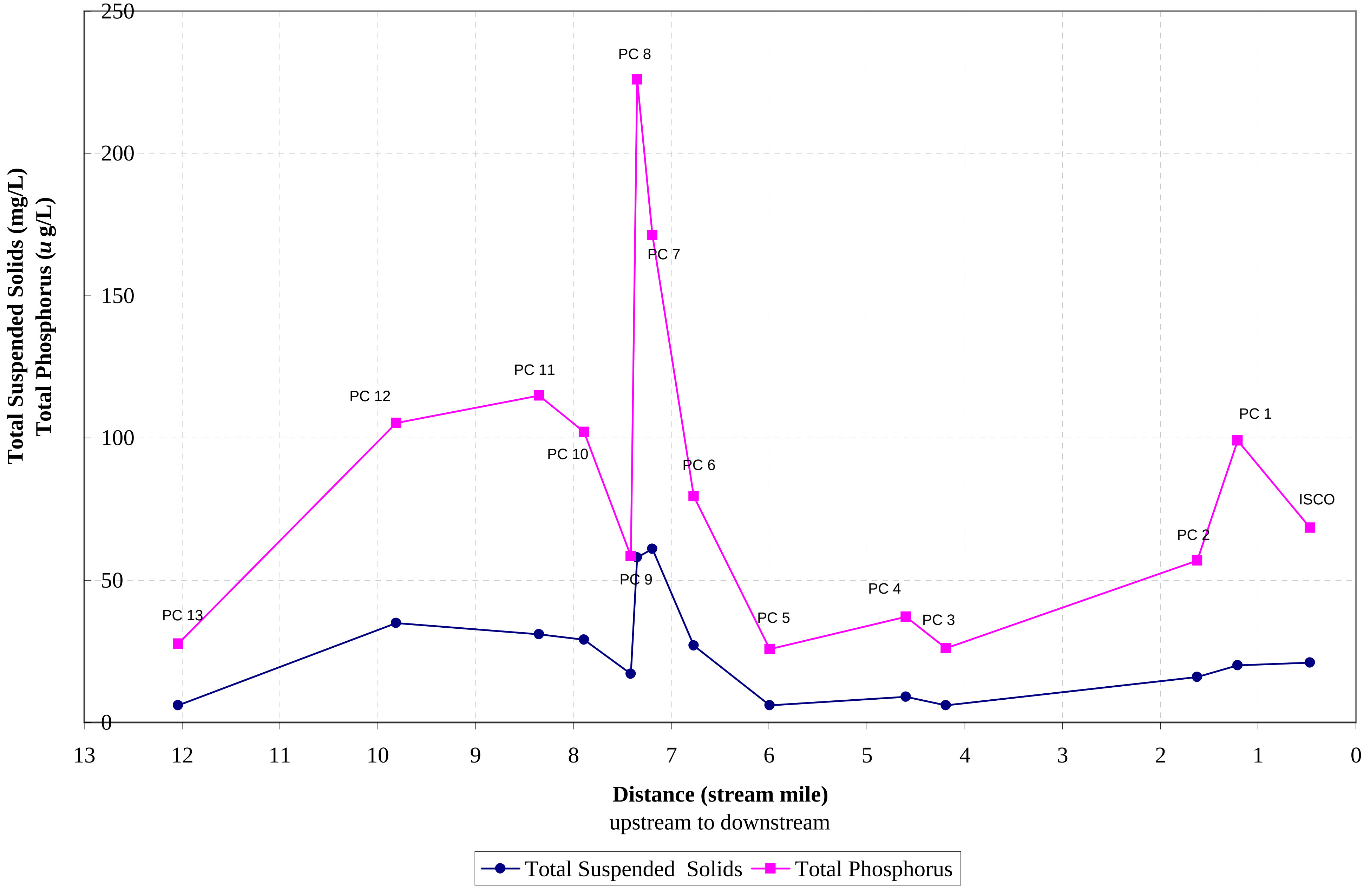
Portage Creek
Total Suspended Solids and Total Phosphorus
Wet weather sampling event, November 27, 2001
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
250
200
150
100
50
0
PC 13
PC 12
PC 11
PC 10
PC 9
PC 8
PC 7
PC 6
PC 5
PC 4
PC 3
PC 2
PC 1
ISCO
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus


Portage Creek
Total Suspended Solids and Total Phosphorus
Wet weather sampling event, March 8, 2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
250
200
150
100
50
0
PC 13
PC 12
PC 11
PC 10
PC 9
PC 8
PC 7
PC 6
PC 5
PC 4
PC 3
PC 2
PC 1
ISCO
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

Portage Creek

Total Suspended Solids and Total Phosphorus

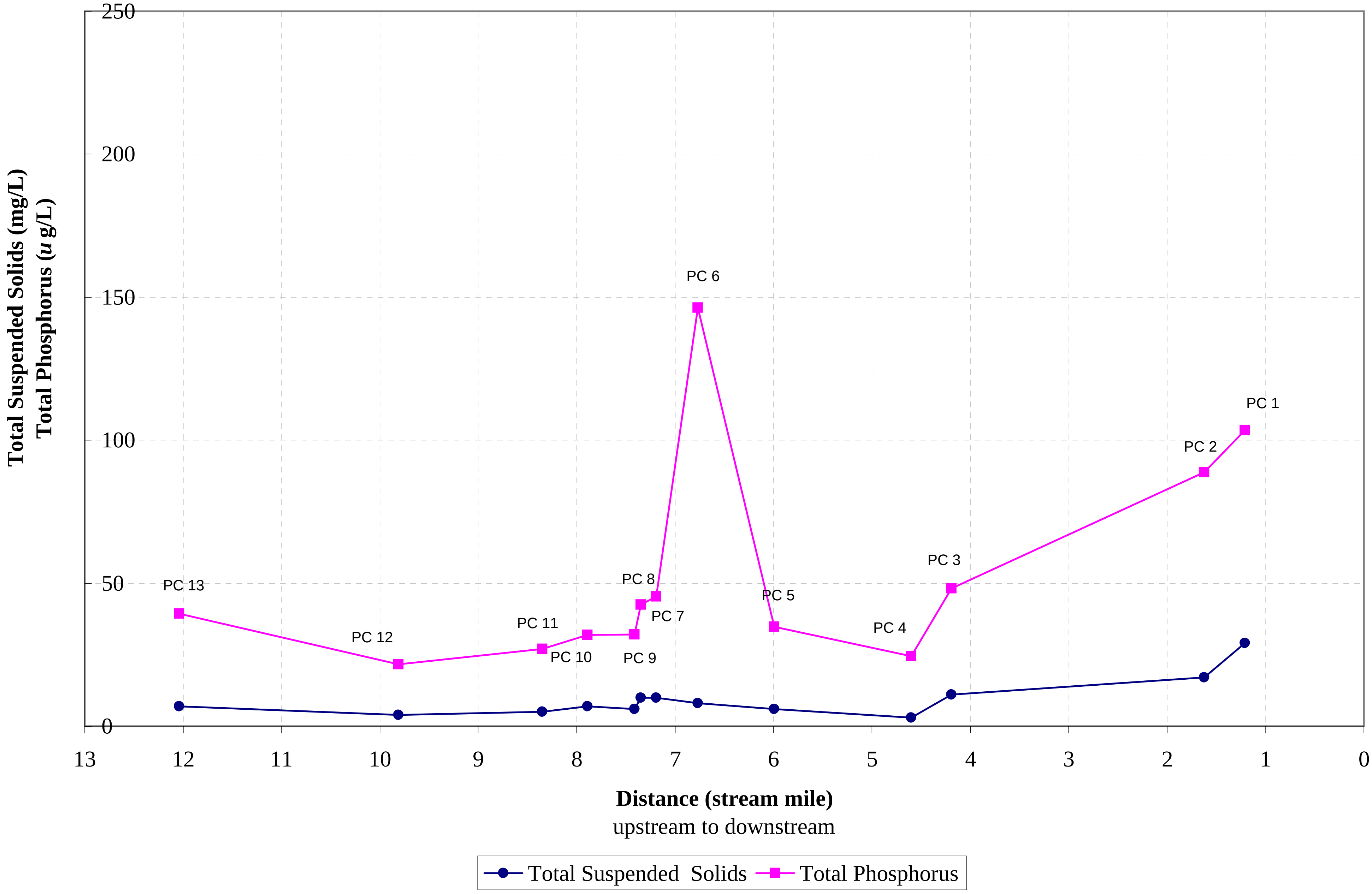
Wet weather sampling event, May 8, 2002



Portage Creek

Total Suspended Solids and Total Phosphorus

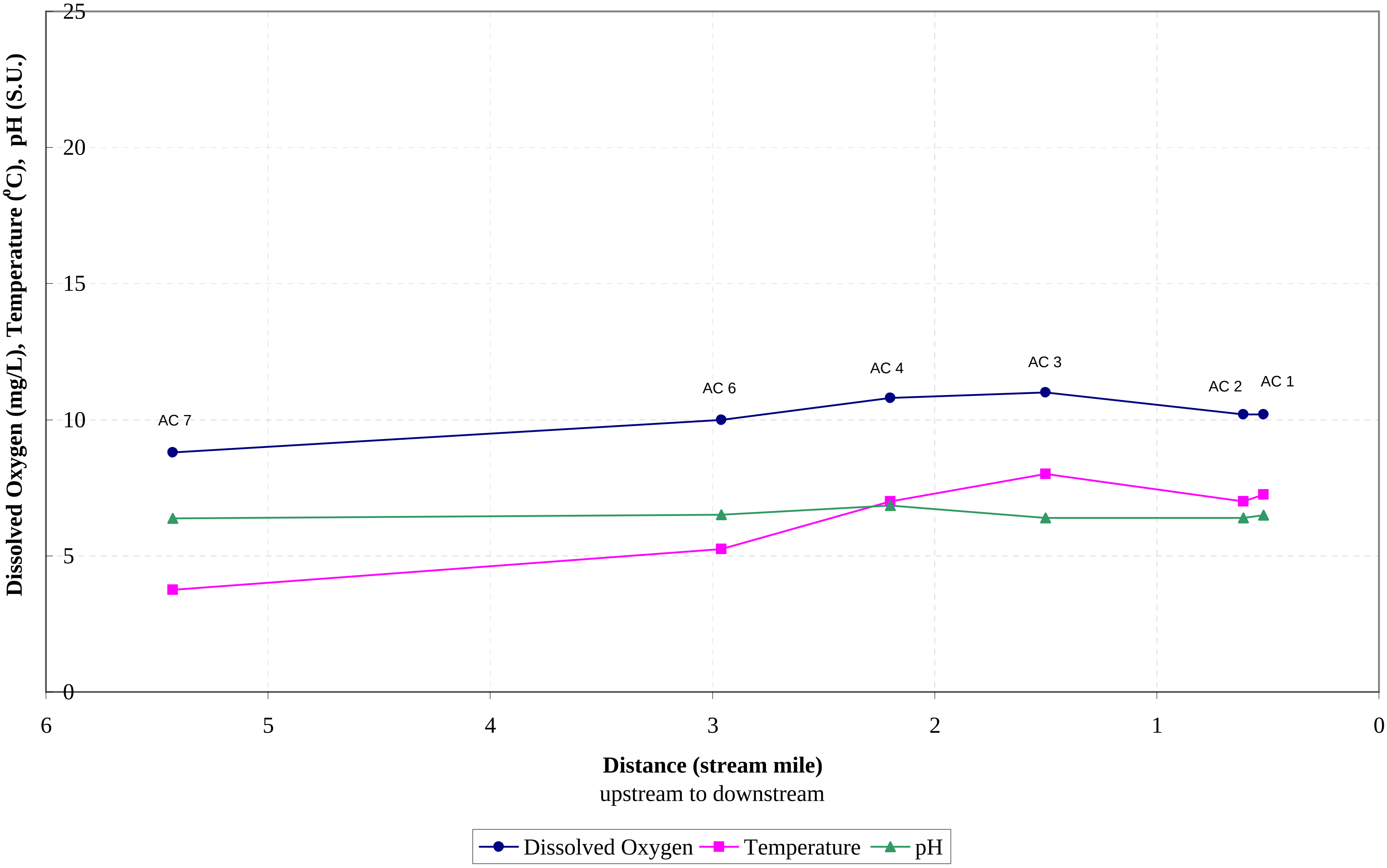
Wet weather sampling event, September 20, 2002



Arcadia Creek

Dissolved Oxygen, Temperature and pH

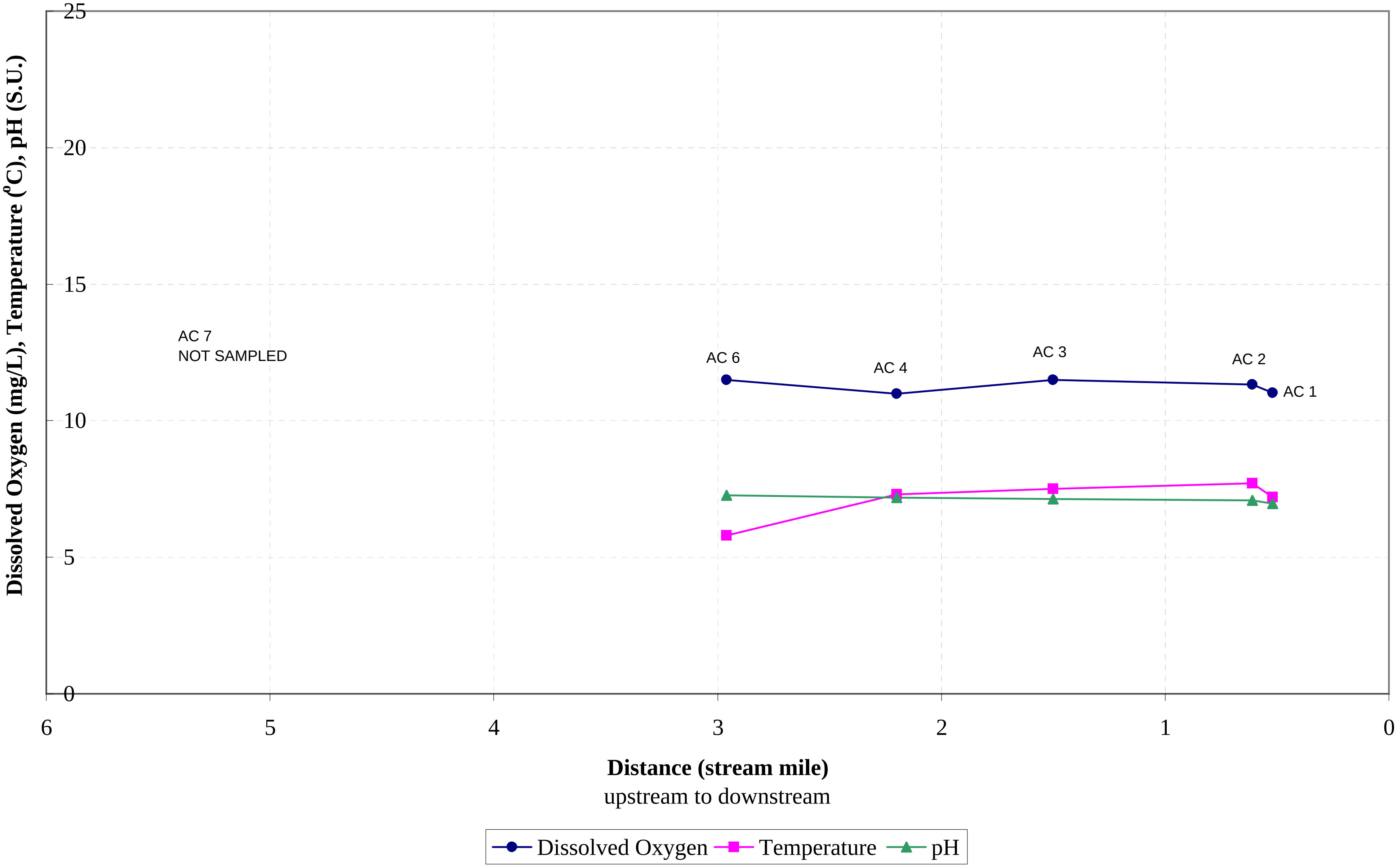
Dry weather sampling event, December 10, 2001



Arcadia Creek

Dissolved Oxygen, Temperature and pH

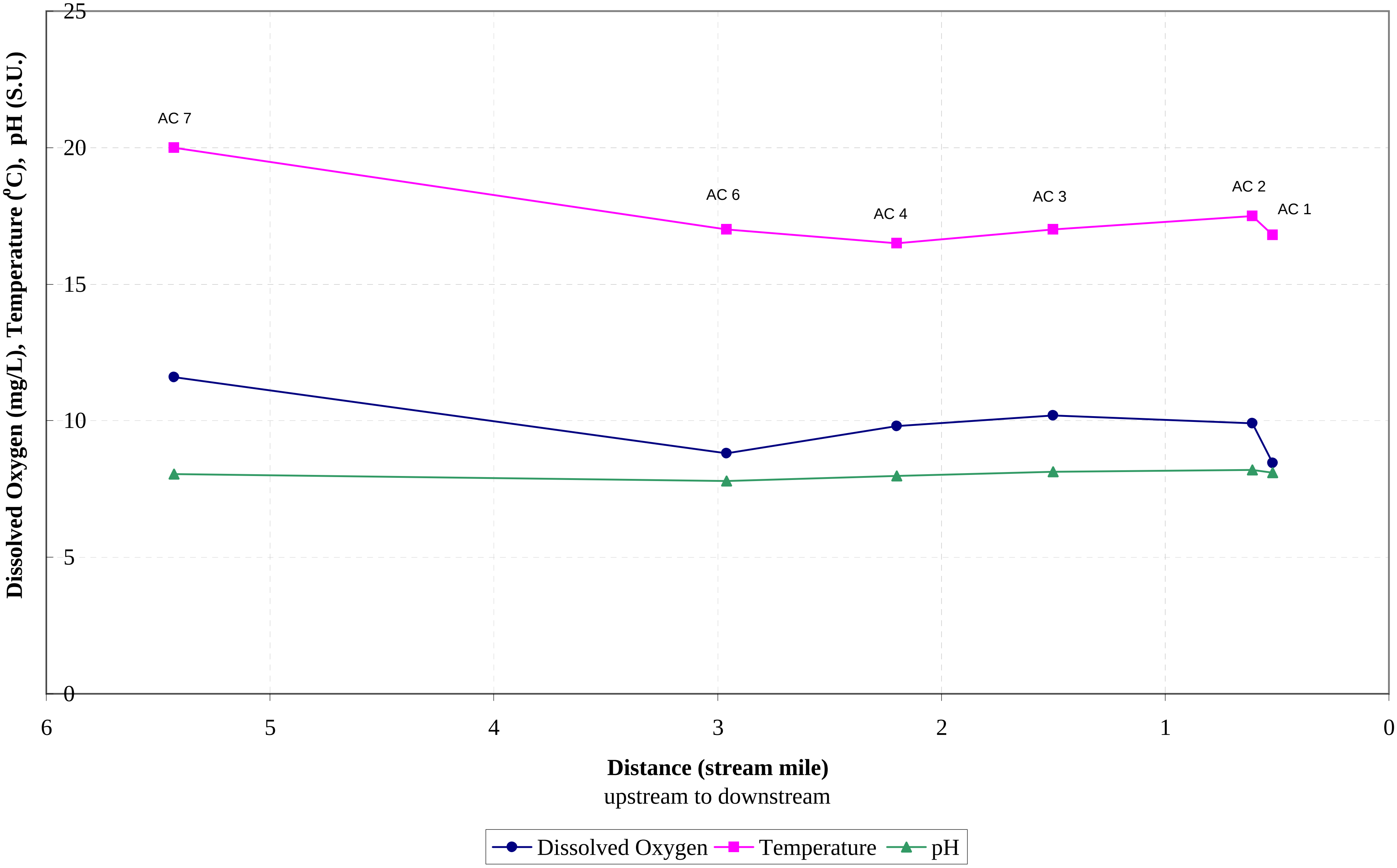
Dry weather sampling event, February 25, 2002

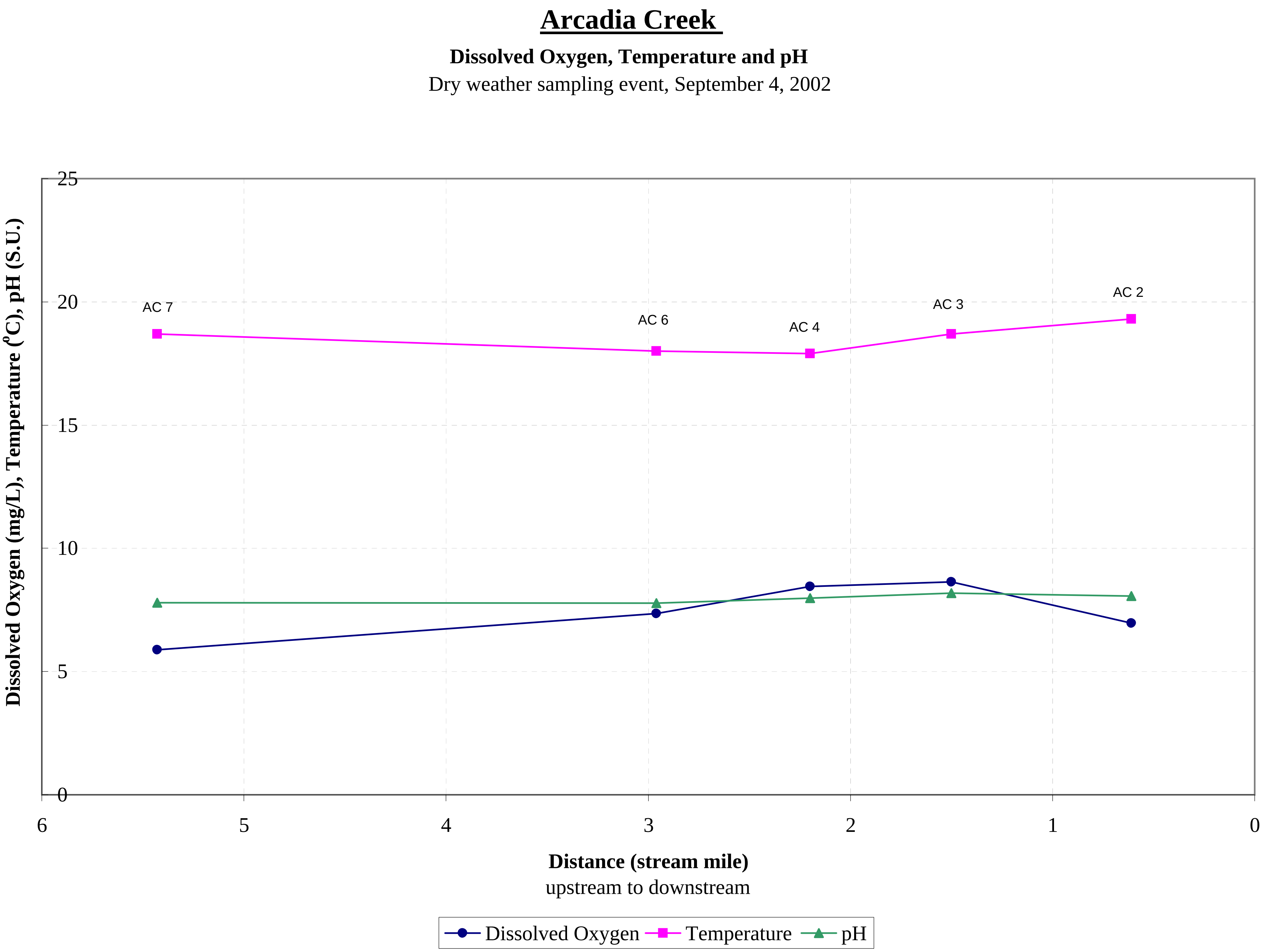


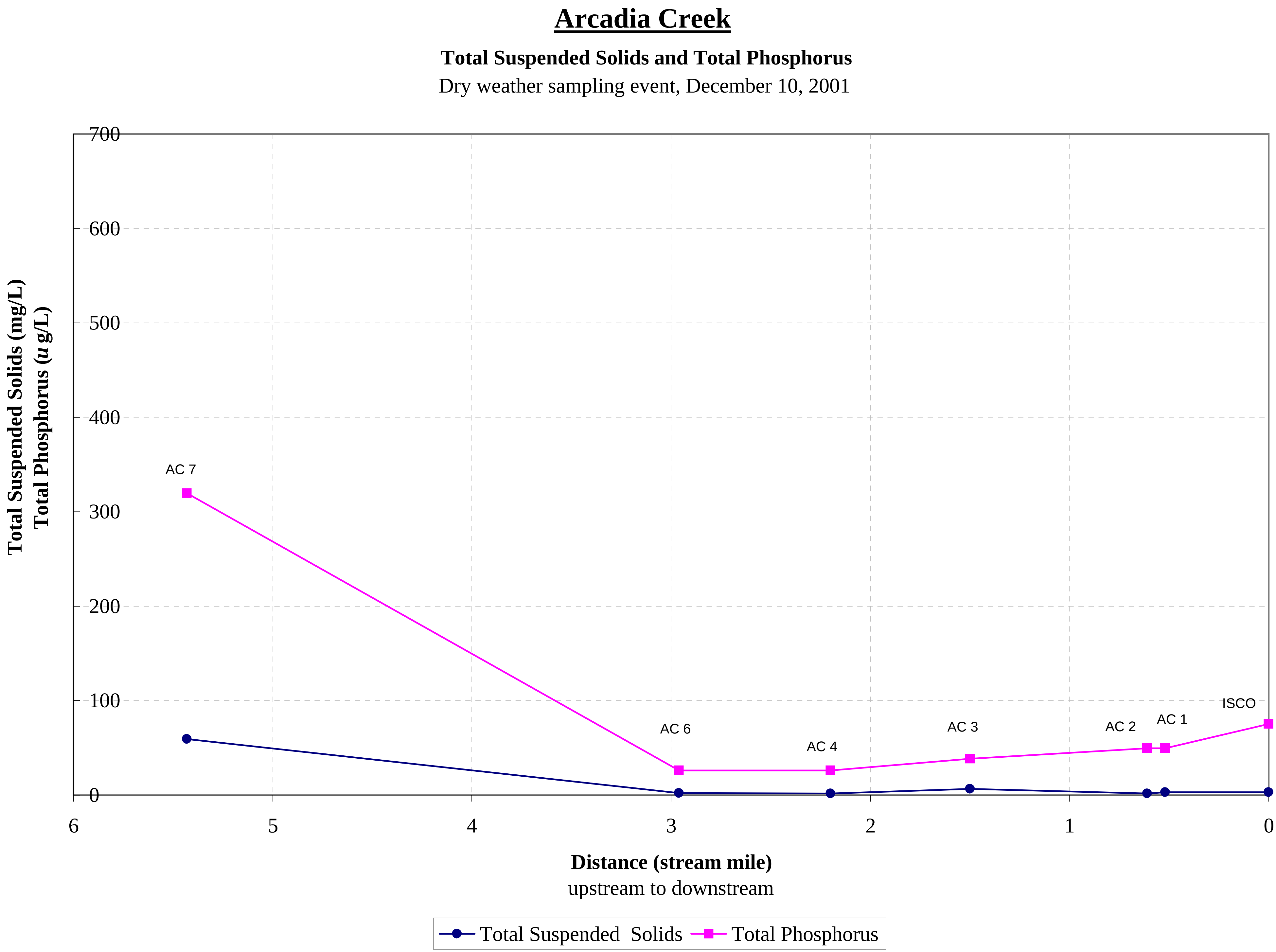
Arcadia Creek

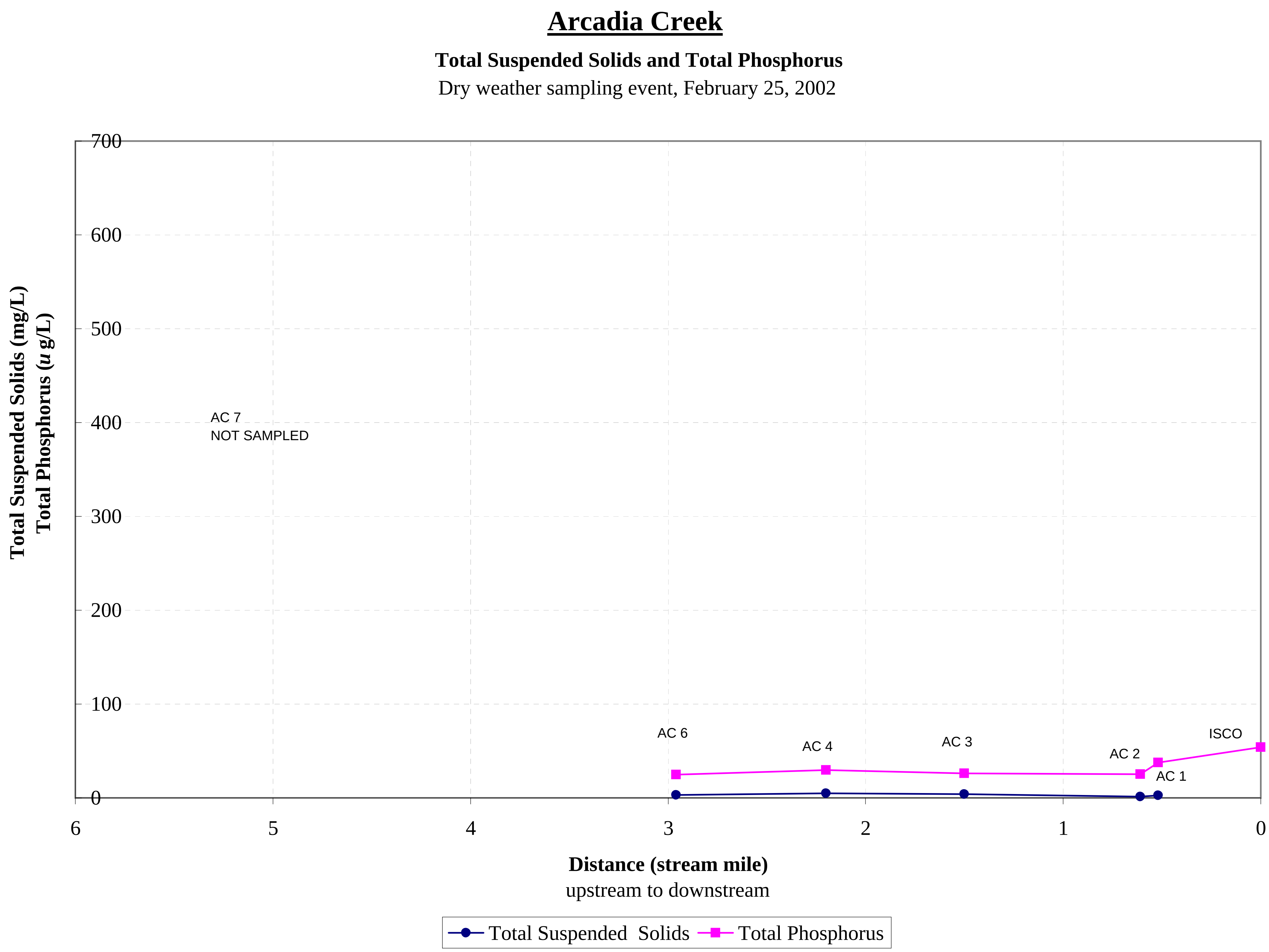
Dissolved Oxygen, Temperature and pH

Dry weather sampling event, June 17, 2002

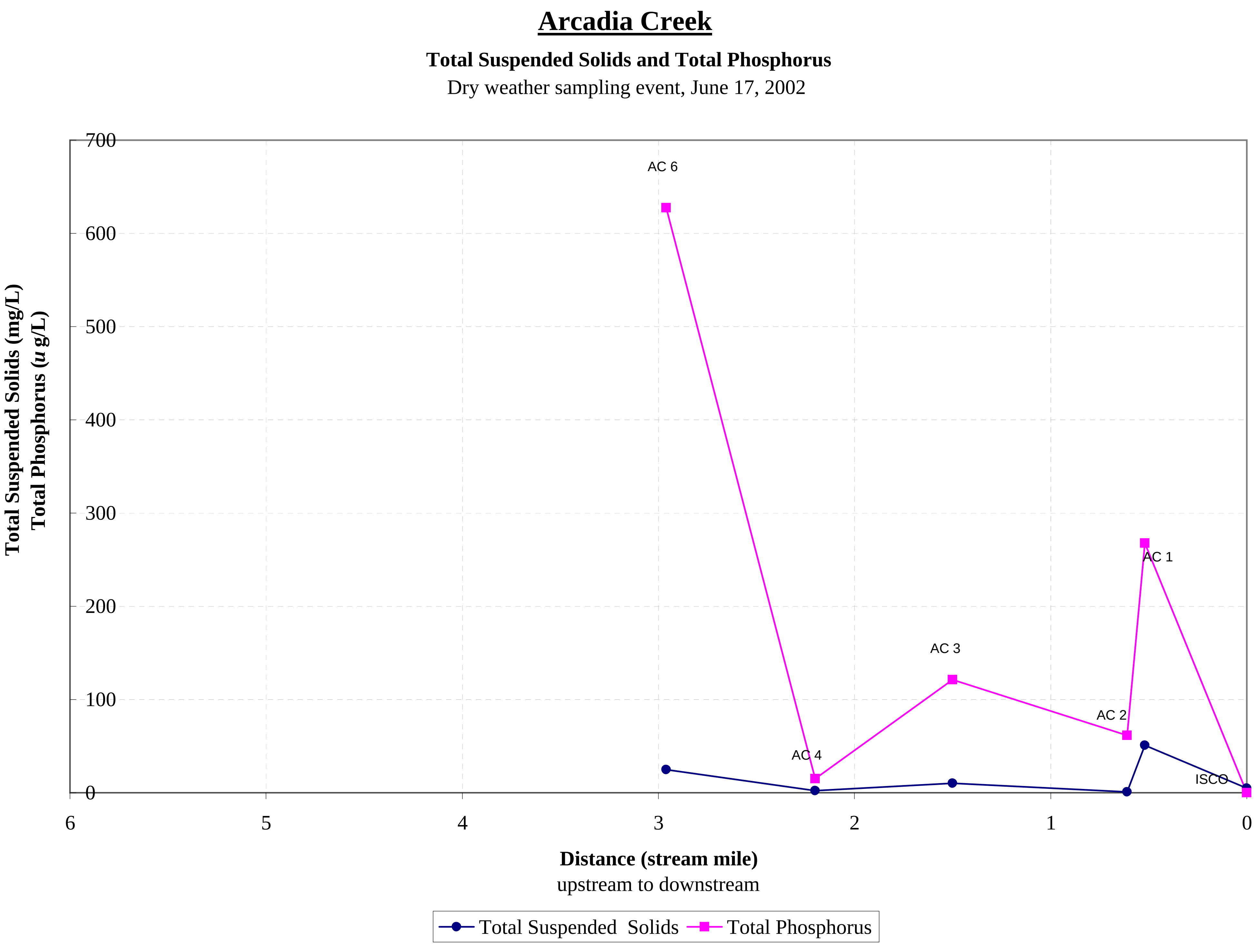



Arcadia Creek
Dissolved Oxygen, Temperature and pH
Dry weather sampling event, September 4, 2002
Dissolved Oxygen (mg/L), Temperature (°C), pH (S.U.)
25
20
15
10
5
0
AC 7
AC 6
AC 4
AC 3
AC 2
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Dissolved Oxygen
Temperature
pH


Arcadia Creek
Total Suspended Solids and Total Phosphorus
Dry weather sampling event, December 10, 2001
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
700
600
500
400
300
200
100
0
6
5
4
3
2
1
0
AC 7
AC 6
AC 4
AC 3
AC 2
AC 1
ISCO
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus



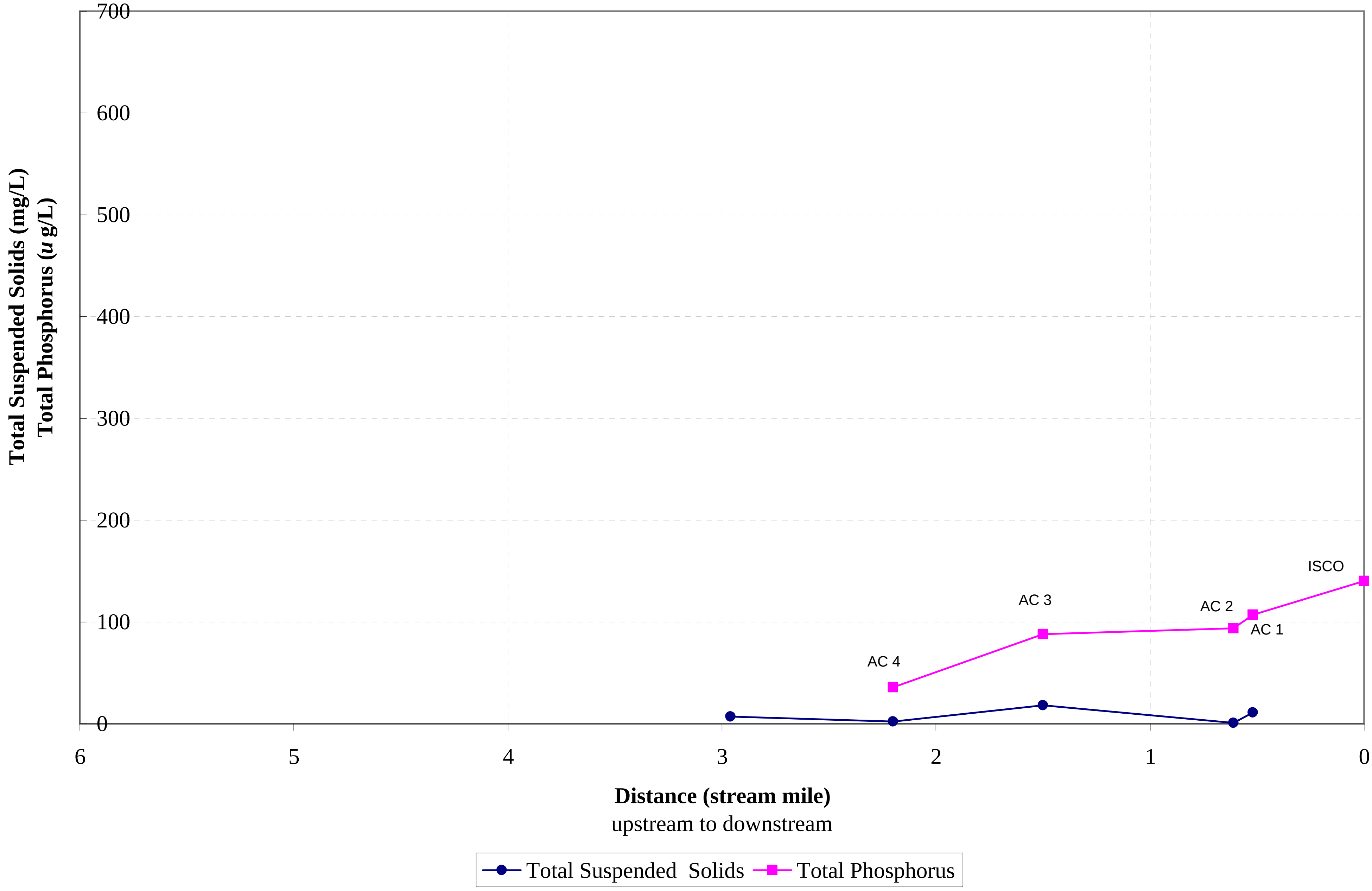
Arcadia Creek
Total Suspended Solids and Total Phosphorus
Dry weather sampling event, February 25, 2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
700
600
500
400
300
200
100
0
AC 7
NOT SAMPLED
AC 6
AC 4
AC 3
AC 2
AC 1
ISCO
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

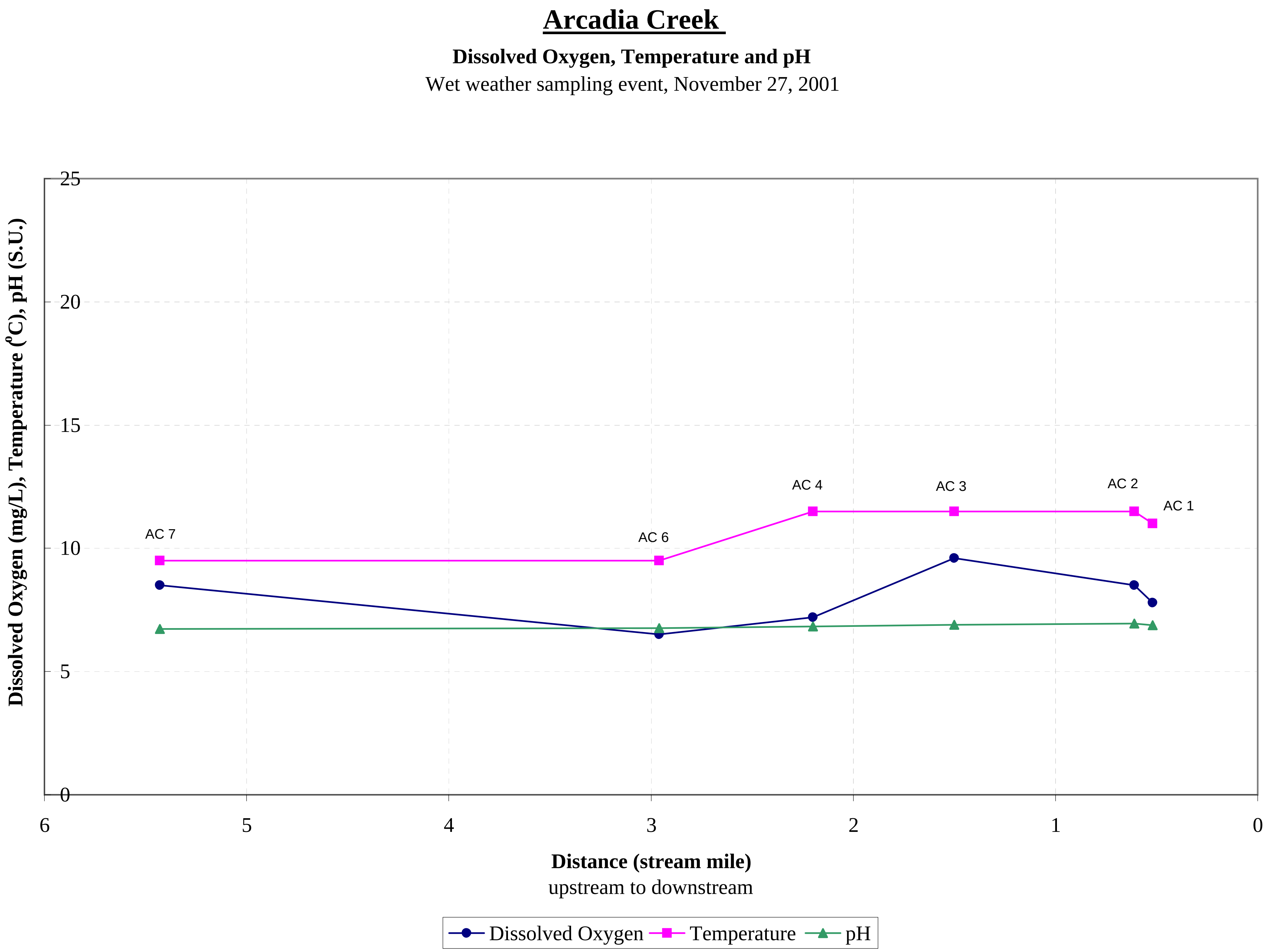

Arcadia Creek
Total Suspended Solids and Total Phosphorus
Dry weather sampling event, June 17, 2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
700
600
500
400
300
200
100
0
AC 6
AC 4
AC 3
AC 2
AC 1
ISCO
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

Arcadia Creek

Total Suspended Solids and Total Phosphorus

Dry weather sampling event, September 4, 2002



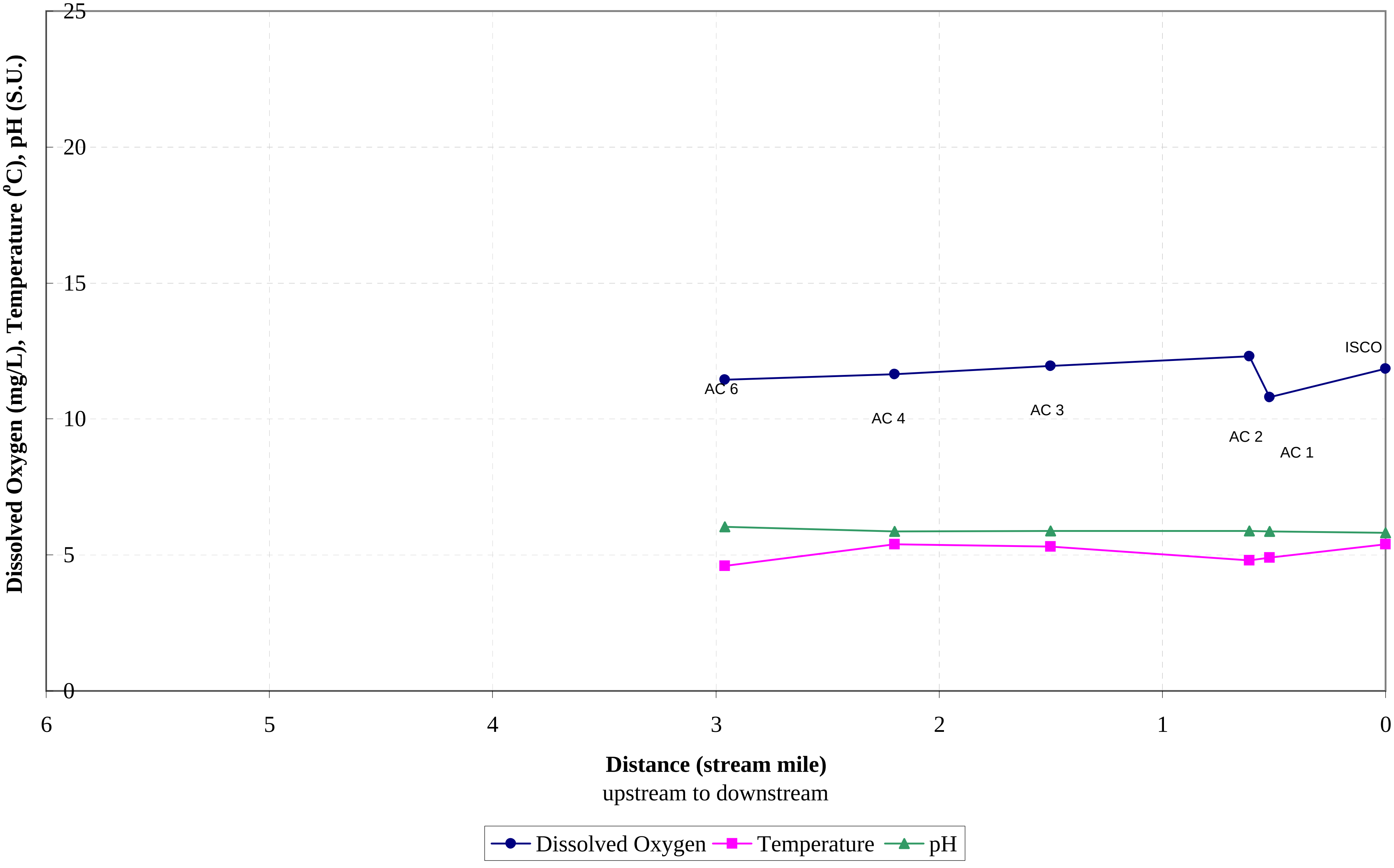


Arcadia Creek
Dissolved Oxygen, Temperature and pH
Wet weather sampling event, November 27, 2001
Dissolved Oxygen (mg/L), Temperature (oC), pH (S.U.)
25
20
15
10
5
0
AC 7
AC 6
AC 4
AC 3
AC 2
AC 1
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Dissolved Oxygen
Temperature
pH

Arcadia Creek

Dissolved Oxygen, Temperature and pH

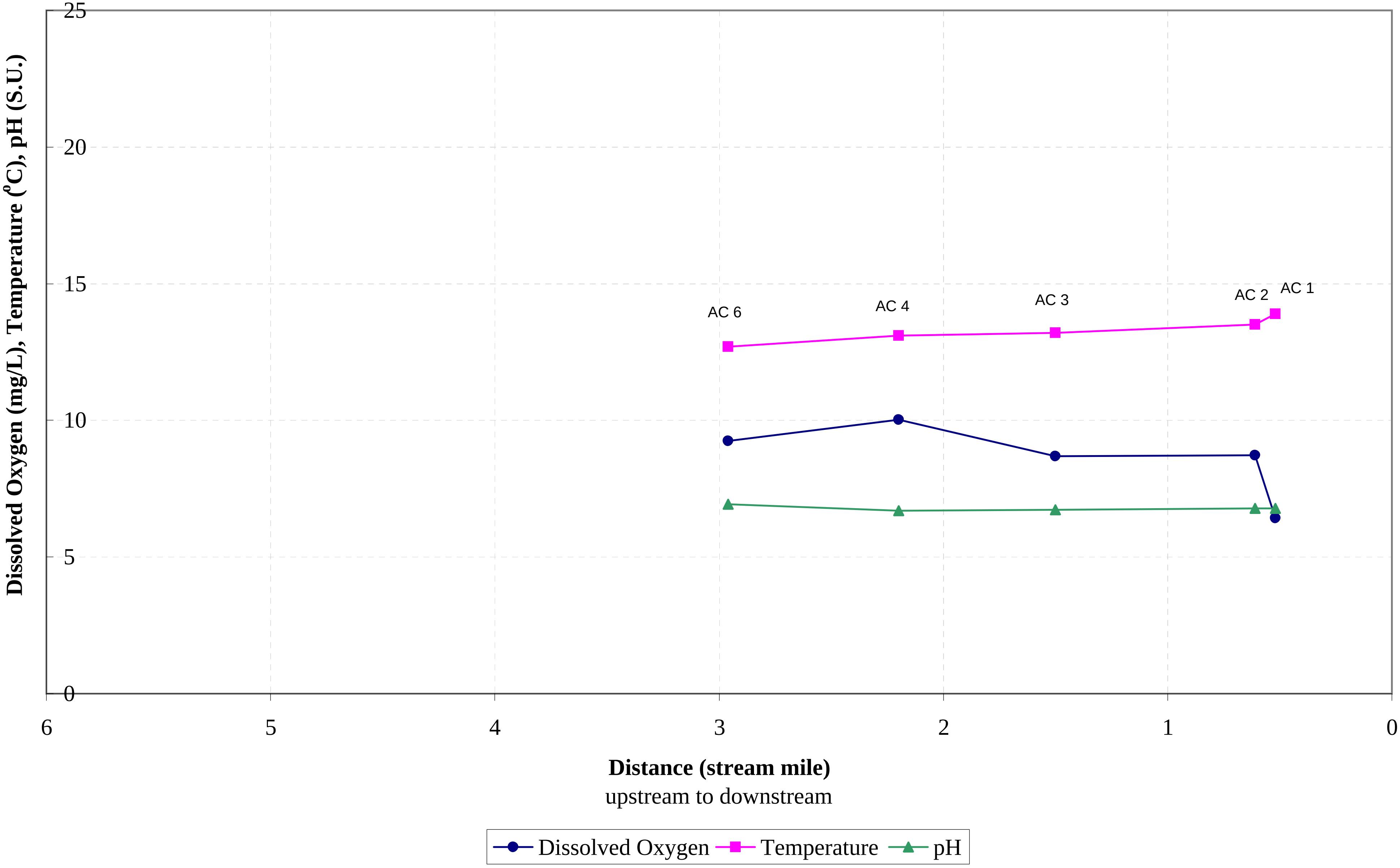
Wet weather sampling event, March 8, 2002



Arcadia Creek

Dissolved Oxygen, Temperature and pH

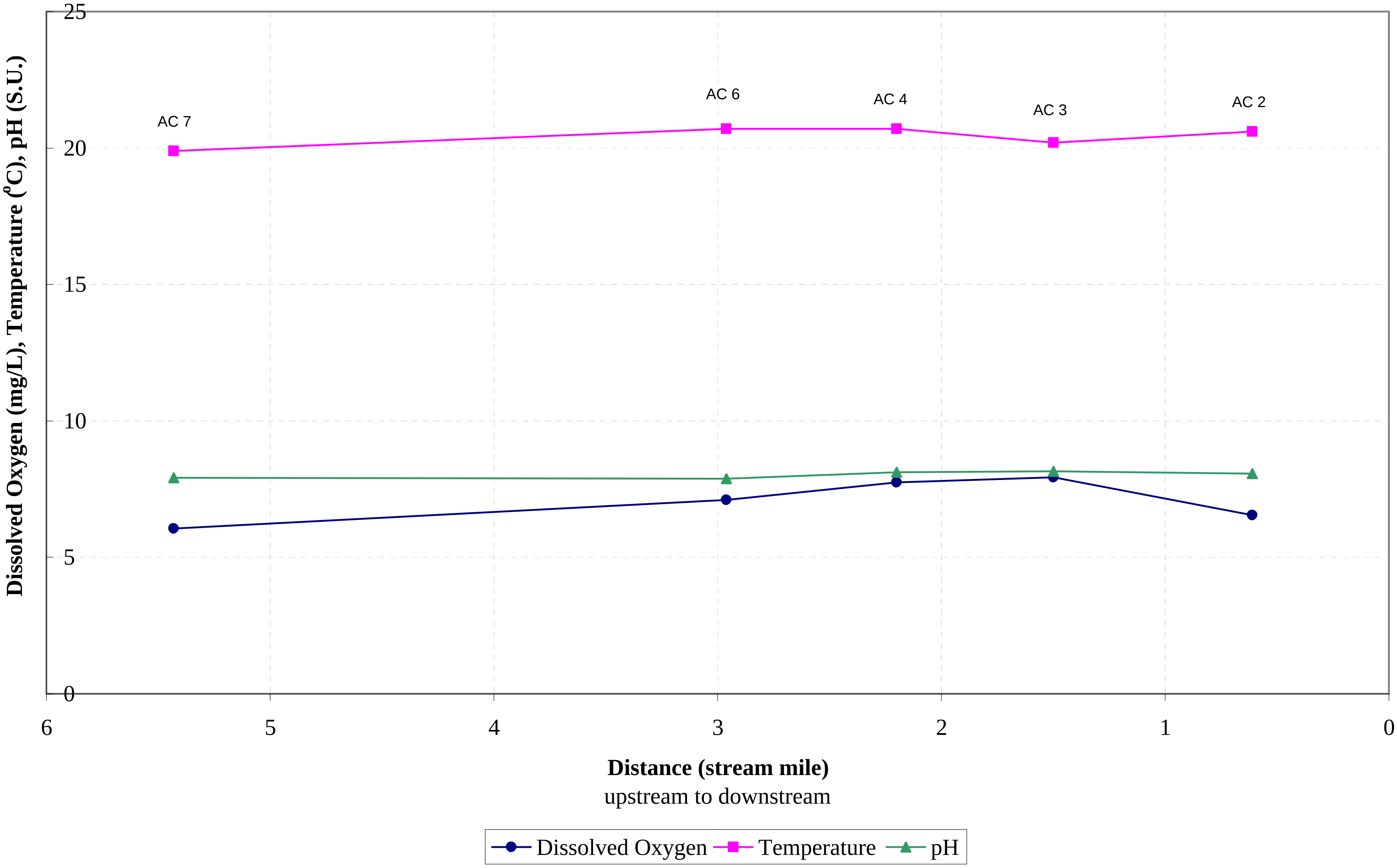
Wet weather sampling event, May 8, 2002



Arcadia Creek

Dissolved Oxygen, Temperature and pH

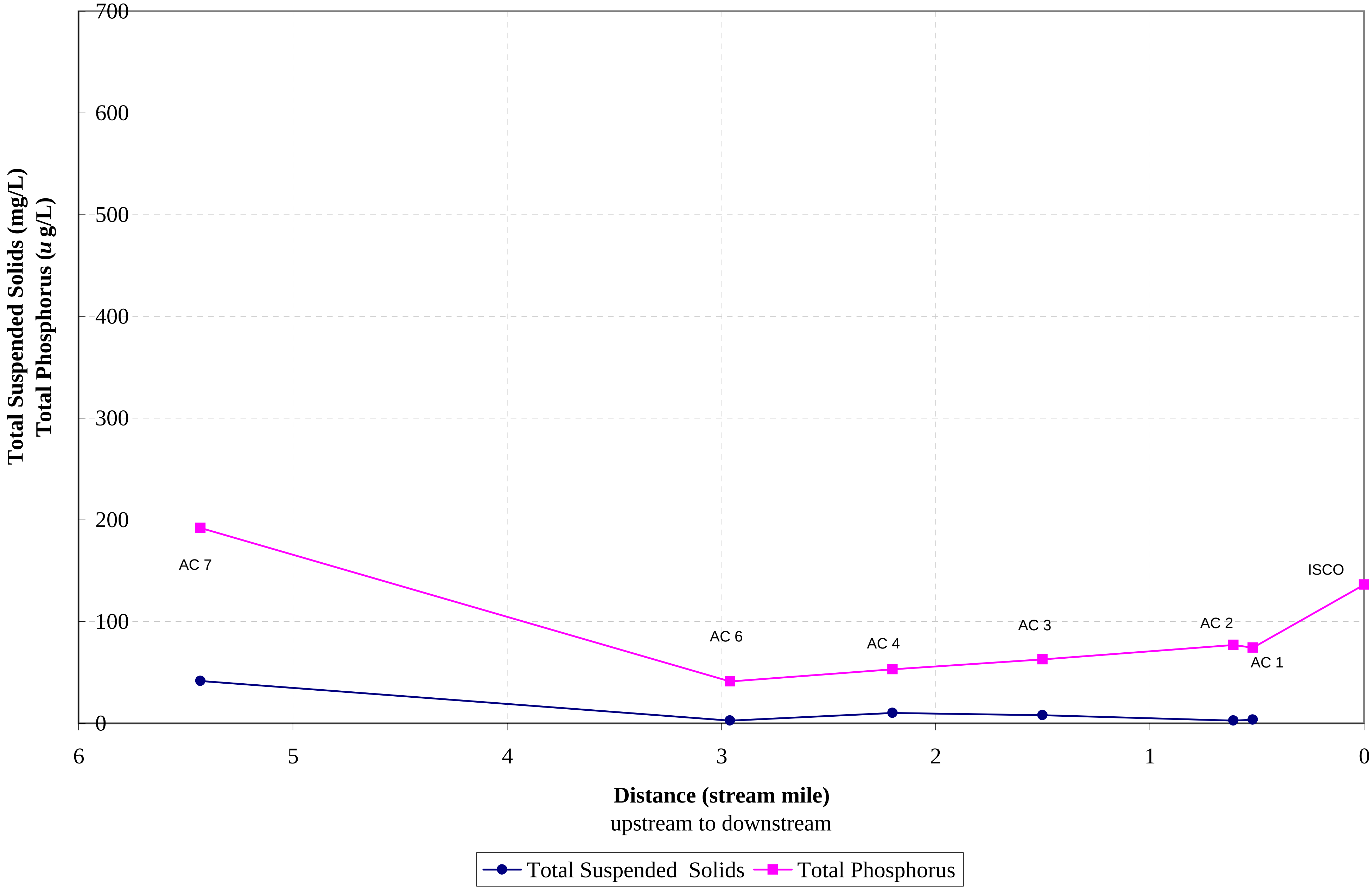
Wet weather sampling event, September 20, 2002



Arcadia Creek

Total Suspended Solids and Total Phosphorus

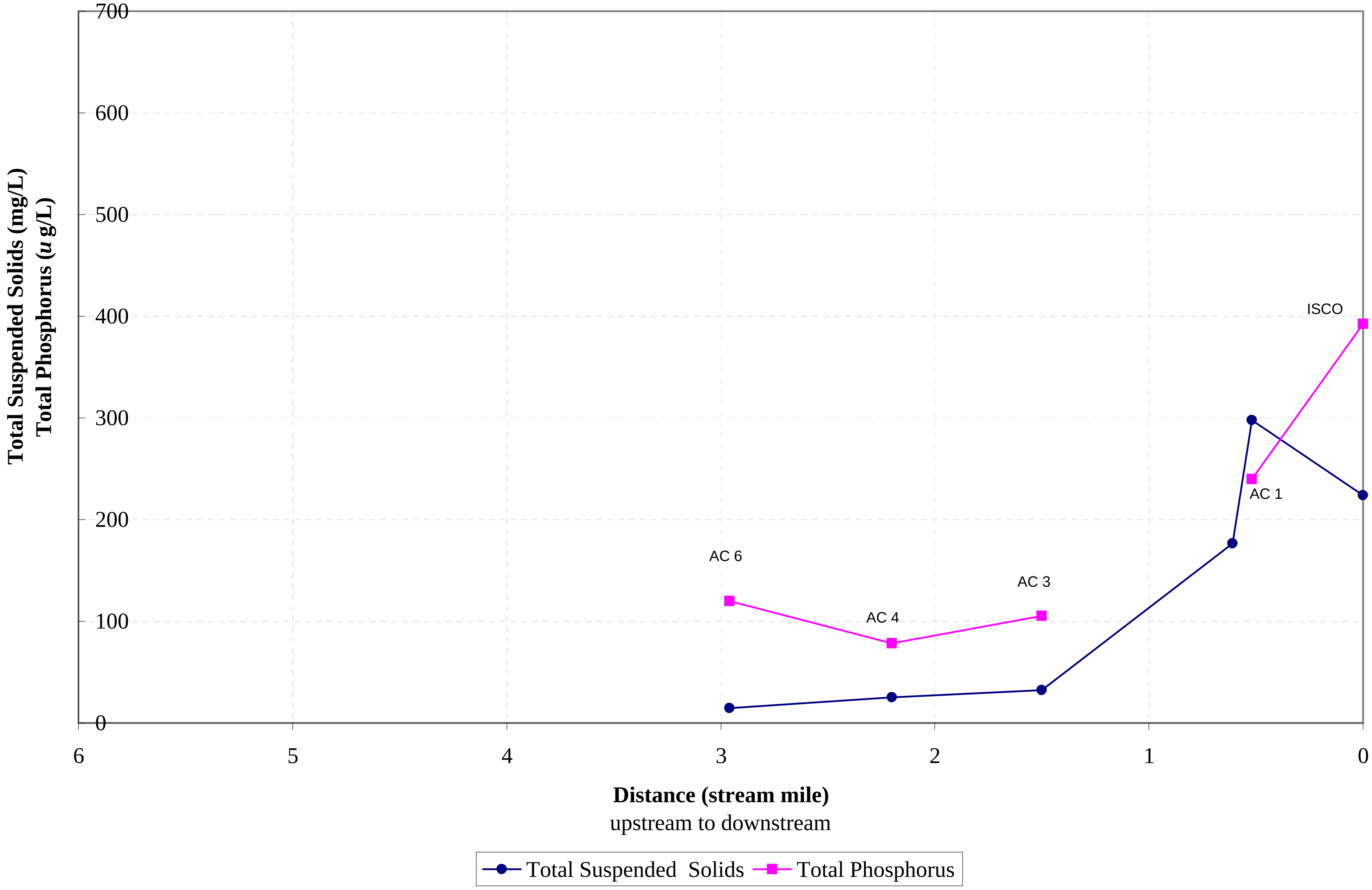
Wet weather sampling event, November 27, 2001



Arcadia Creek

Total Suspended Solids and Total Phosphorus

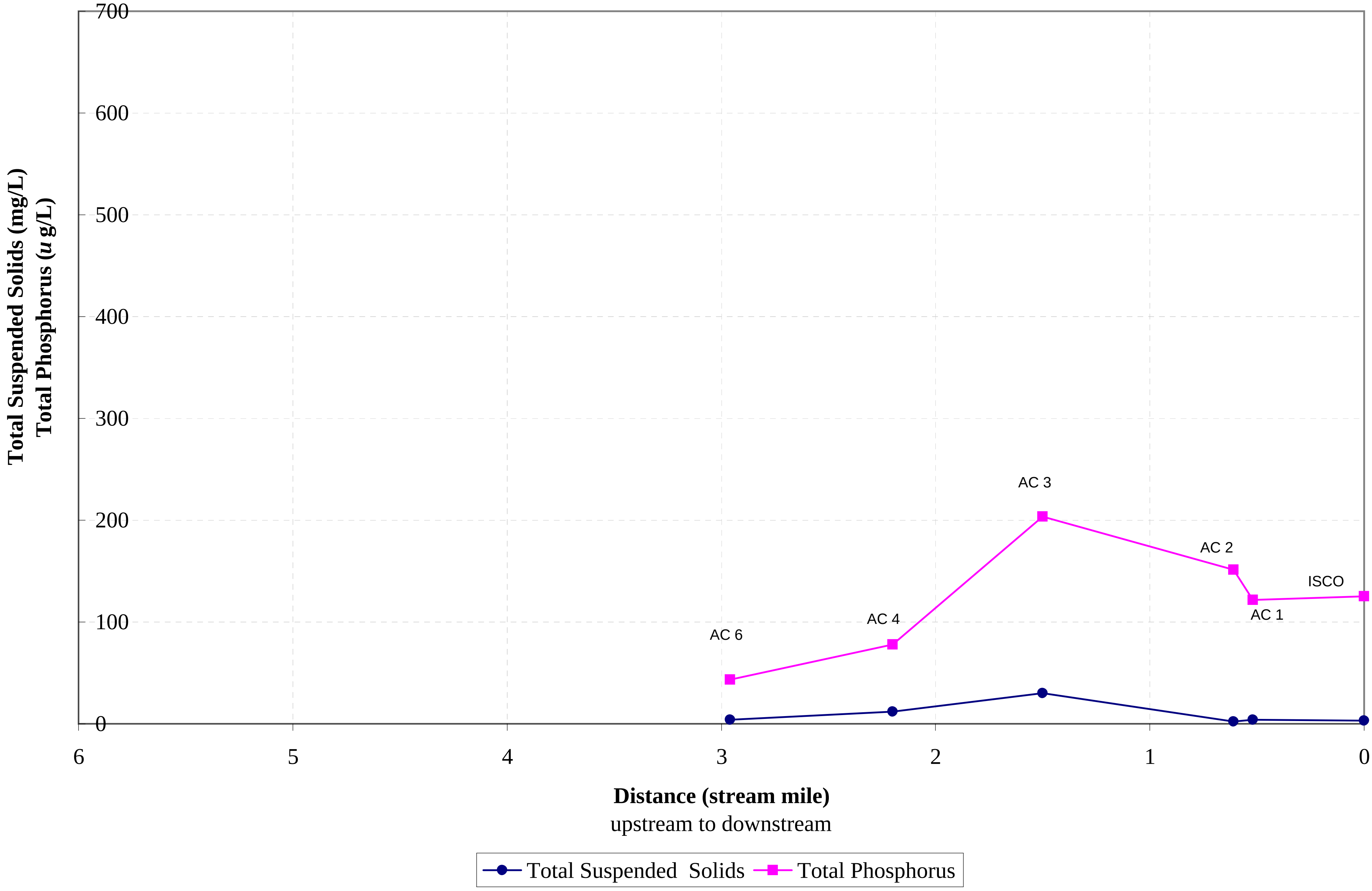
Wet weather sampling event, March 8, 2002

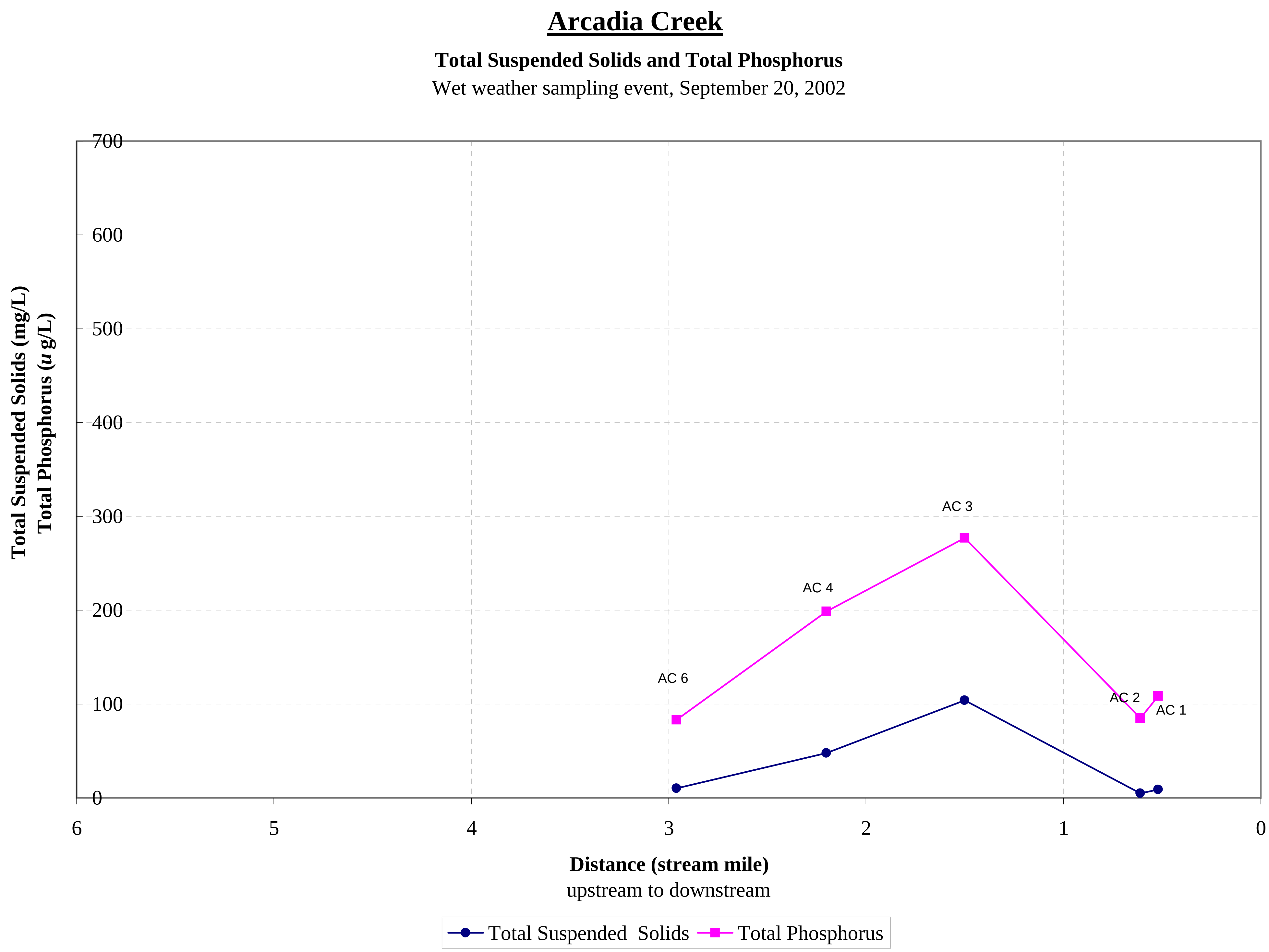


Arcadia Creek

Total Suspended Solids and Total Phosphorus

Wet weather sampling event, May 8, 2002



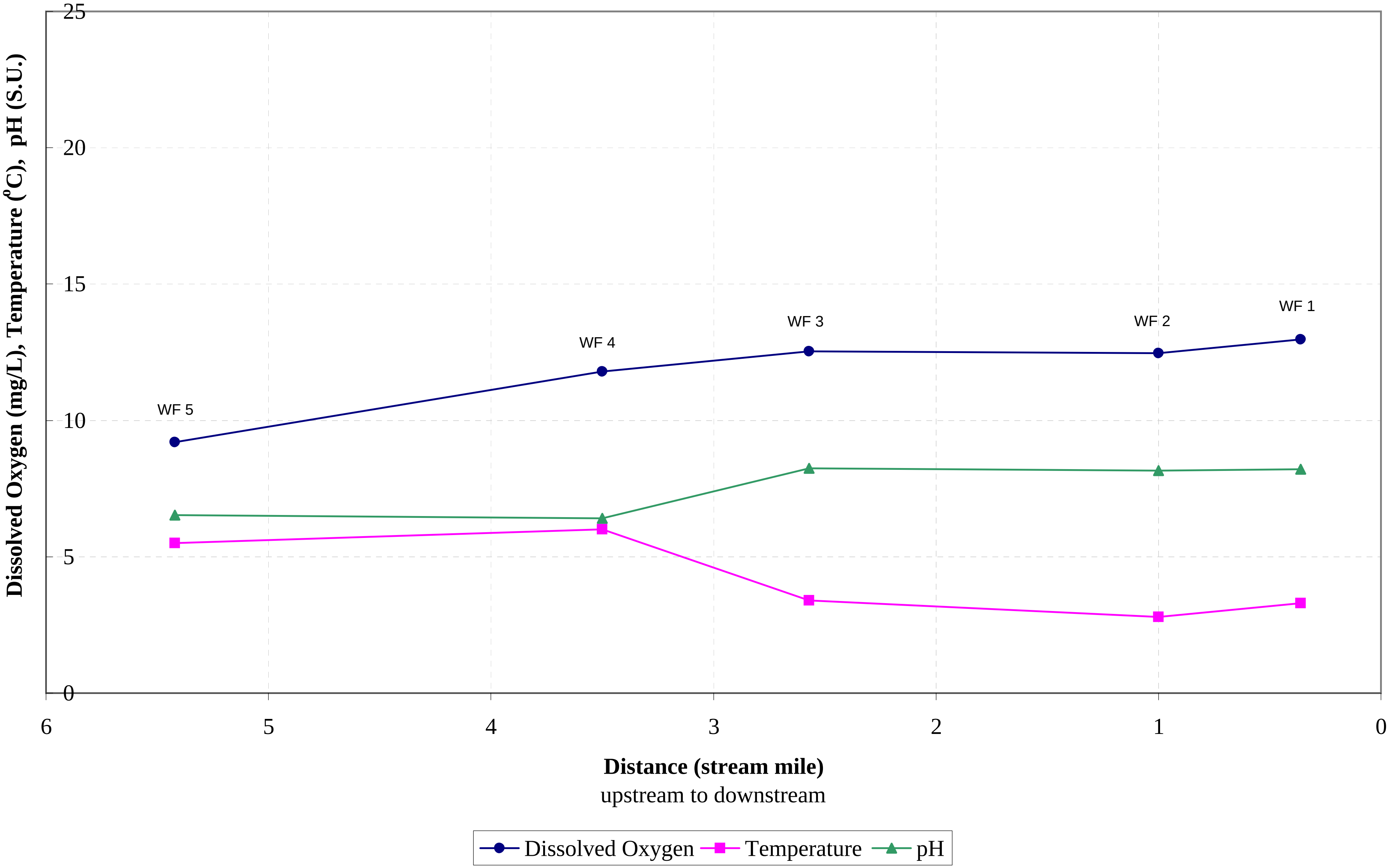


Arcadia Creek
Total Suspended Solids and Total Phosphorus
Wet weather sampling event, September 20, 2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
700
600
500
400
300
200
100
0
AC 3
AC 4
AC 6
AC 2
AC 1
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

West Fork Portage Creek

Dissolved Oxygen, Temperature and pH

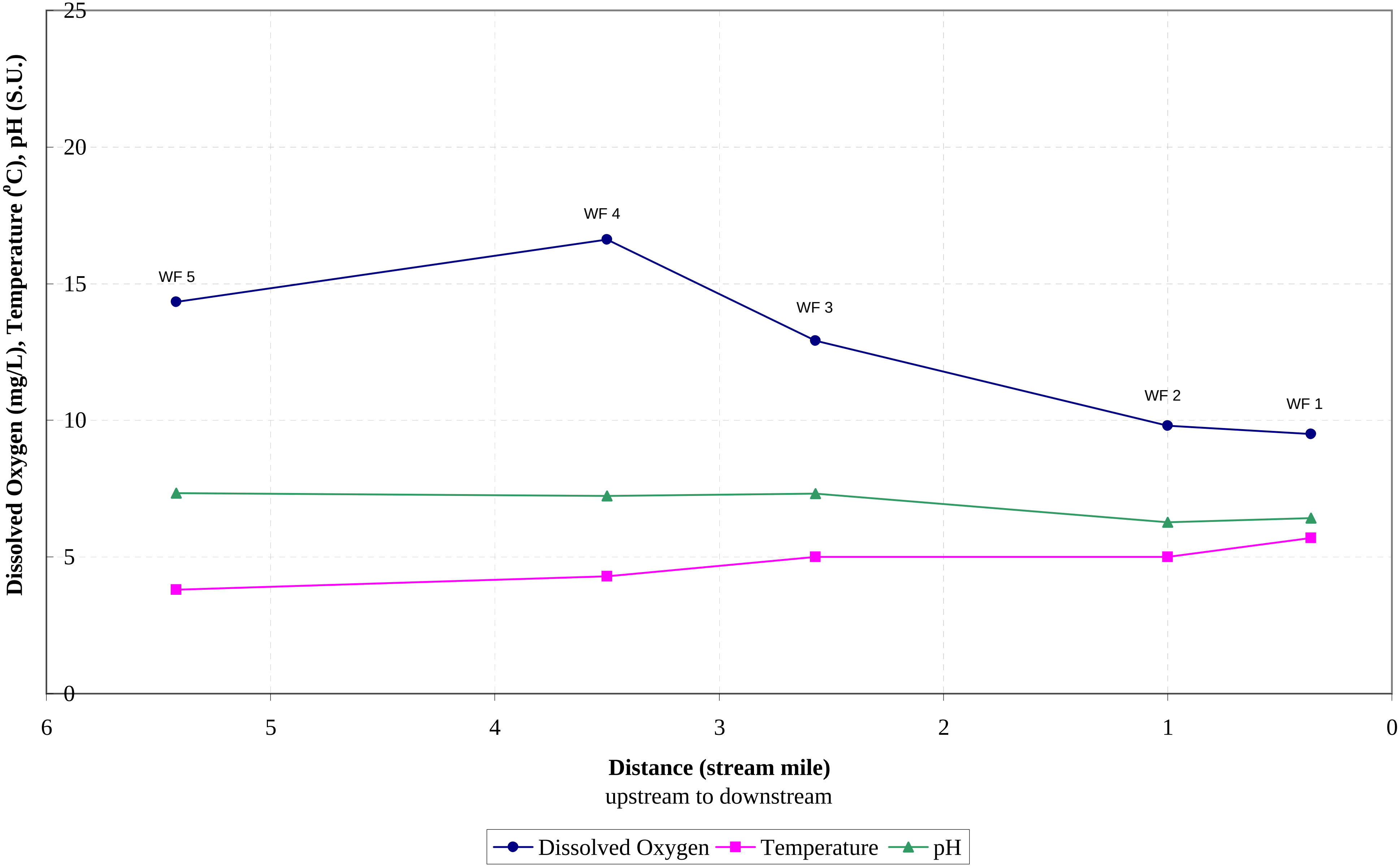
Dry weather sampling event, December 10, 2001



West Fork Portage Creek

Dissolved Oxygen, Temperature and pH

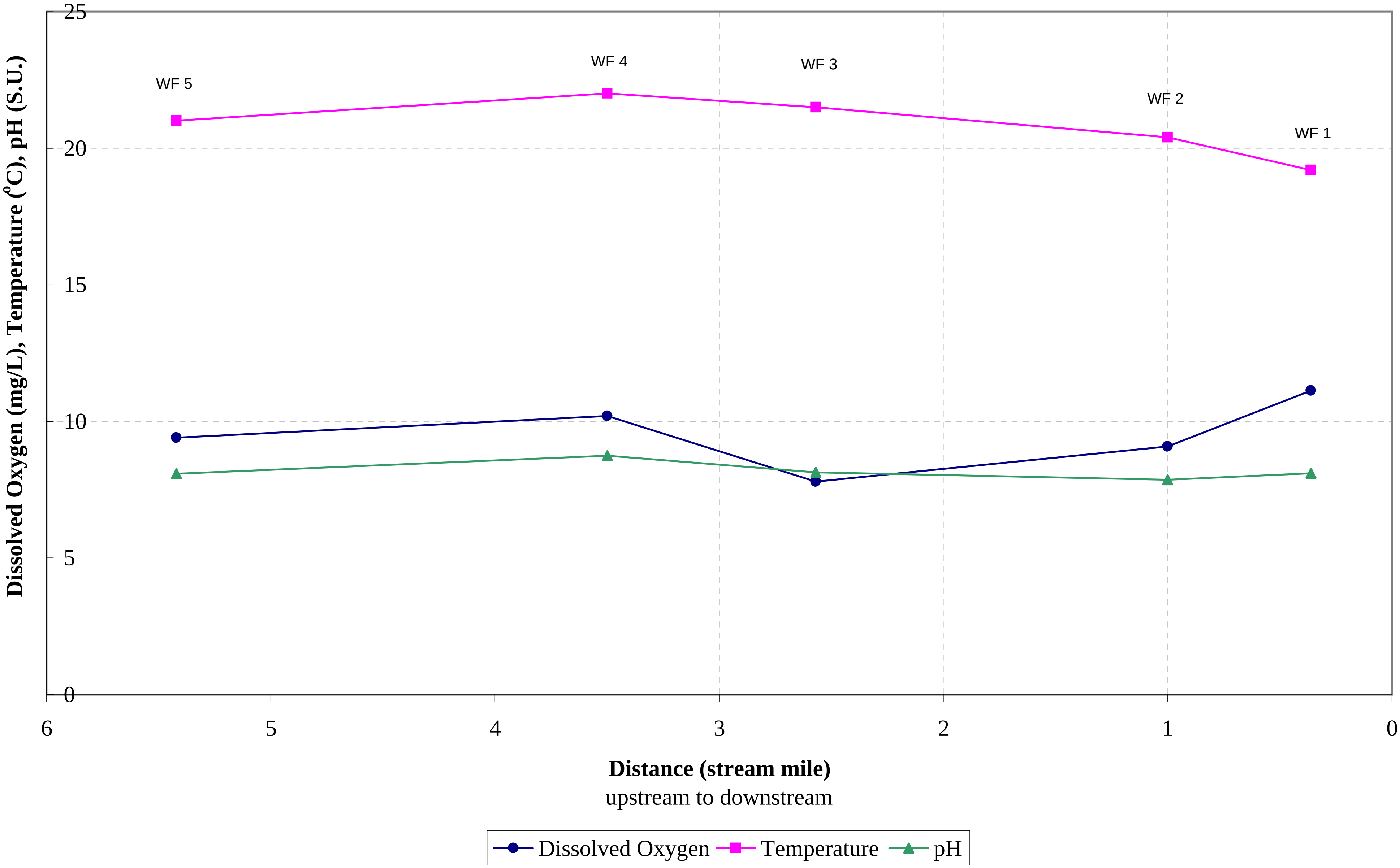
Dry weather sampling event, February 25, 2002



West Fork Portage Creek

Dissolved Oxygen, Temperature and pH

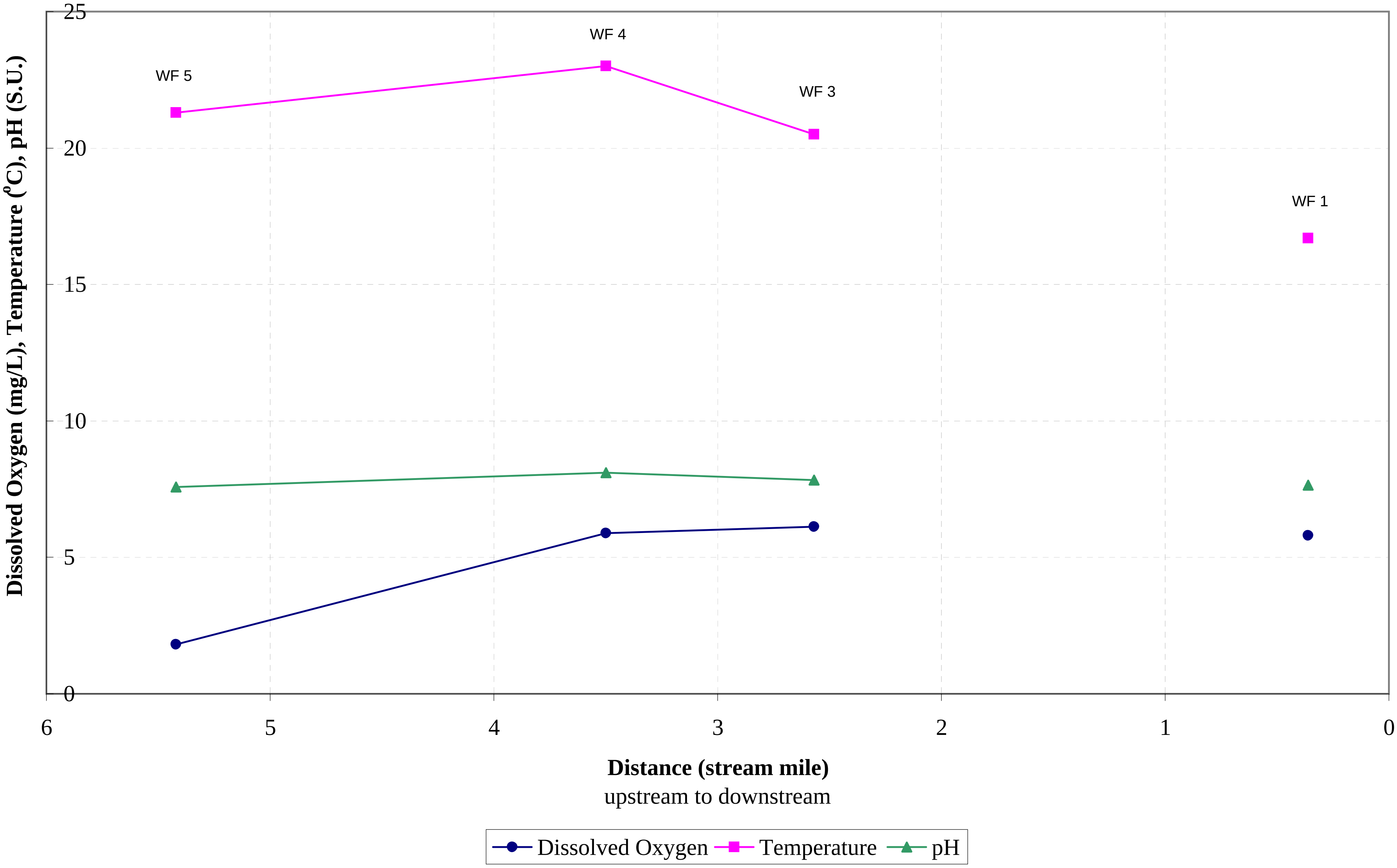
Dry weather sampling event, June 17, 2002

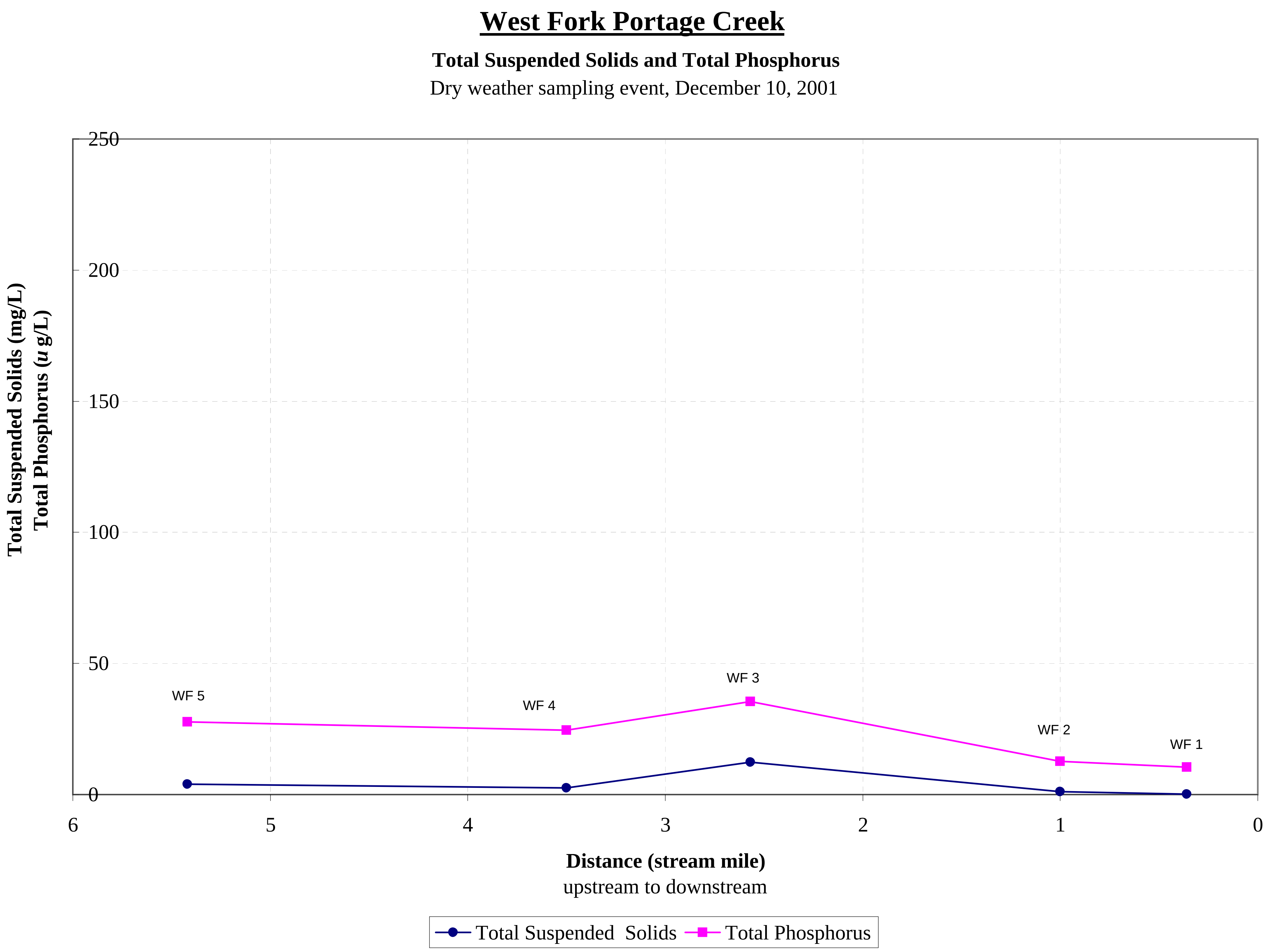


West Fork Portage Creek

Dissolved Oxygen, Temperature and pH

Dry weather sampling event September 4, 2002

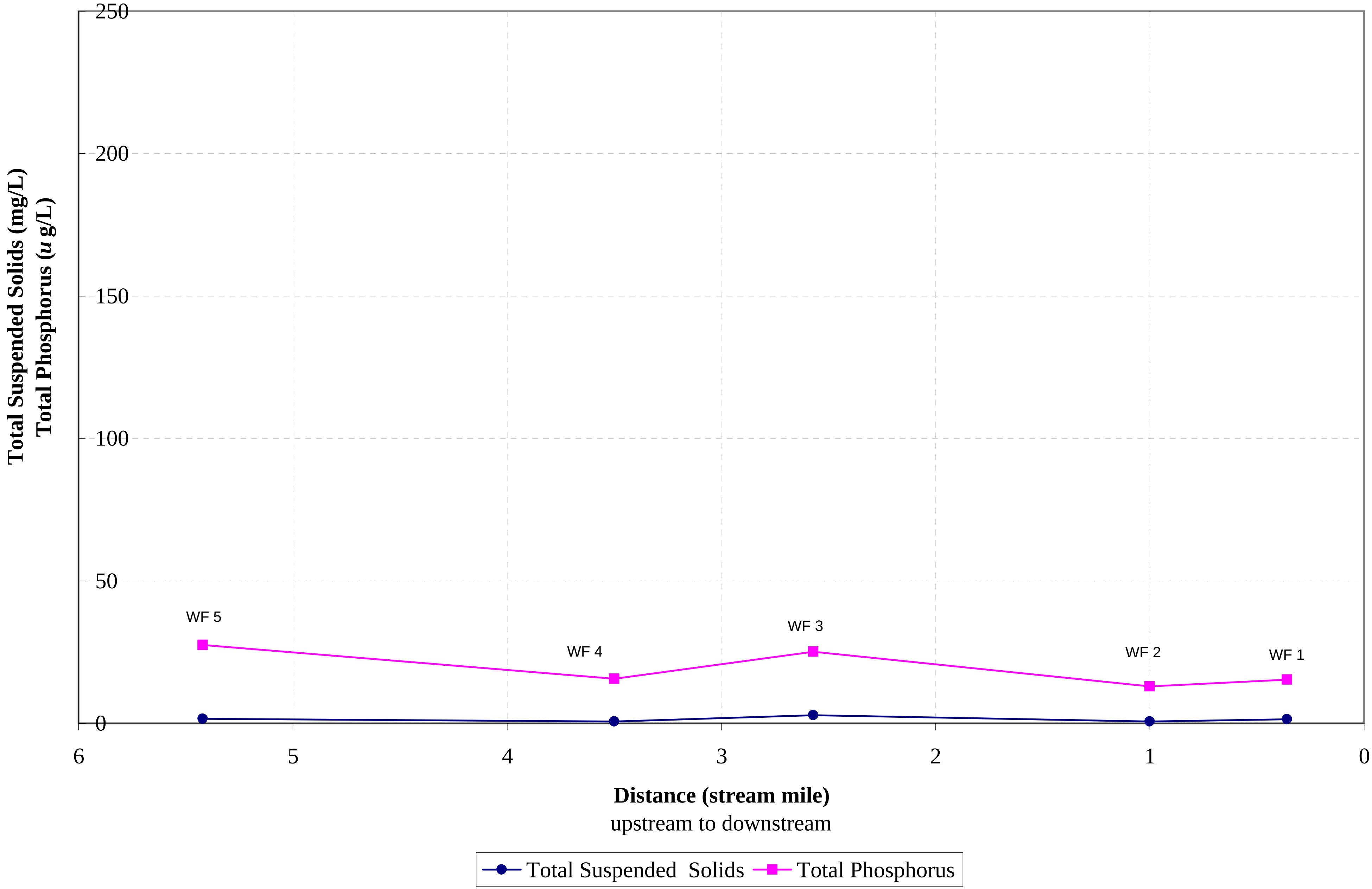


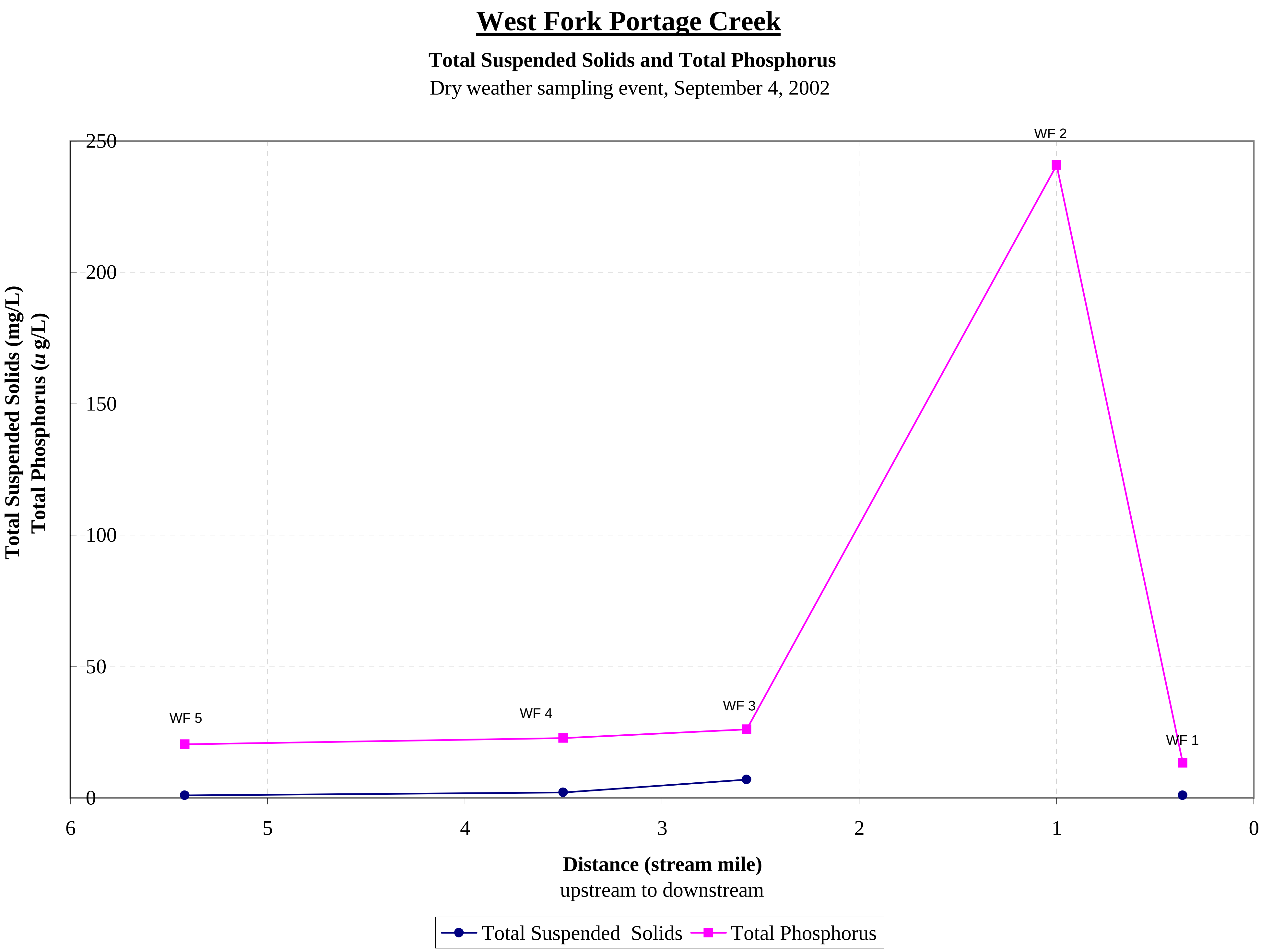

West Fork Portage Creek
Total Suspended Solids and Total Phosphorus
Dry weather sampling event, December 10, 2001
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
250
200
150
100
50
0
WF 5
WF 4
WF 3
WF 2
WF 1
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

West Fork Portage Creek

Total Suspended Solids and Total Phosphorus

Dry weather sampling event, February 25, 2002

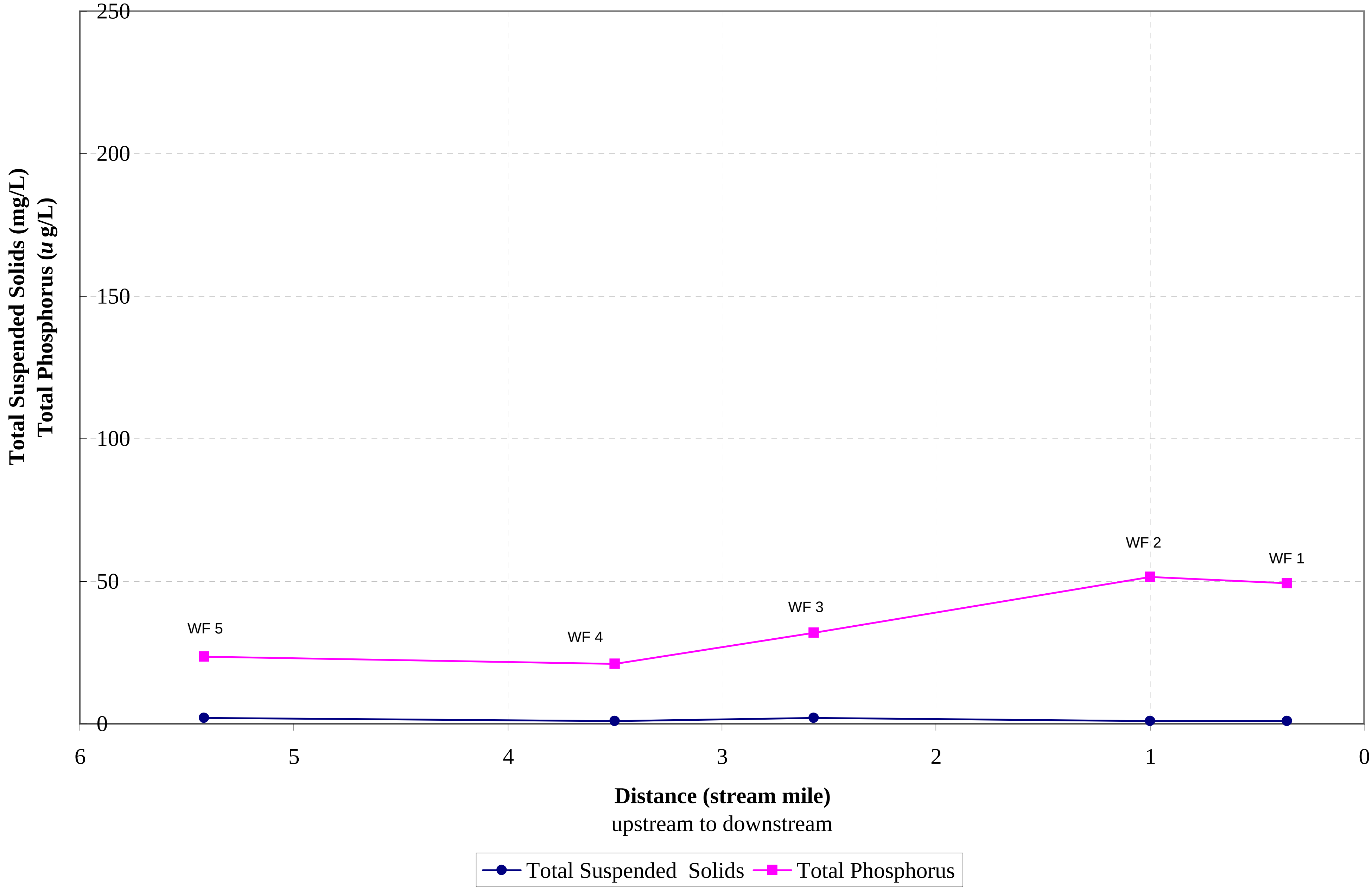


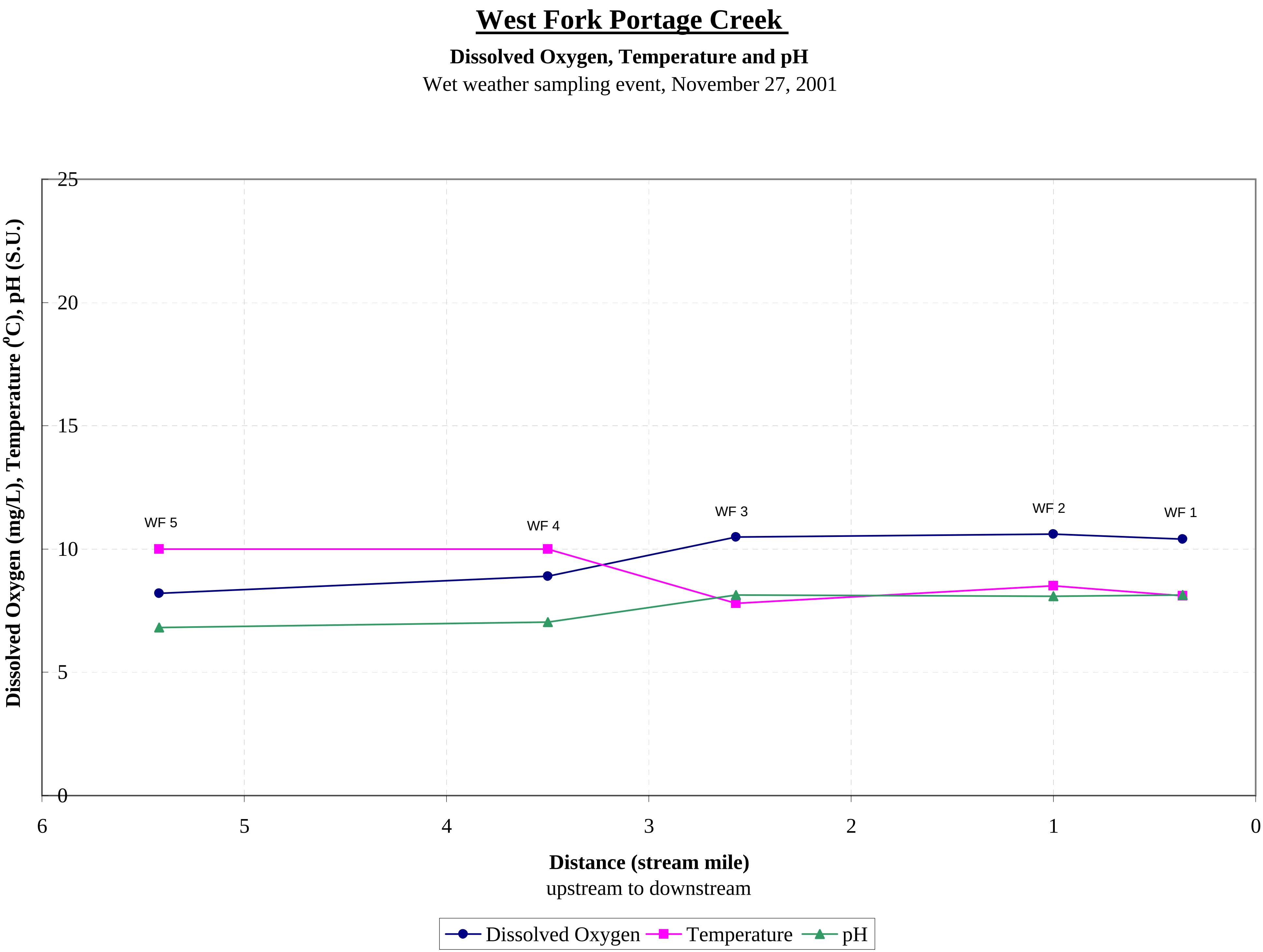

West Fork Portage Creek
Total Suspended Solids and Total Phosphorus
Dry weather sampling event, September 4, 2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
250
200
150
100
50
0
6
5
4
3
2
1
0
WF 5
WF 4
WF 3
WF 2
WF 1
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

West Fork Portage Creek

Total Suspended Solids and Total Phosphorus

Dry weather sampling event, June 17, 2002



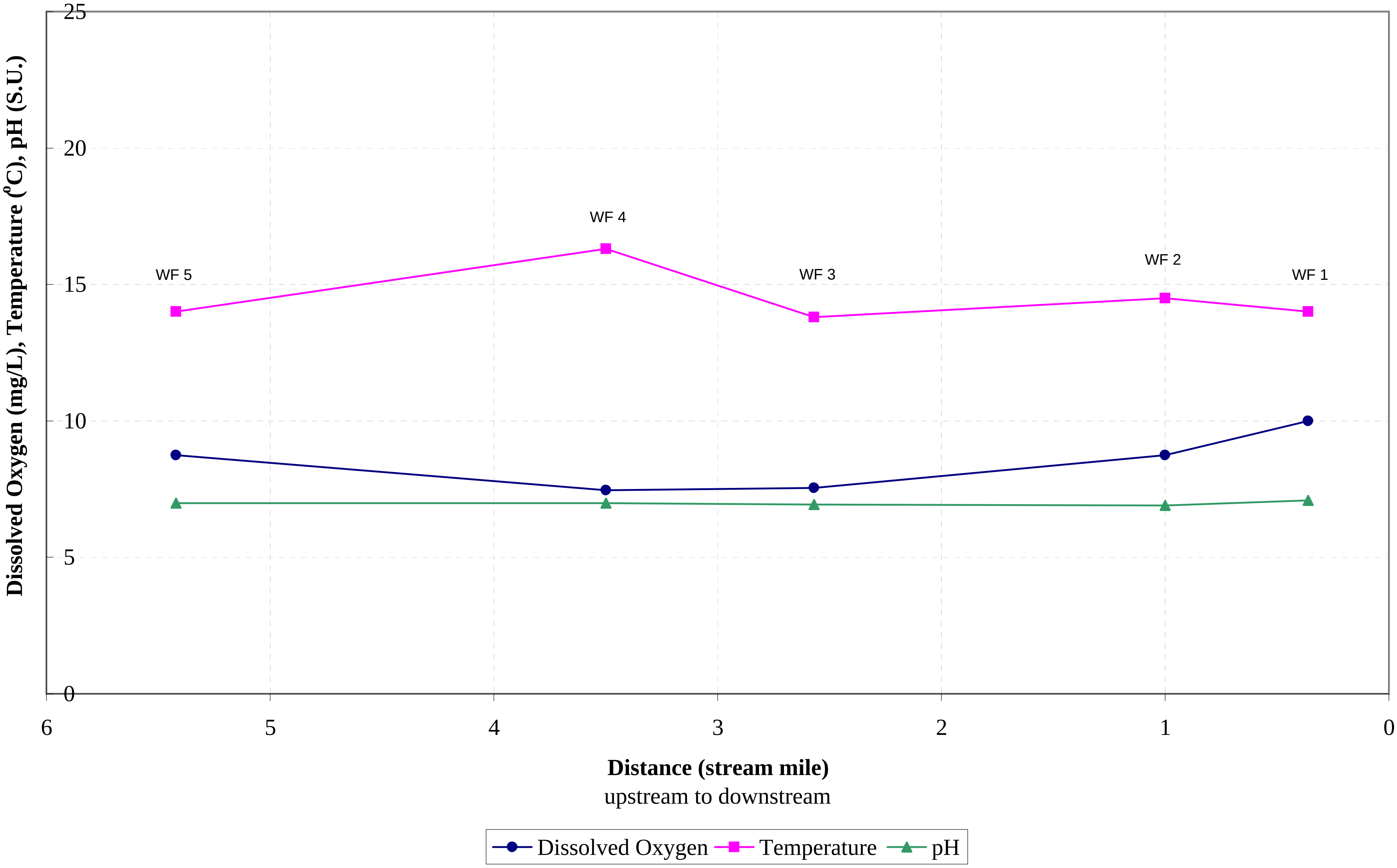


West Fork Portage Creek
Dissolved Oxygen, Temperature and pH
Wet weather sampling event, November 27, 2001
Dissolved Oxygen (mg/L), Temperature (°C), pH (S.U.)
0
5
10
15
20
25
WF 5
WF 4
WF 3
WF 2
WF 1
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream
Dissolved Oxygen
Temperature
pH

West Fork Portage Creek

Dissolved Oxygen, Temperature and pH

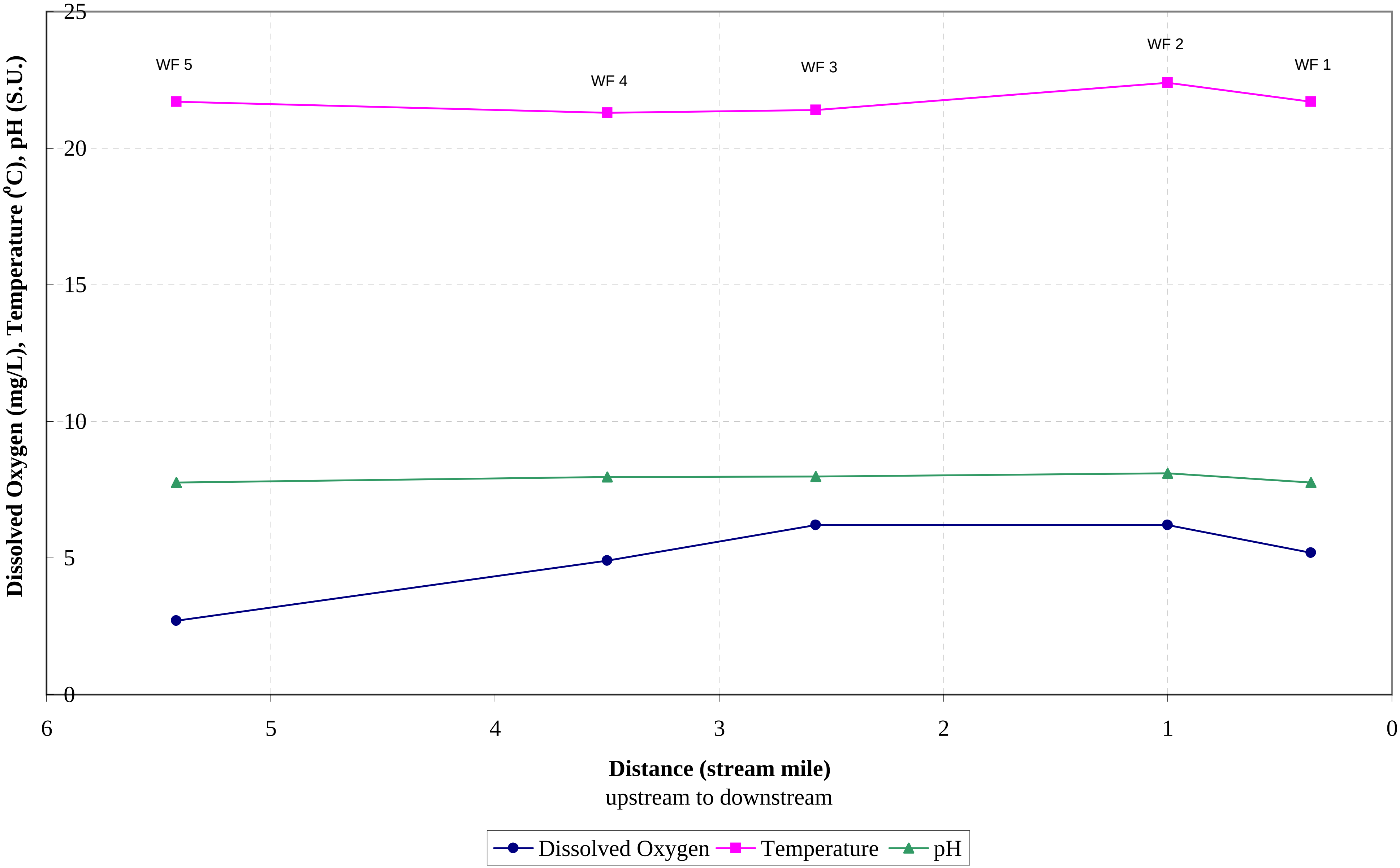
Wet weather sampling event, May 8, 2002



West Fork Portage Creek

Dissolved Oxygen, Temperature and pH

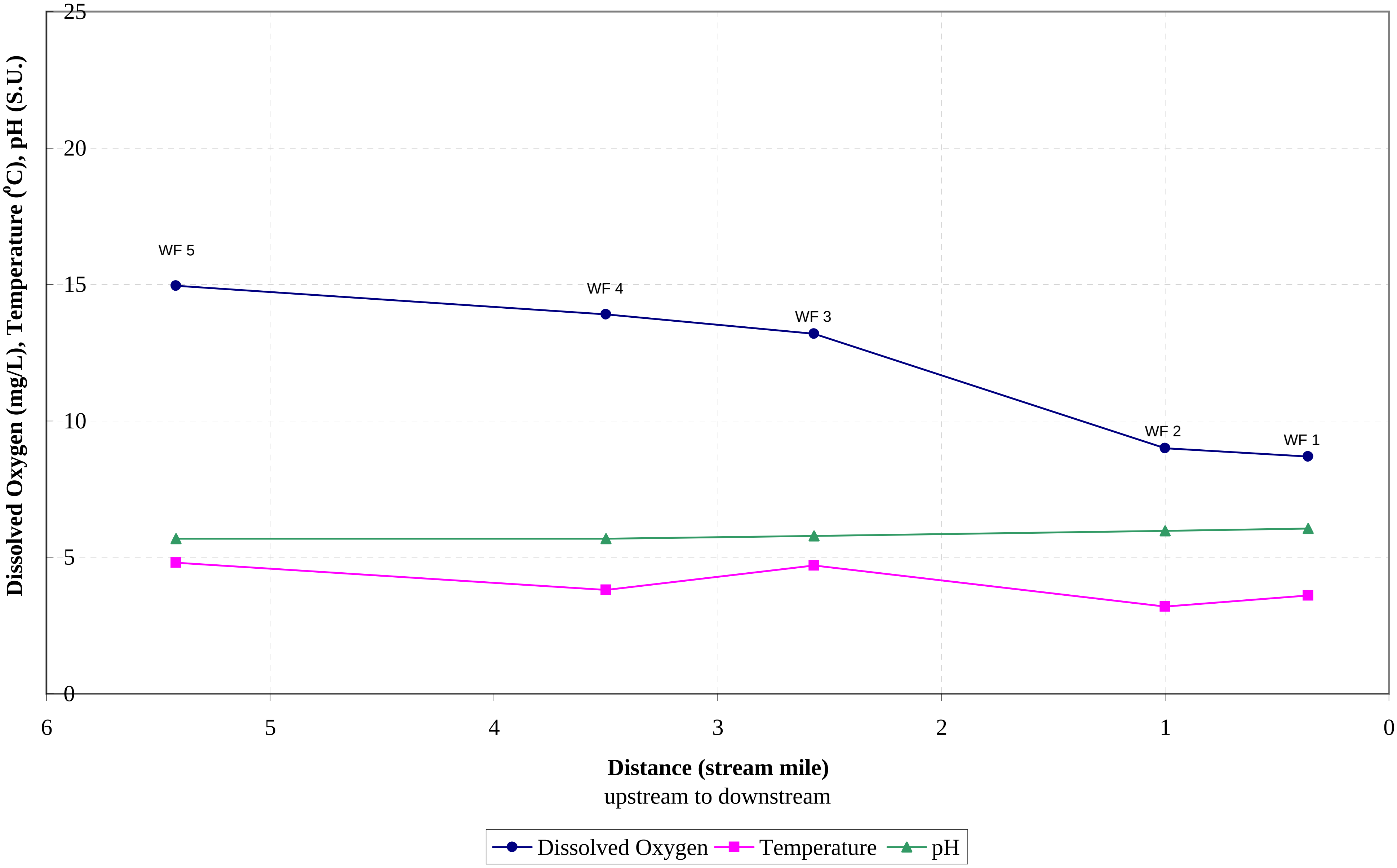
Wet weather sampling event, September 20, 2002

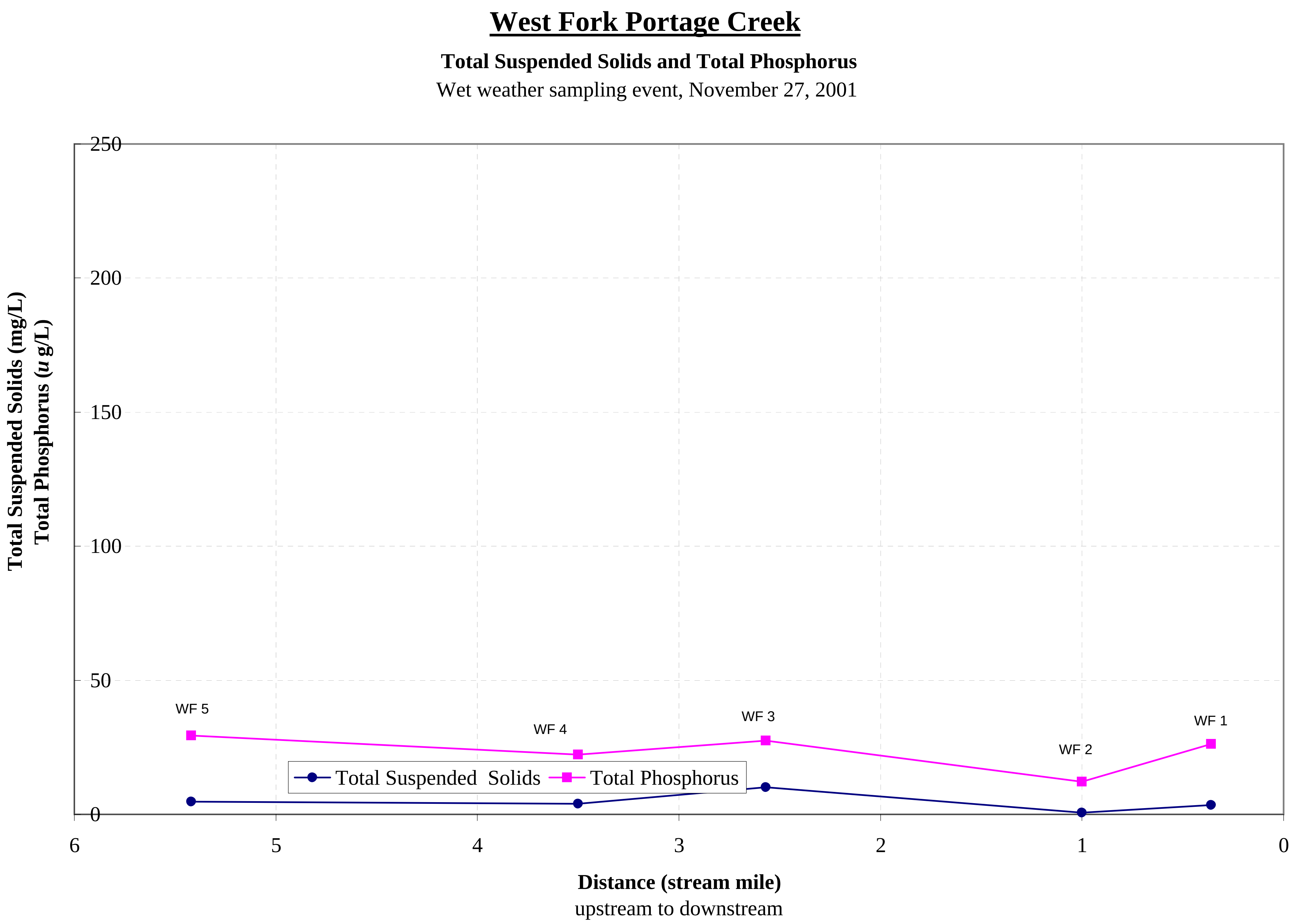


West Fork Portage Creek

Dissolved Oxygen, Temperature and pH

Wet weather sampling event, March 8, 2002



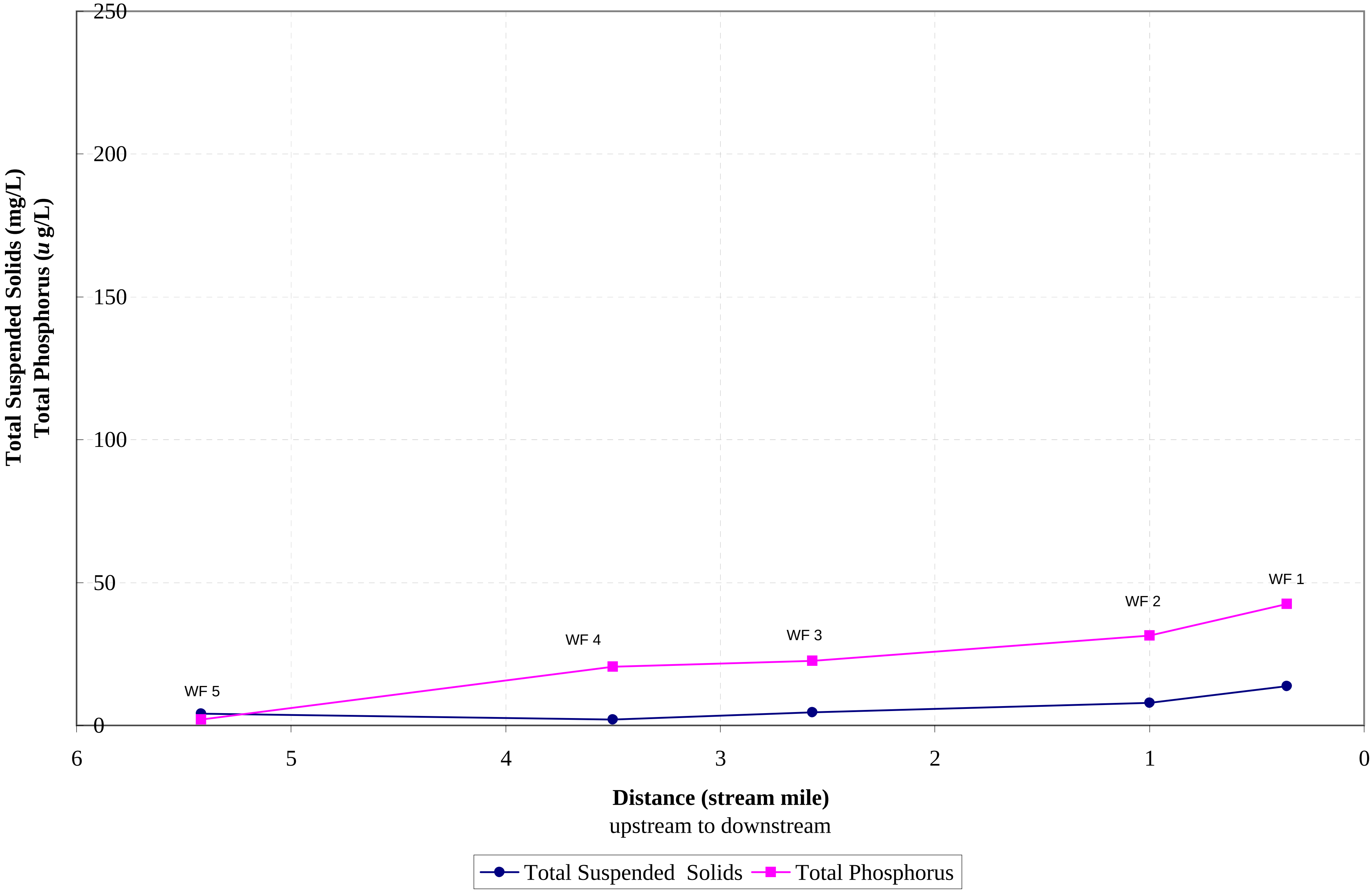


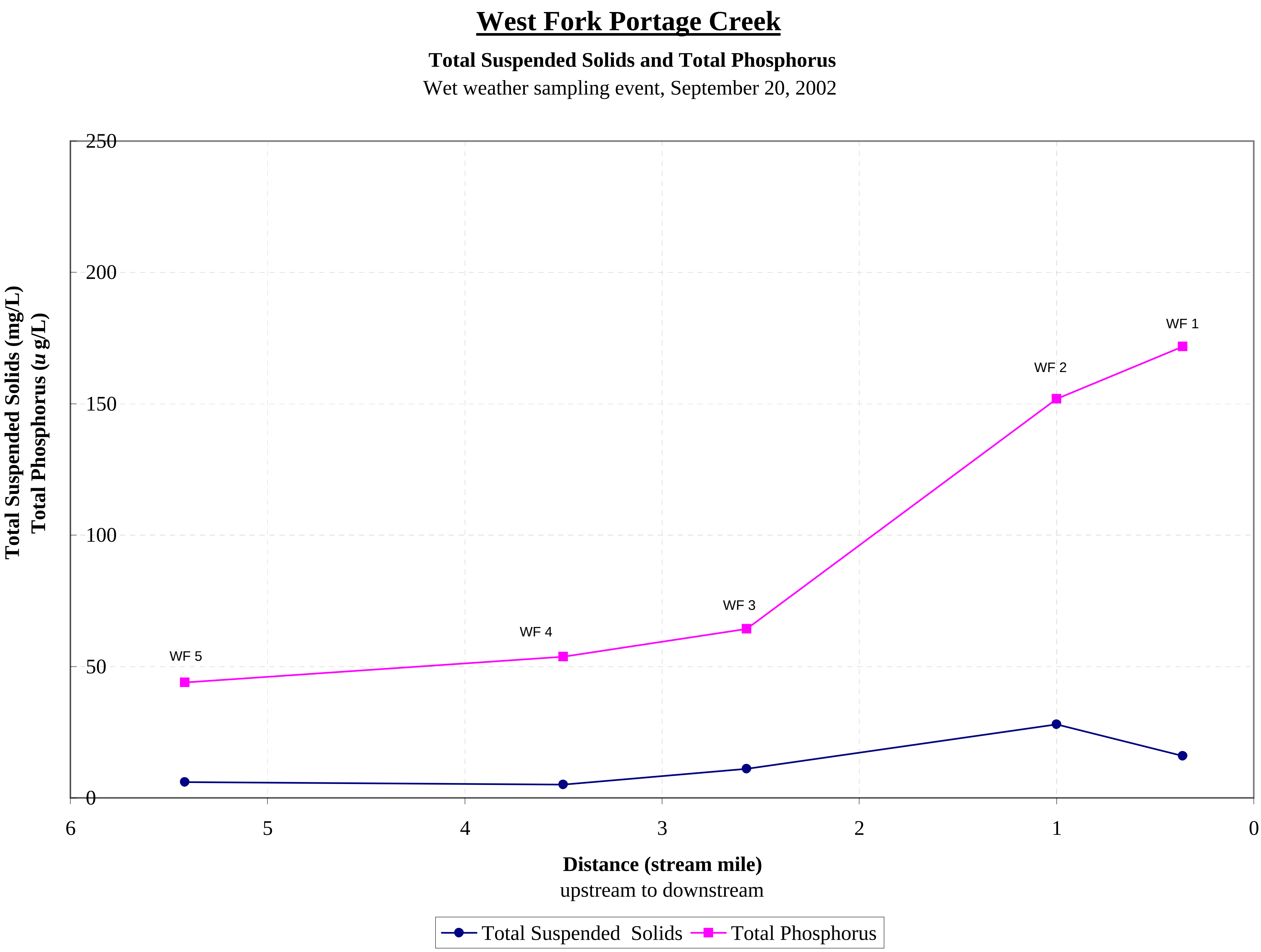
West Fork Portage Creek
Total Suspended Solids and Total Phosphorus
Wet weather sampling event, November 27, 2001
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
250
200
150
100
50
0
WF 5
WF 4
WF 3
WF 2
WF 1
Total Suspended Solids
Total Phosphorus
6
5
4
3
2
1
0
Distance (stream mile)
upstream to downstream

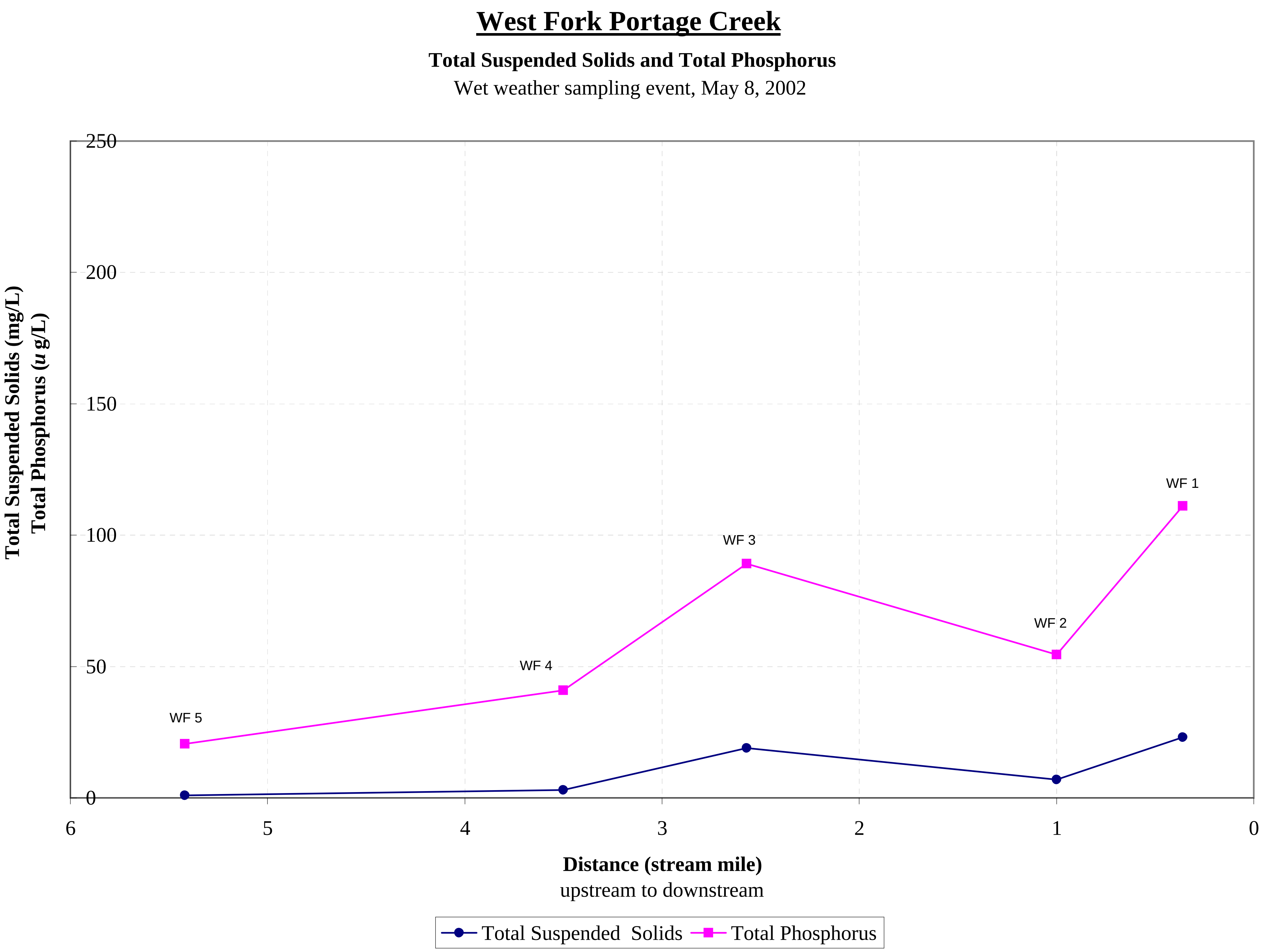
West Fork Portage Creek

Total Suspended Solids and Total Phosphorus

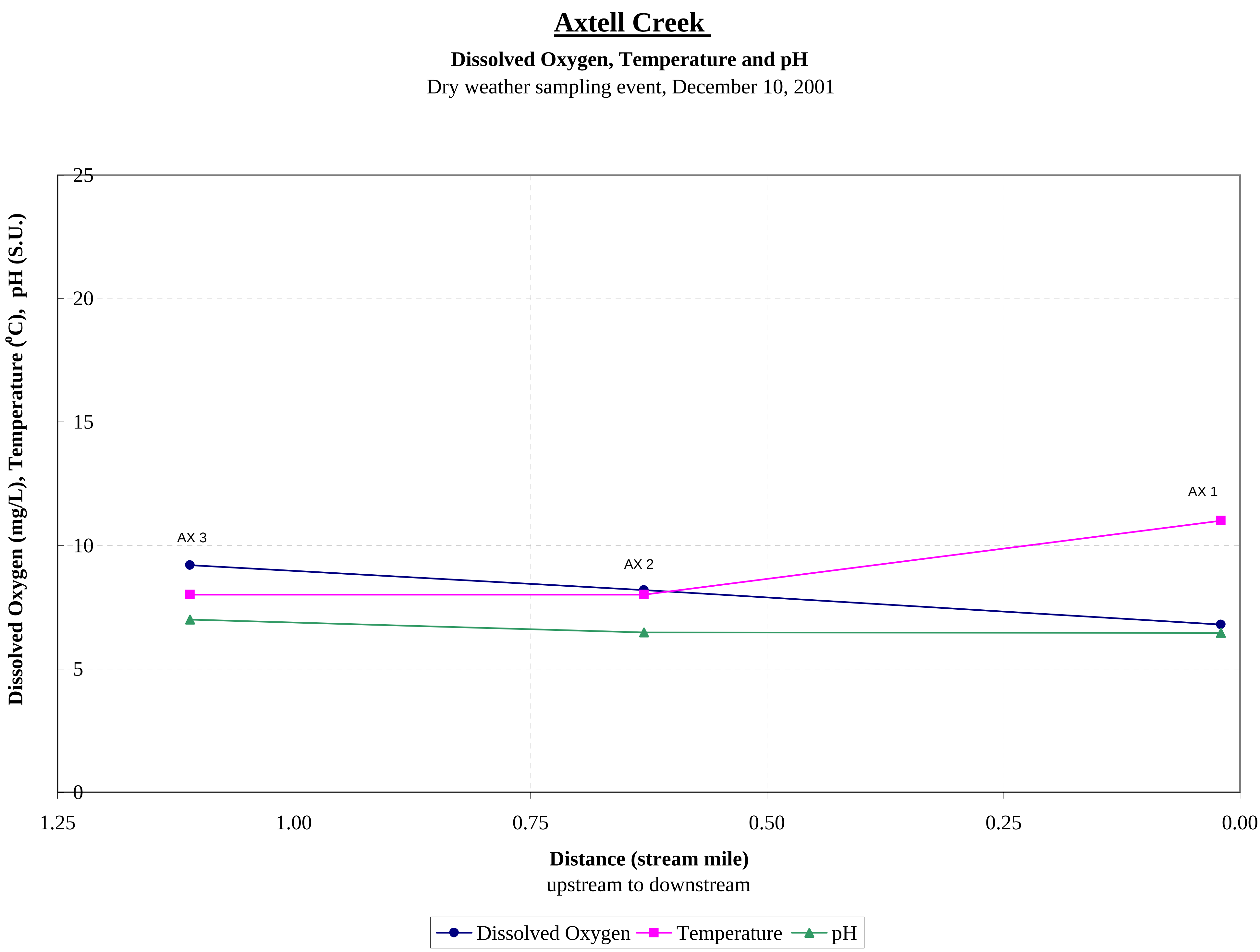
Wet weather sampling event, March 8, 2002




West Fork Portage Creek
Total Suspended Solids and Total Phosphorus
Wet weather sampling event, September 20, 2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
250
200
150
100
50
0
6
5
4
3
2
1
0
WF 5
WF 4
WF 3
WF 2
WF 1
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus



West Fork Portage Creek
Total Suspended Solids and Total Phosphorus
Wet weather sampling event, May 8, 2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
250
200
150
100
50
0
6
5
4
3
2
1
0
WF 5
WF 4
WF 3
WF 2
WF 1
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

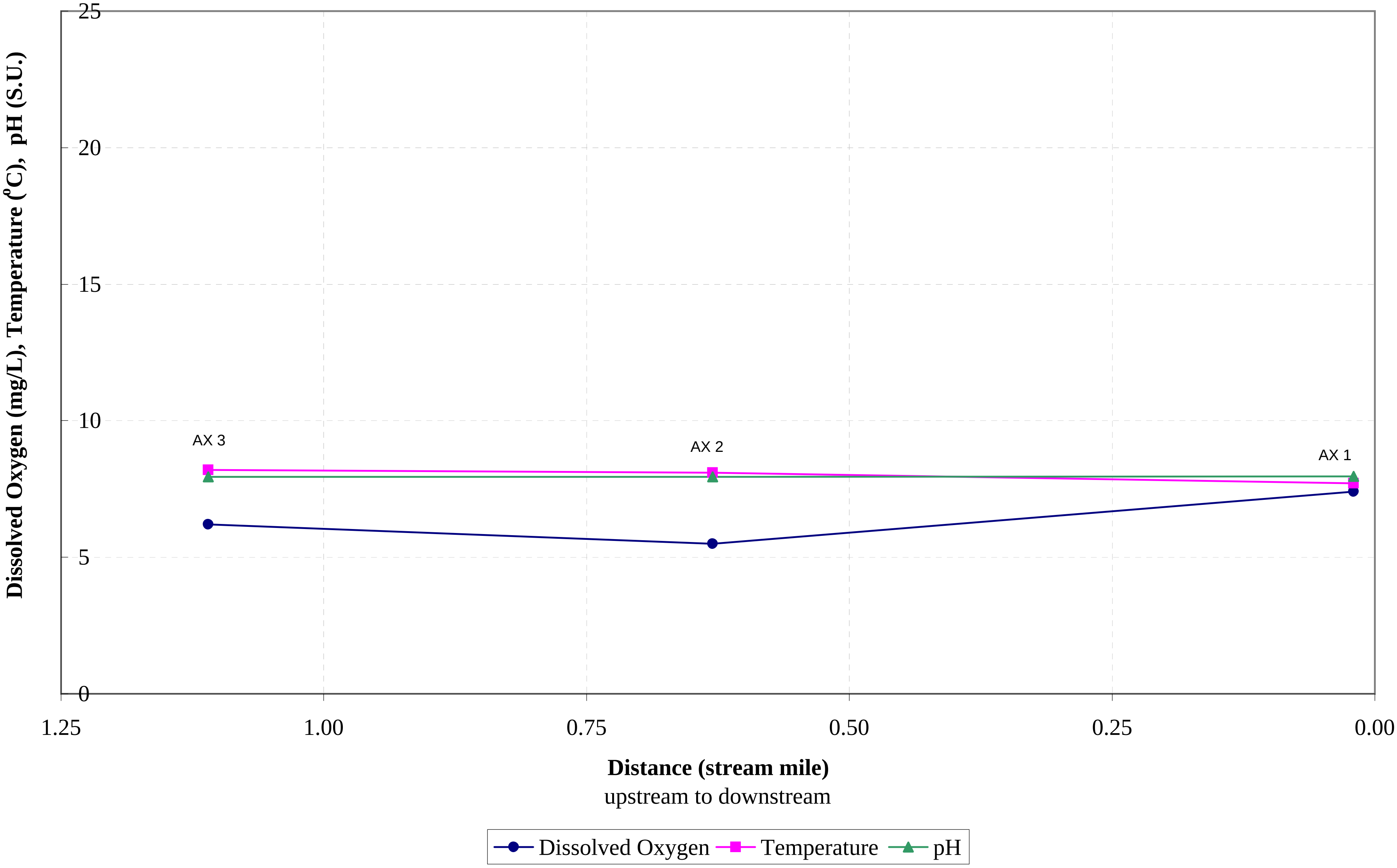


Axtell Creek
Dissolved Oxygen, Temperature and pH
Dry weather sampling event, December 10, 2001
Dissolved Oxygen (mg/L), Temperature (°C), pH (S.U.)
25
20
15
10
5
0
AX 3
AX 2
AX 1
1.25
1.00
0.75
0.50
0.25
0.00
Distance (stream mile)
upstream to downstream
Dissolved Oxygen
Temperature
pH

Axtell Creek

Dissolved Oxygen, Temperature and pH

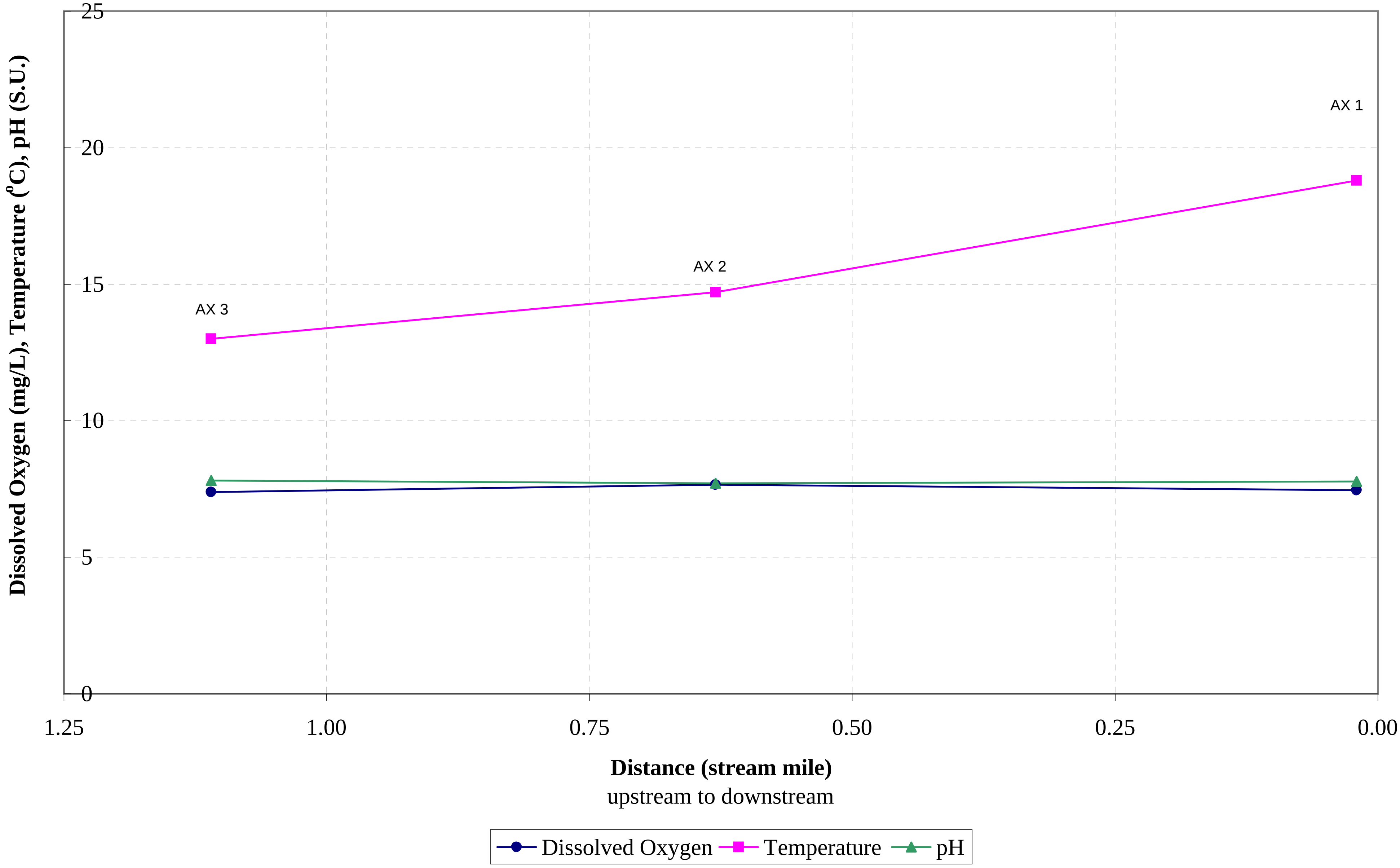
Dry weather sampling event, February 25, 2002

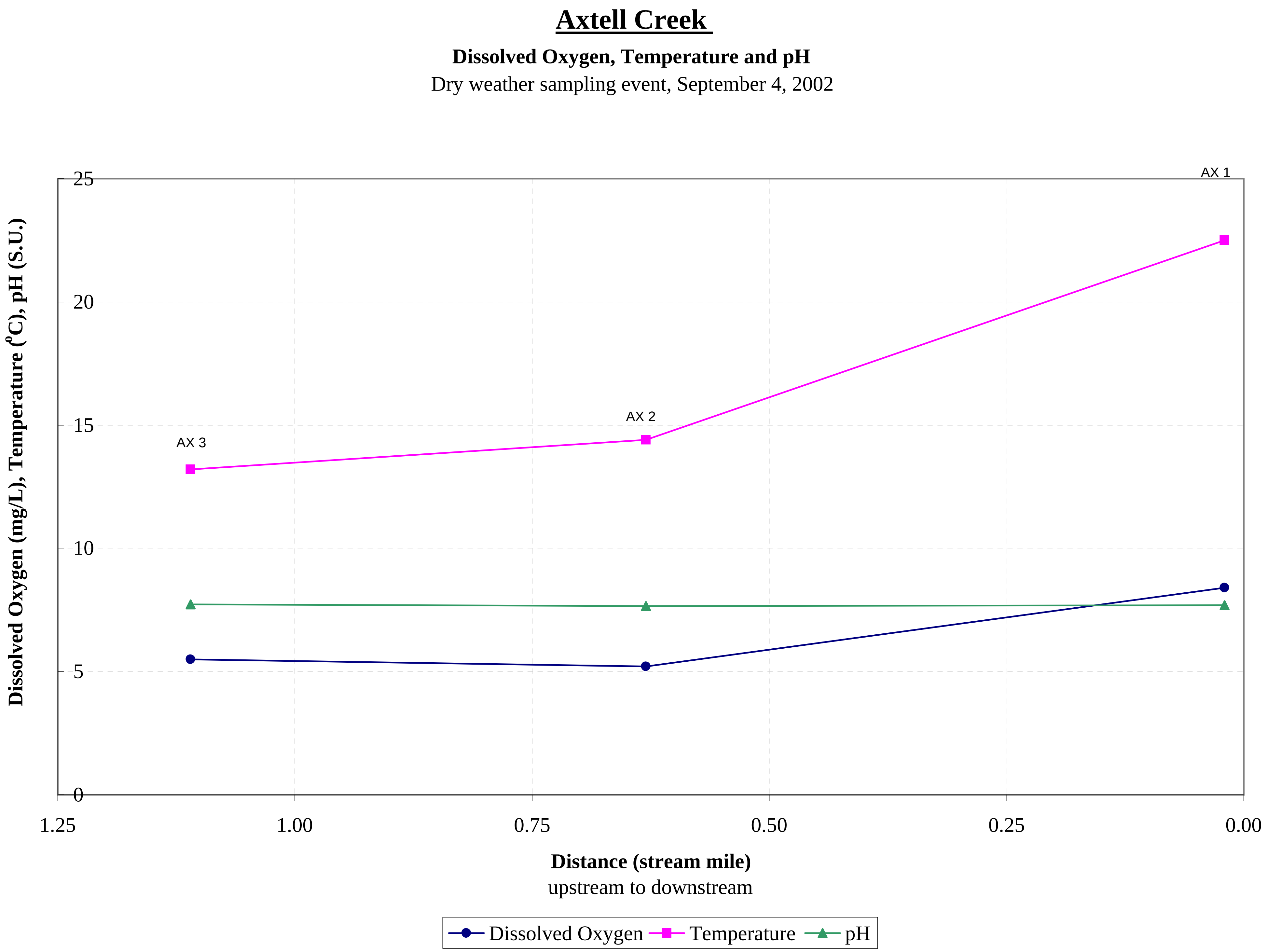


Axtell Creek

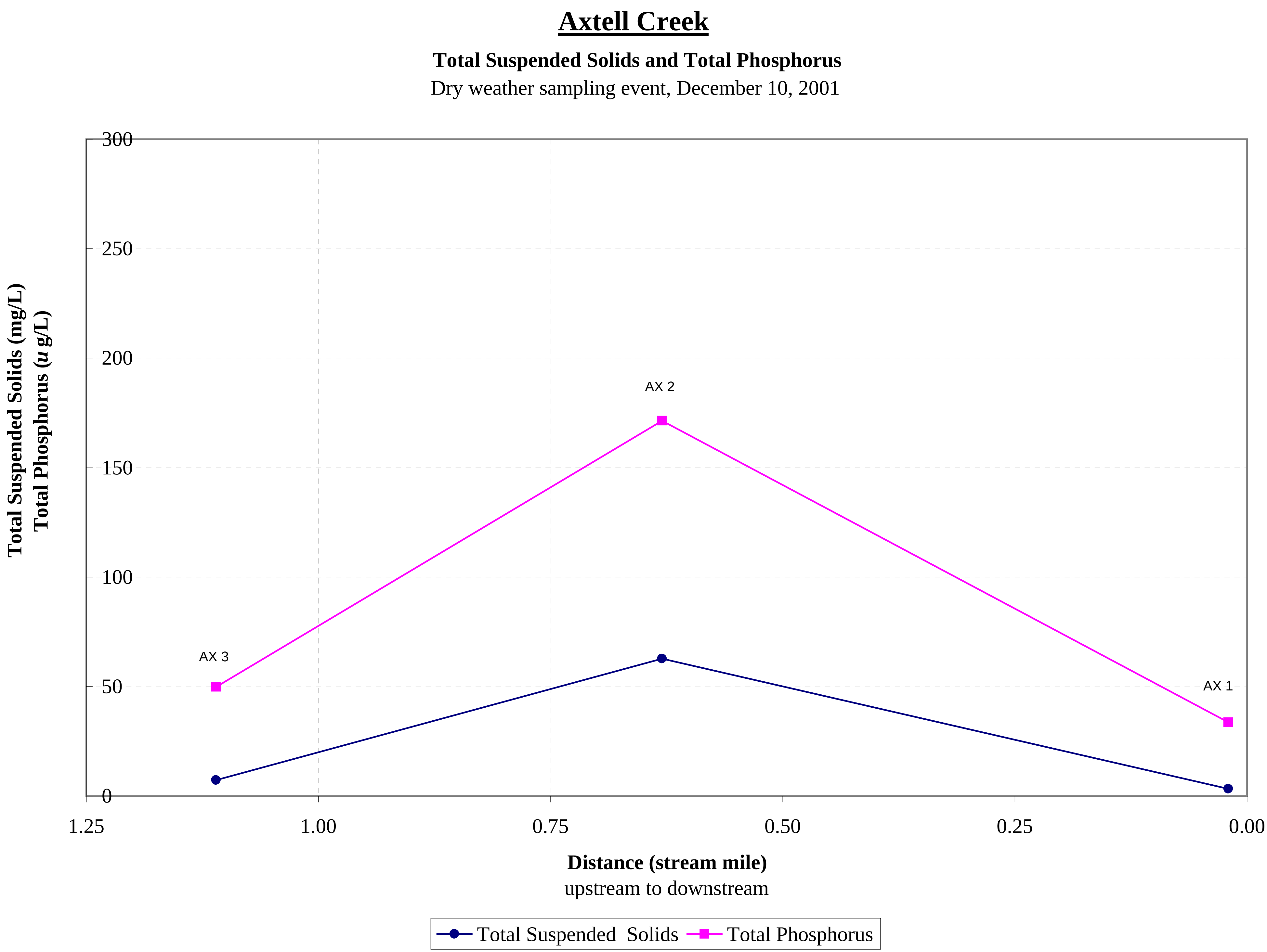
Dissolved Oxygen, Temperature and pH

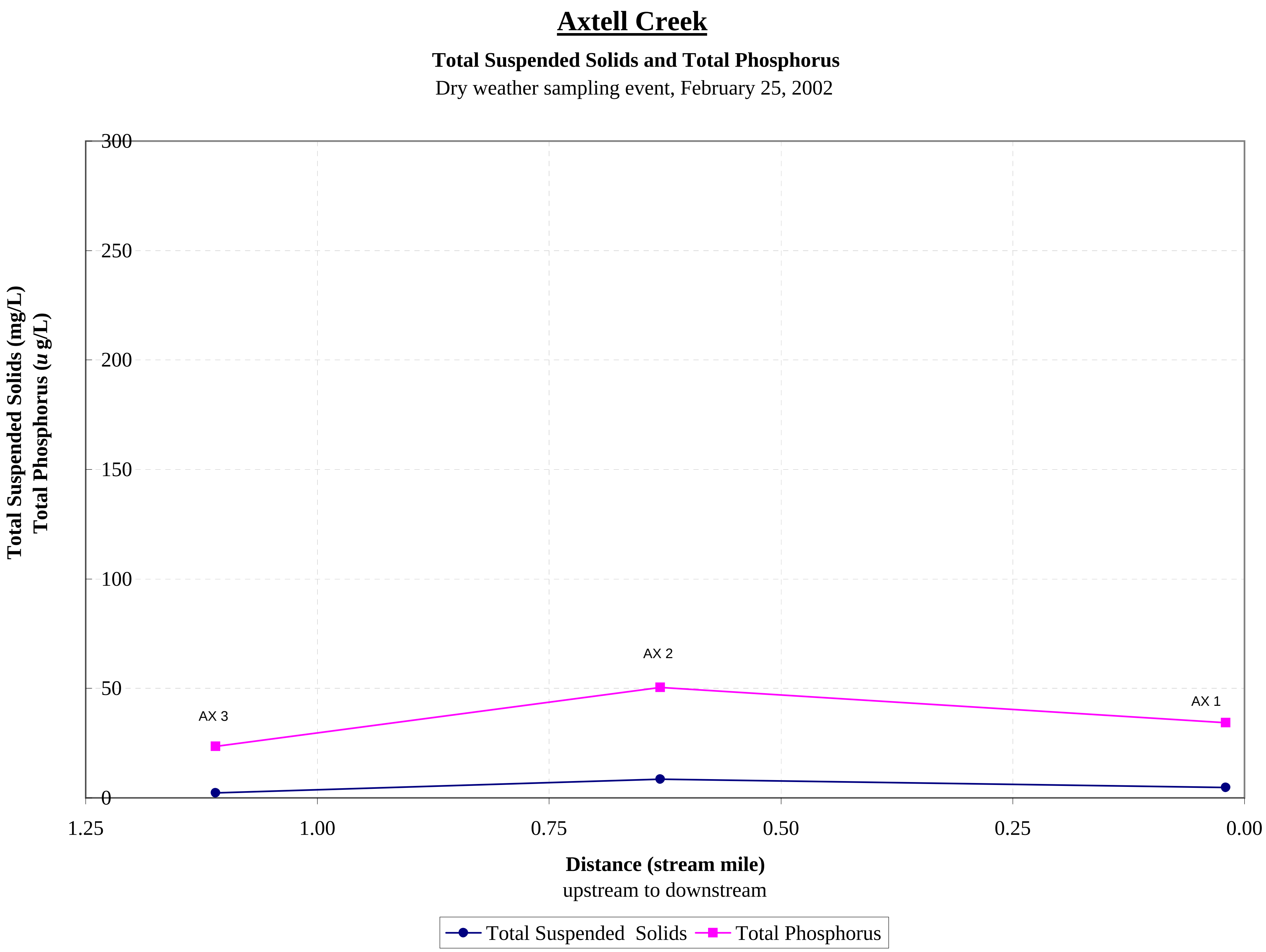
Dry weather sampling event, June 17, 2002



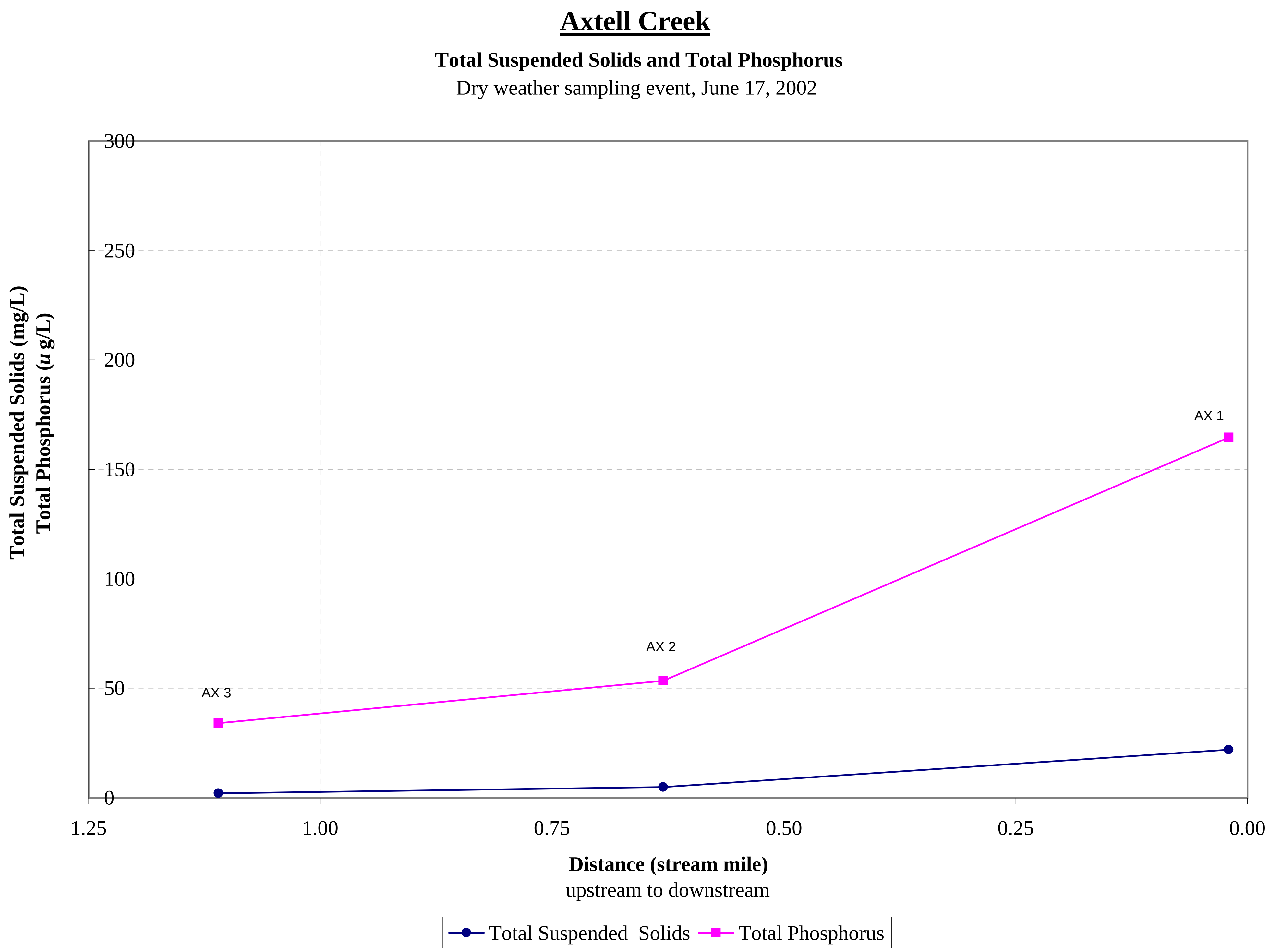


Axtell Creek
Dissolved Oxygen, Temperature and pH
Dry weather sampling event, September 4, 2002
Dissolved Oxygen (mg/L), Temperature (^oC), pH (S.U.)
0
5
10
15
20
25
AX 3
AX 2
AX 1
1.25
1.00
0.75
0.50
0.25
0.00
Distance (stream mile)
upstream to downstream
Dissolved Oxygen
Temperature
pH


Axtell Creek
Total Suspended Solids and Total Phosphorus
Dry weather sampling event, December 10, 2001
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
300
250
200
150
100
50
0
AX 3
AX 2
AX 1
1.25
1.00
0.75
0.50
0.25
0.00
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus



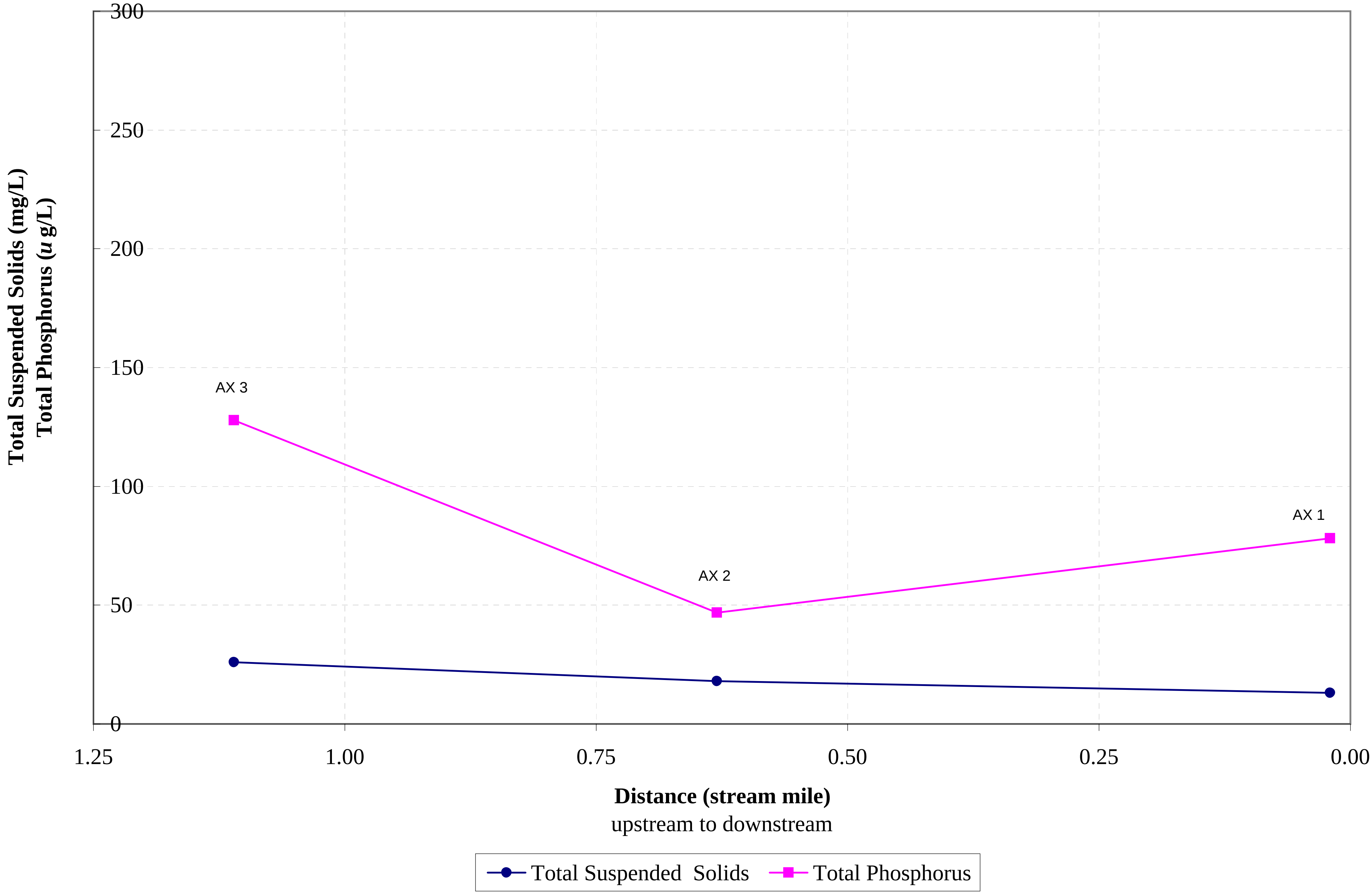
Axtell Creek
Total Suspended Solids and Total Phosphorus
Dry weather sampling event, February 25, 2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
300
250
200
150
100
50
0
AX 3
AX 2
AX 1
1.25
1.00
0.75
0.50
0.25
0.00
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus


Axtell Creek
Total Suspended Solids and Total Phosphorus
Dry weather sampling event, June 17, 2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
300
250
200
150
100
50
0
AX 3
AX 2
AX 1
1.25
1.00
0.75
0.50
0.25
0.00
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

Axtell Creek

Total Suspended Solids and Total Phosphorus

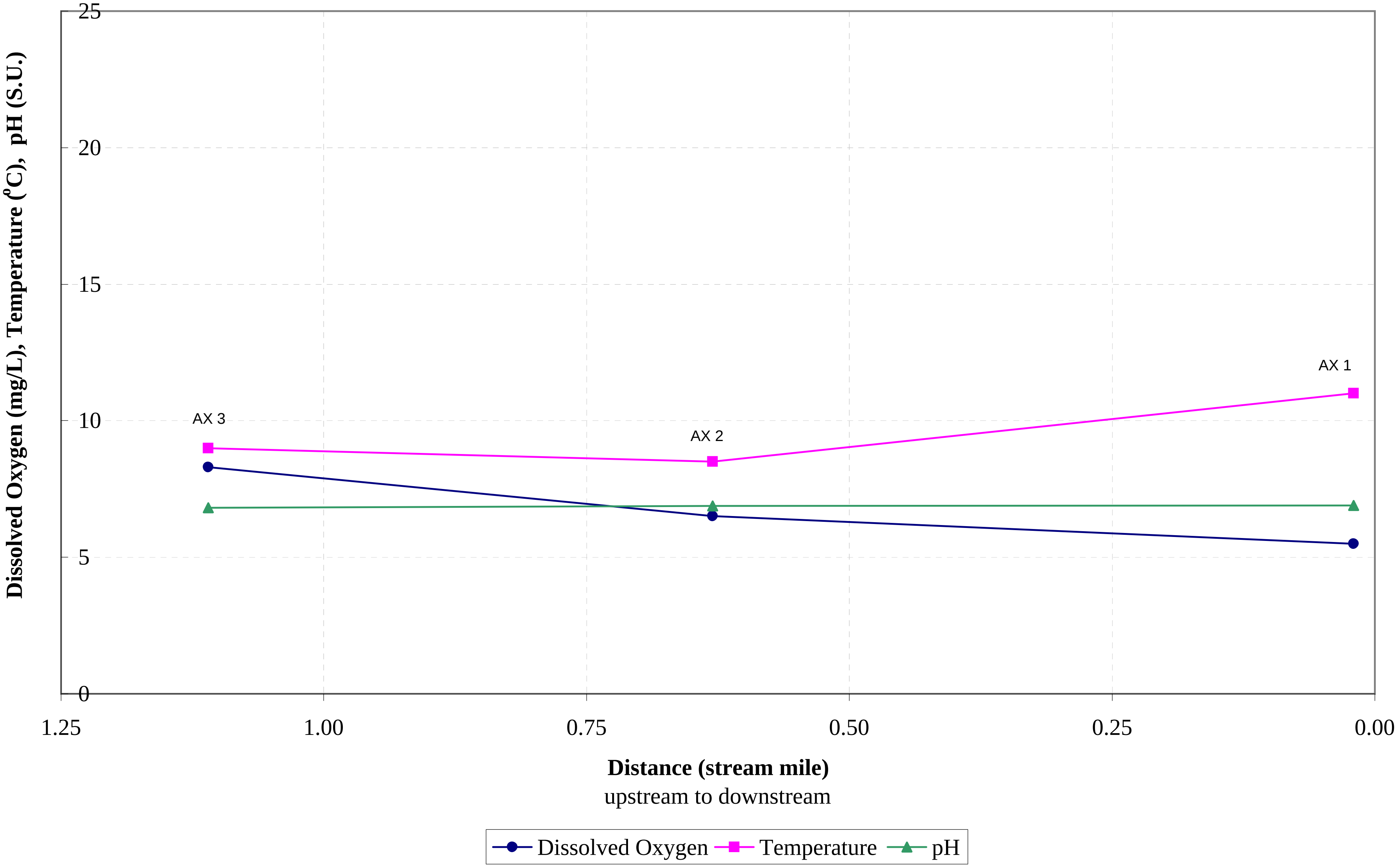
Dry weather sampling event, September 4, 2002



Axtell Creek

Dissolved Oxygen, Temperature and pH

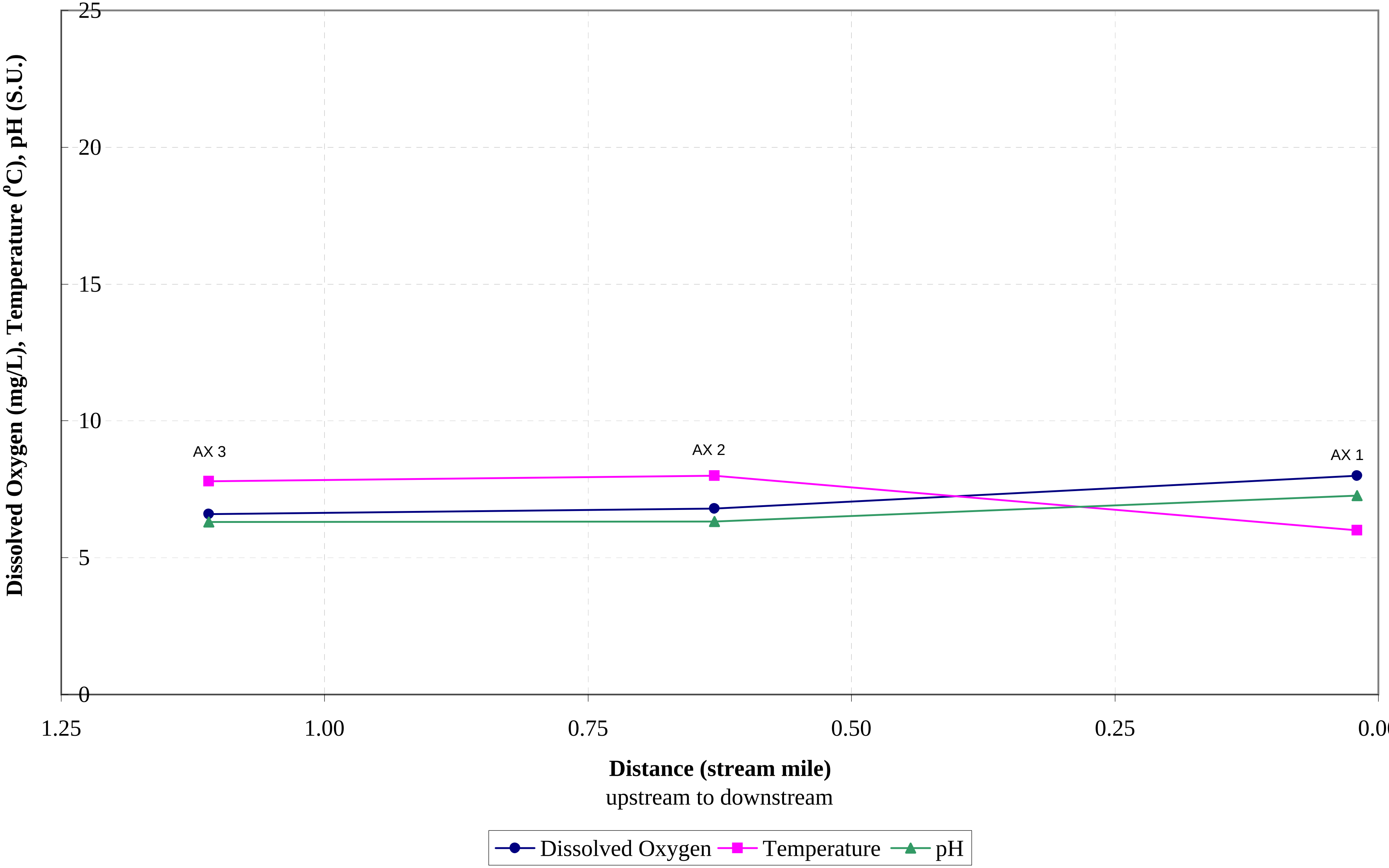
Wet weather sampling event, November 27, 2001



Axtell Creek

Dissolved Oxygen, Temperature and pH

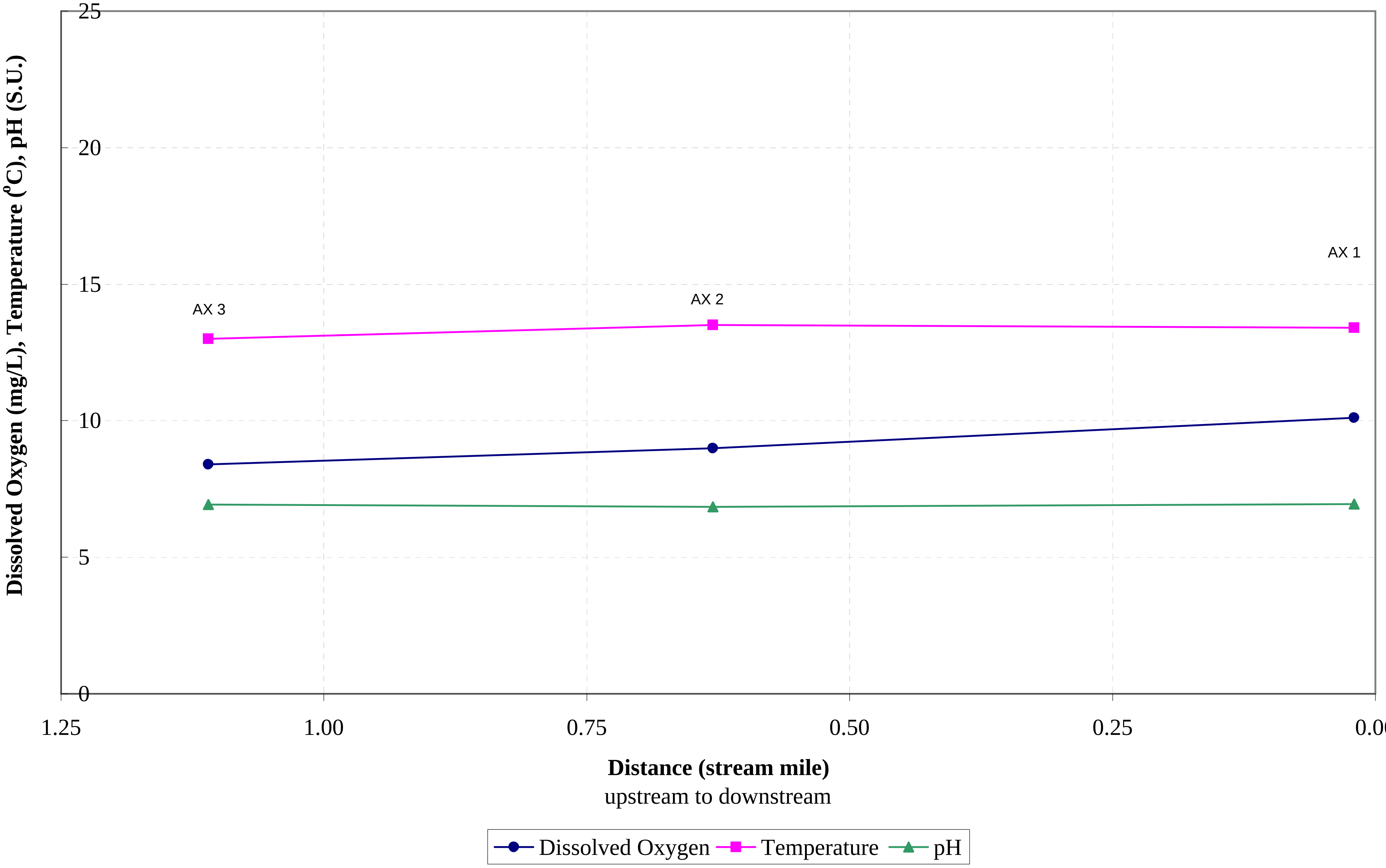
Wet weather sampling event, March 8, 2002



Axtell Creek

Dissolved Oxygen, Temperature and pH

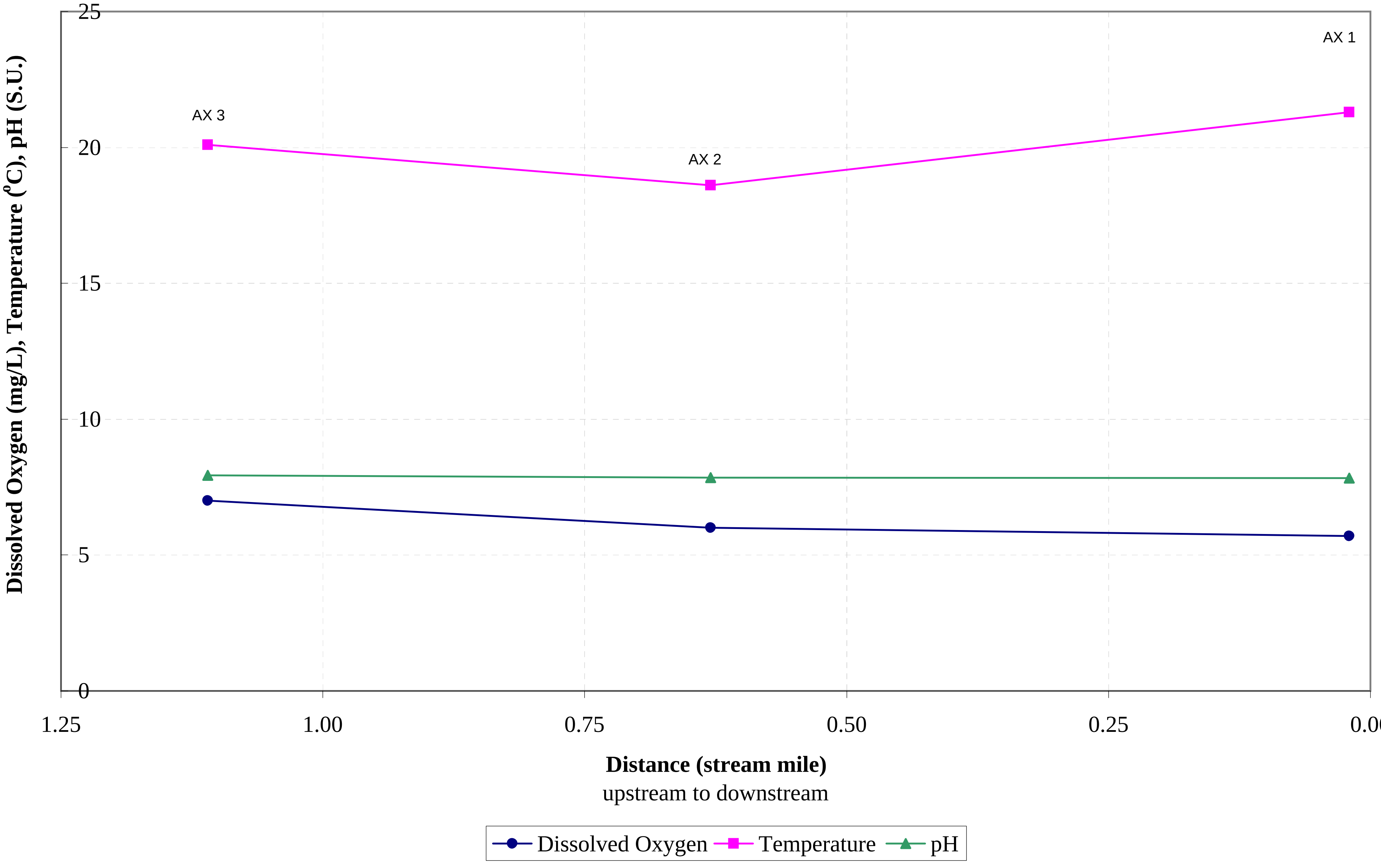
Wet weather sampling event, May 8, 2002

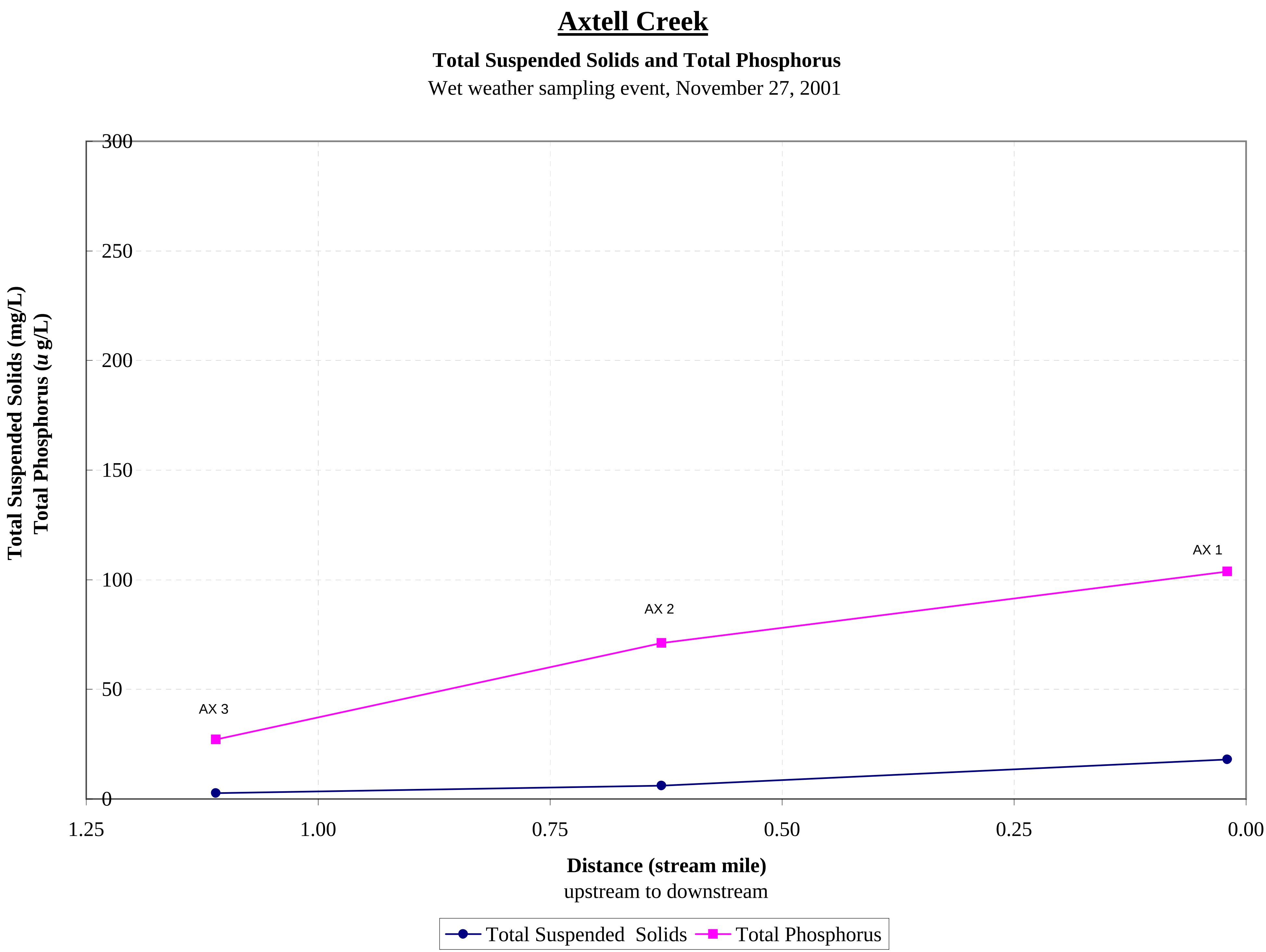


Axtell Creek

Dissolved Oxygen, Temperature and pH

Wet weather sampling event, September 20, 2002



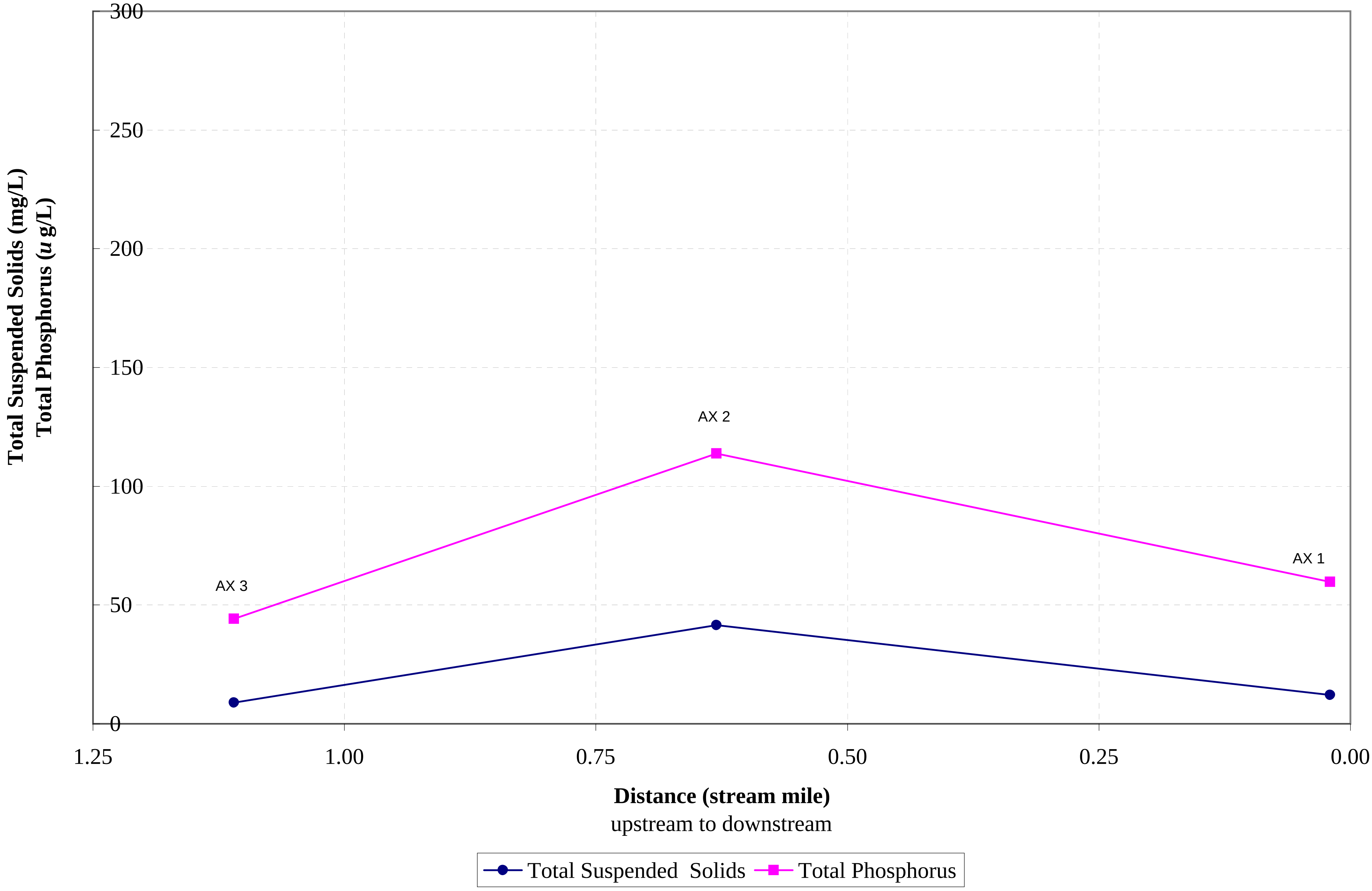


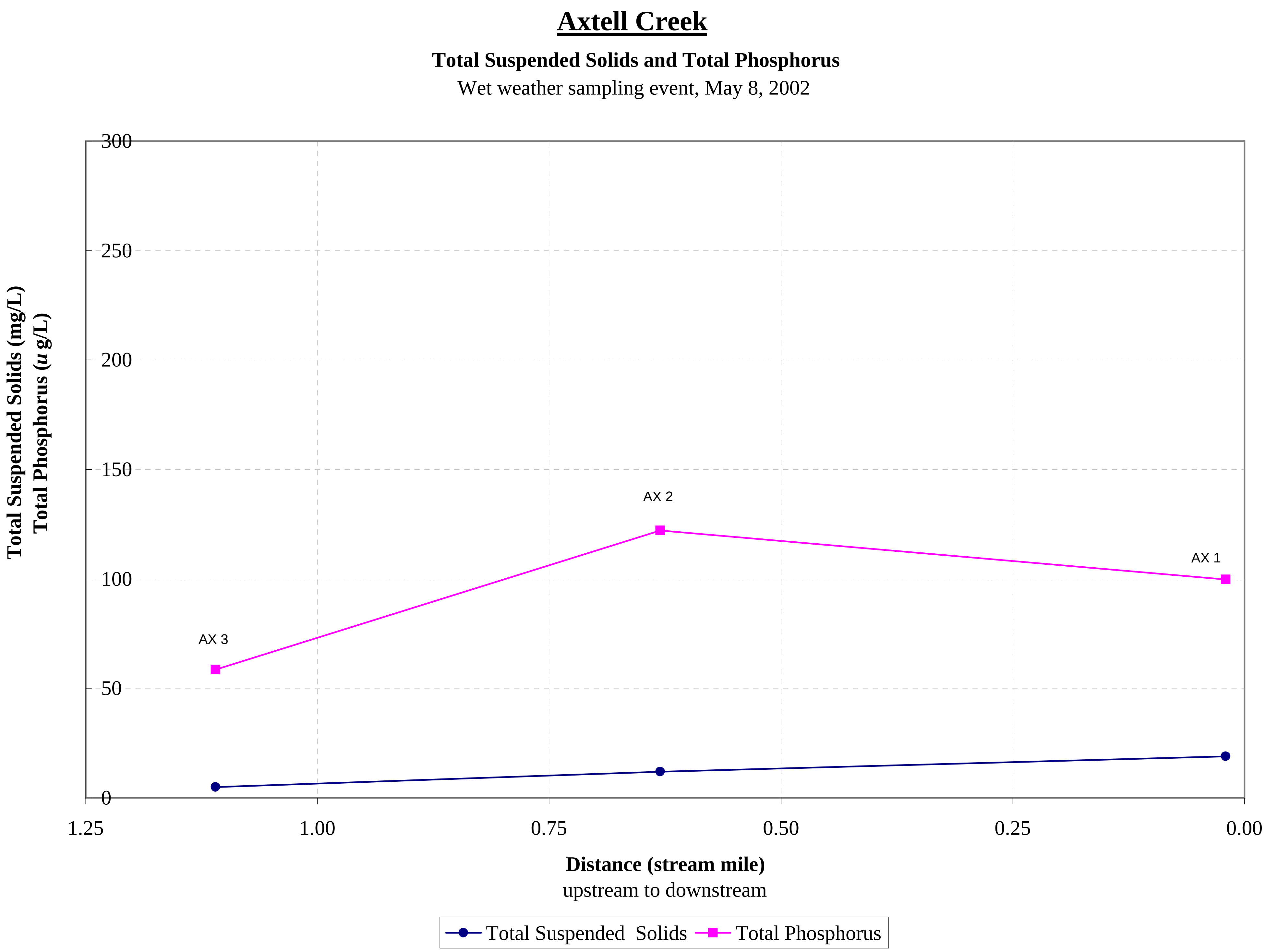
Axtell Creek
Total Suspended Solids and Total Phosphorus
Wet weather sampling event, November 27, 2001
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
300
250
200
150
100
50
0
AX 3
AX 2
AX 1
1.25
1.00
0.75
0.50
0.25
0.00
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

Axtell Creek

Total Suspended Solids and Total Phosphorus

Wet weather sampling event, March 8, 2002



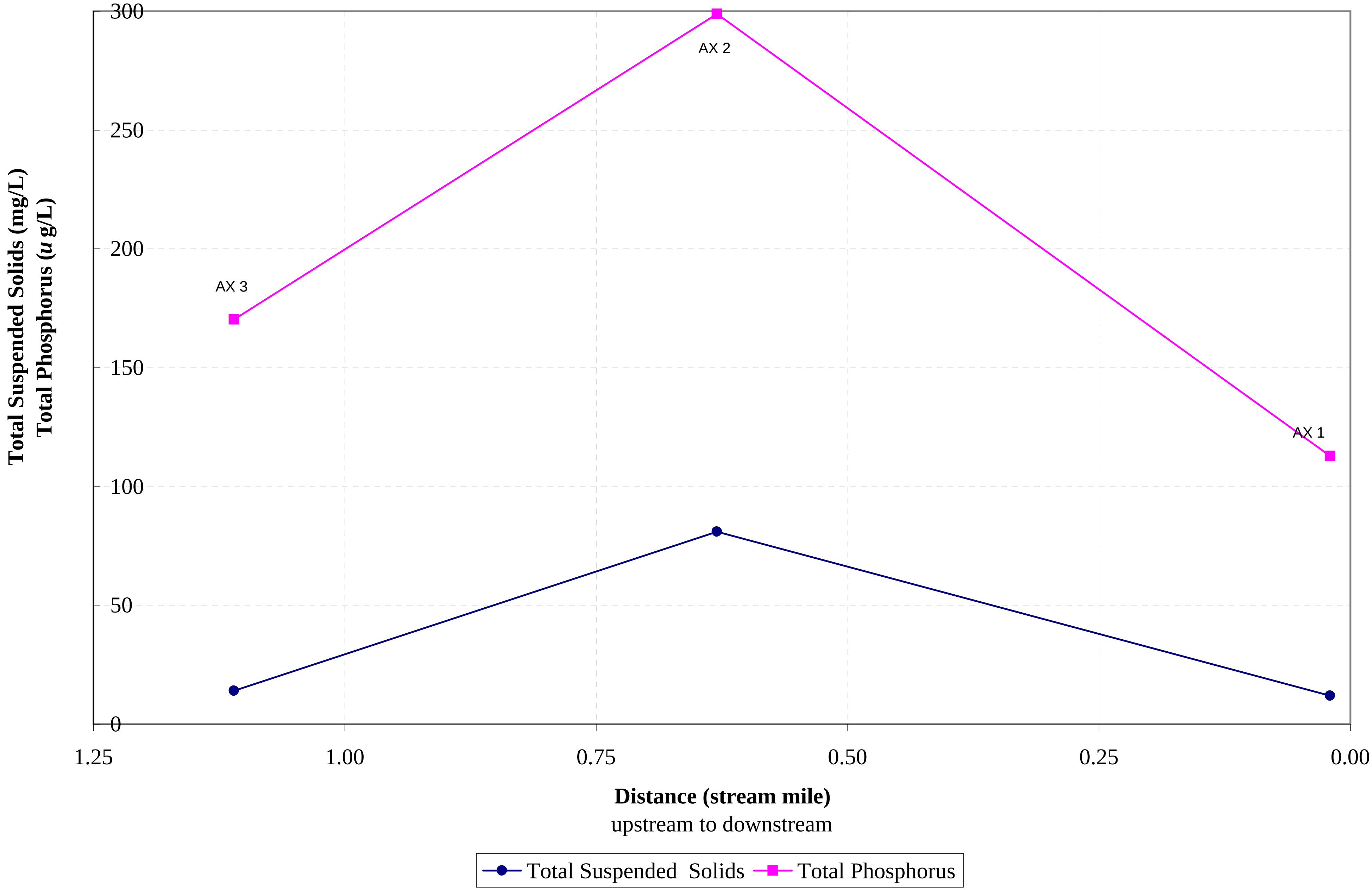


Axtell Creek
Total Suspended Solids and Total Phosphorus
Wet weather sampling event, May 8, 2002
Total Suspended Solids (mg/L)
Total Phosphorus (u g/L)
300
250
200
150
100
50
0
AX 3
AX 2
AX 1
1.25
1.00
0.75
0.50
0.25
0.00
Distance (stream mile)
upstream to downstream
Total Suspended Solids
Total Phosphorus

Axtell Creek

Total Suspended Solids and Total Phosphorus

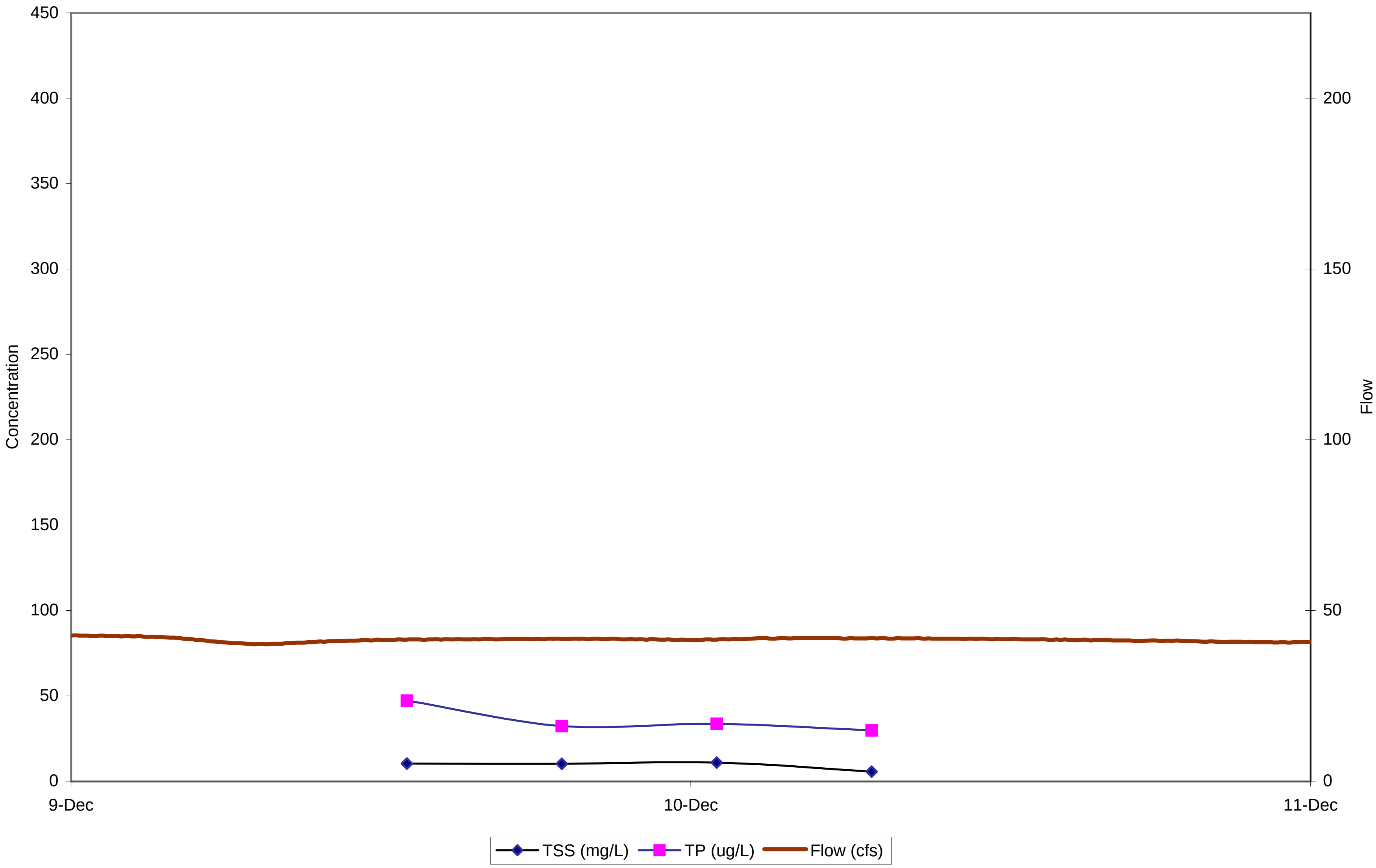
Wet weather sampling event, September 20, 2002

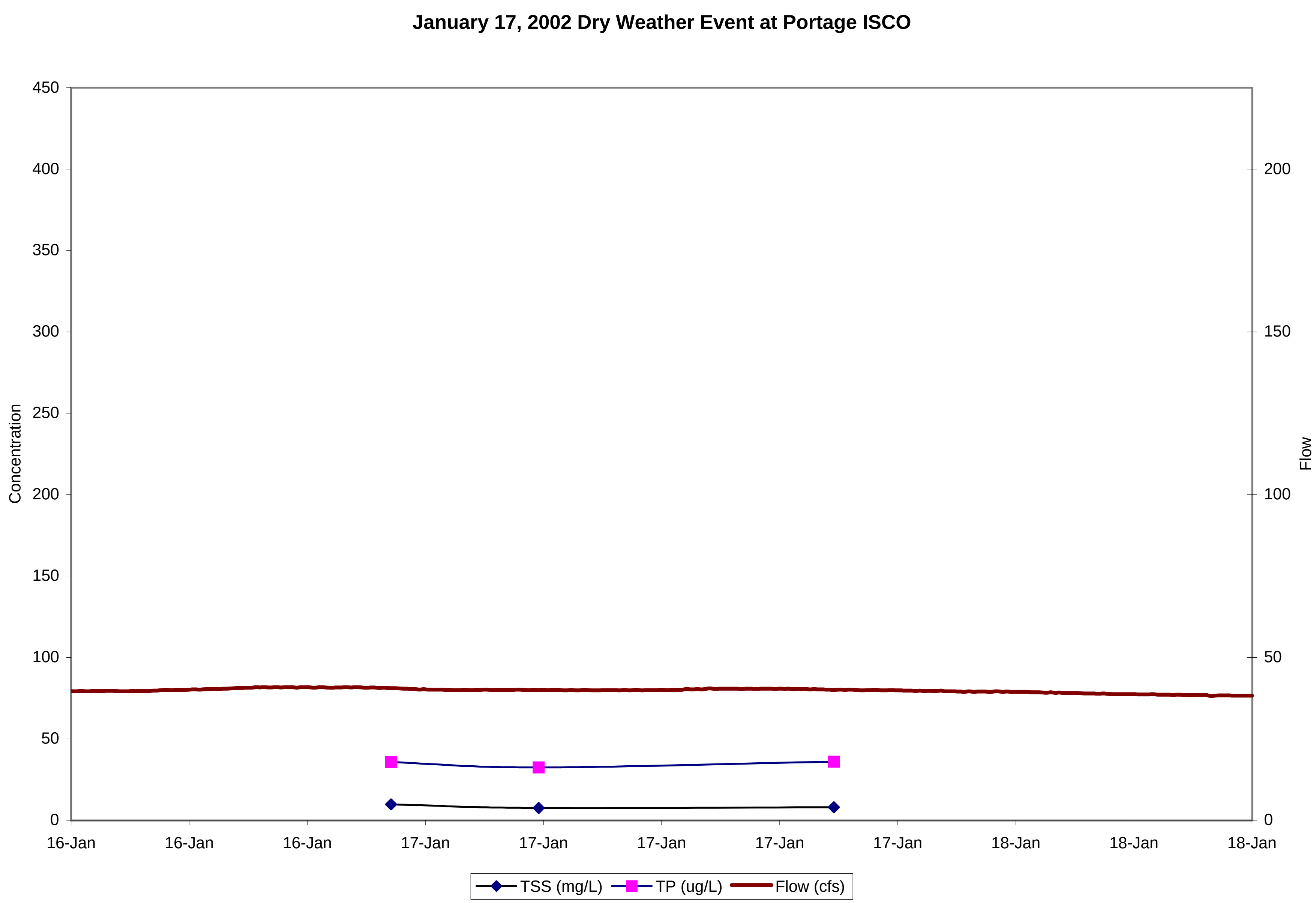


Attachment C

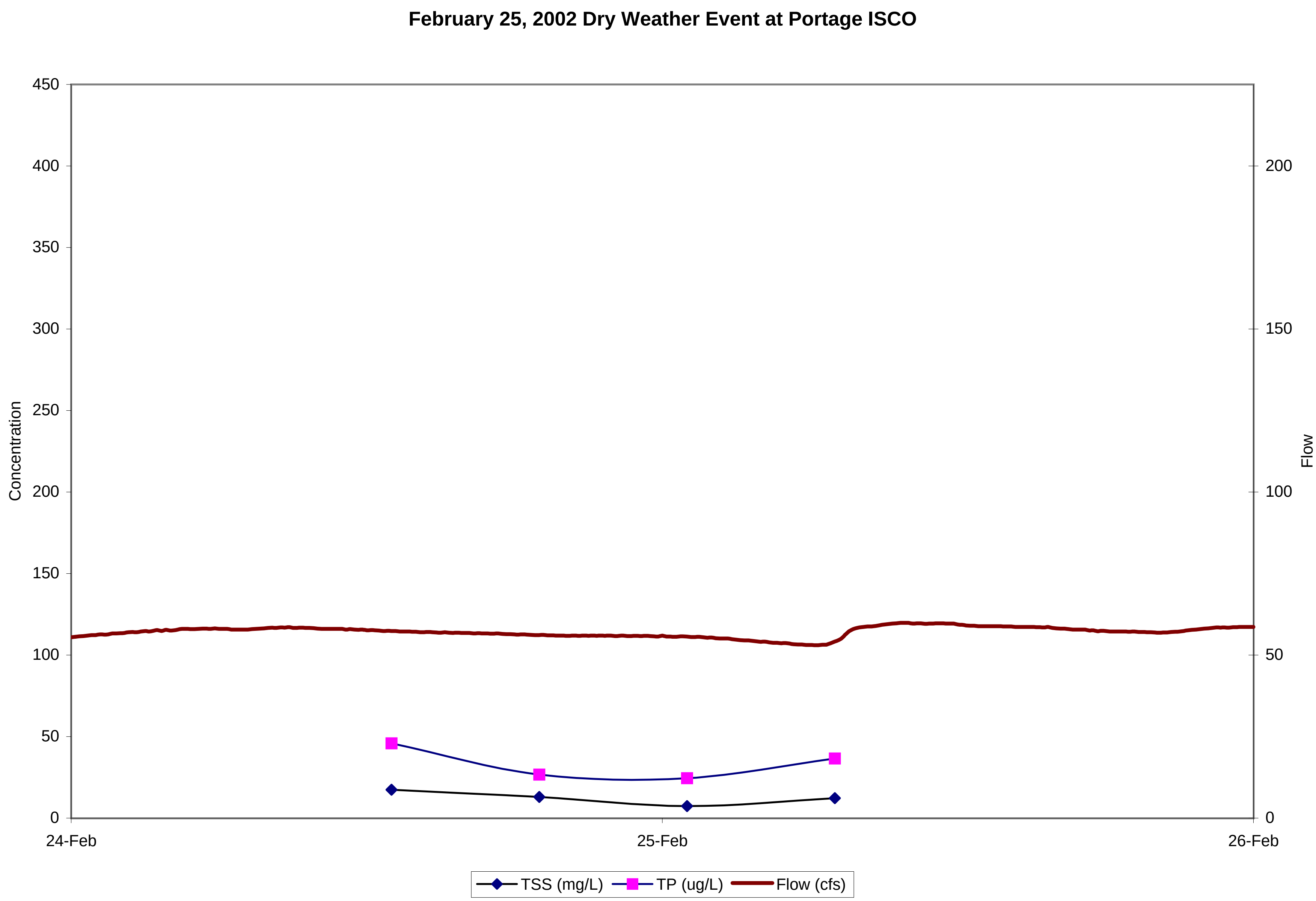
Wet and Dry Event Hydrographs and Concentrations of TP and TSS at the Mouth of Portage and Arcadia Creek

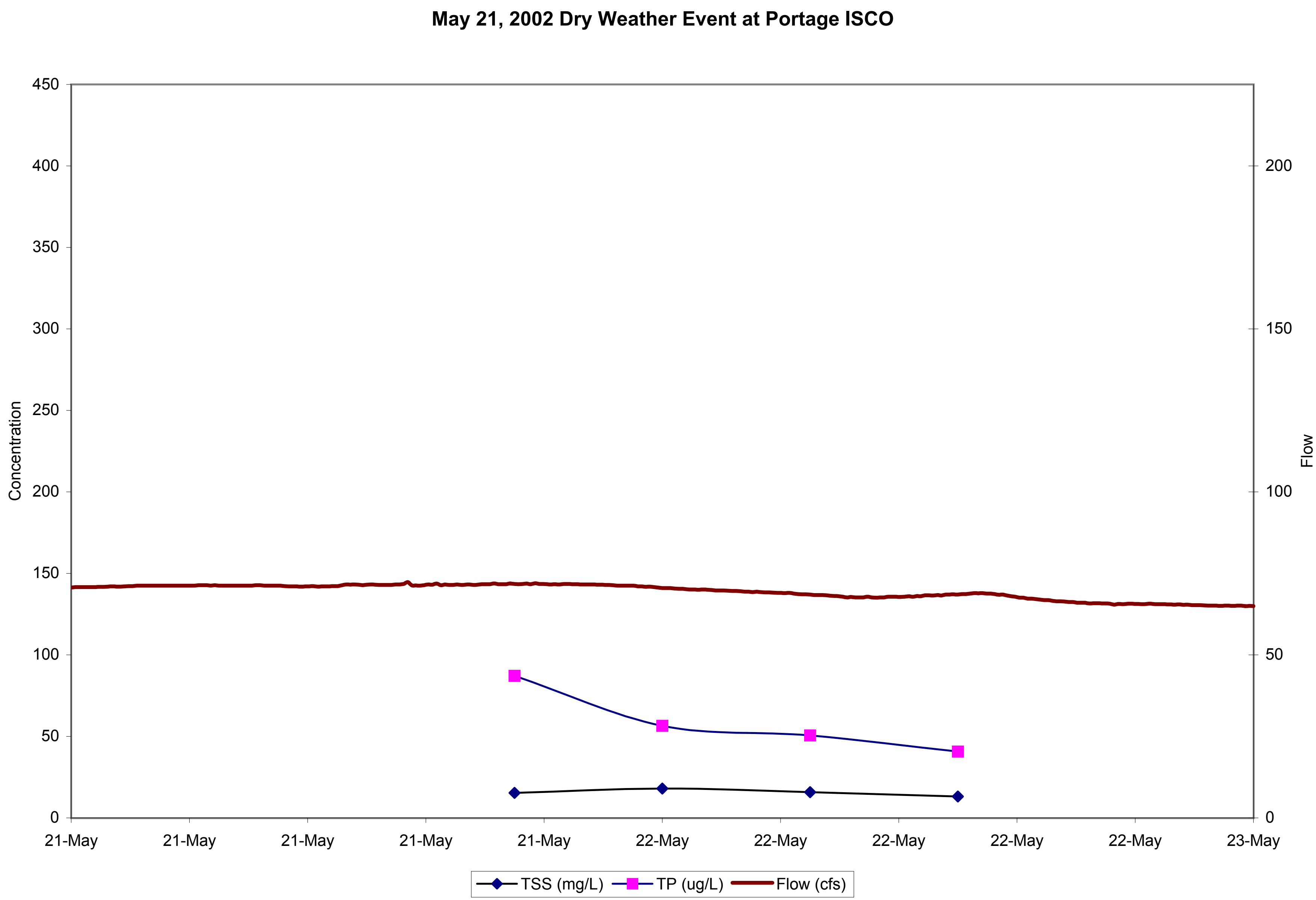
December 10, 2001 Dry Weather Event at Portage ISCO

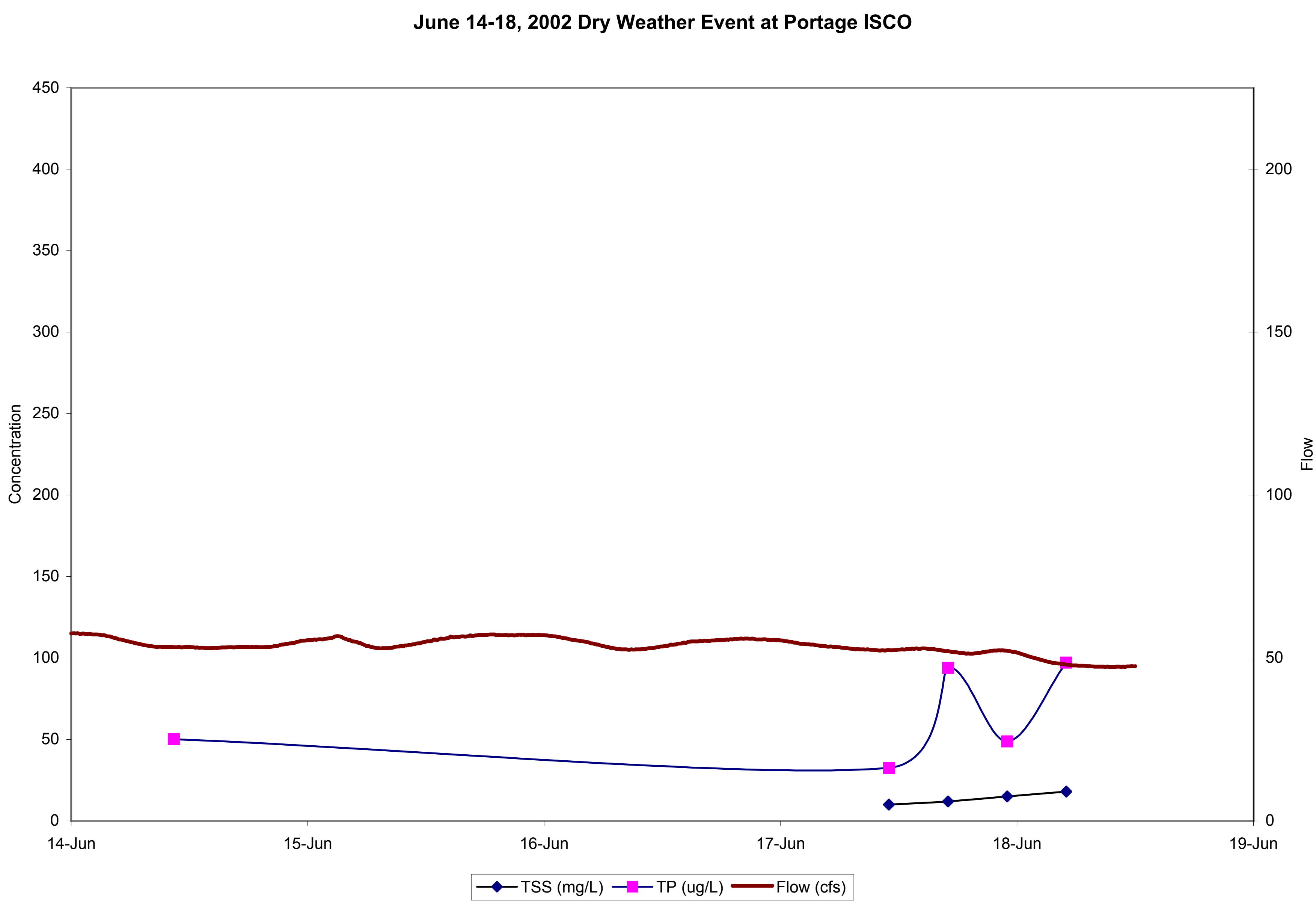


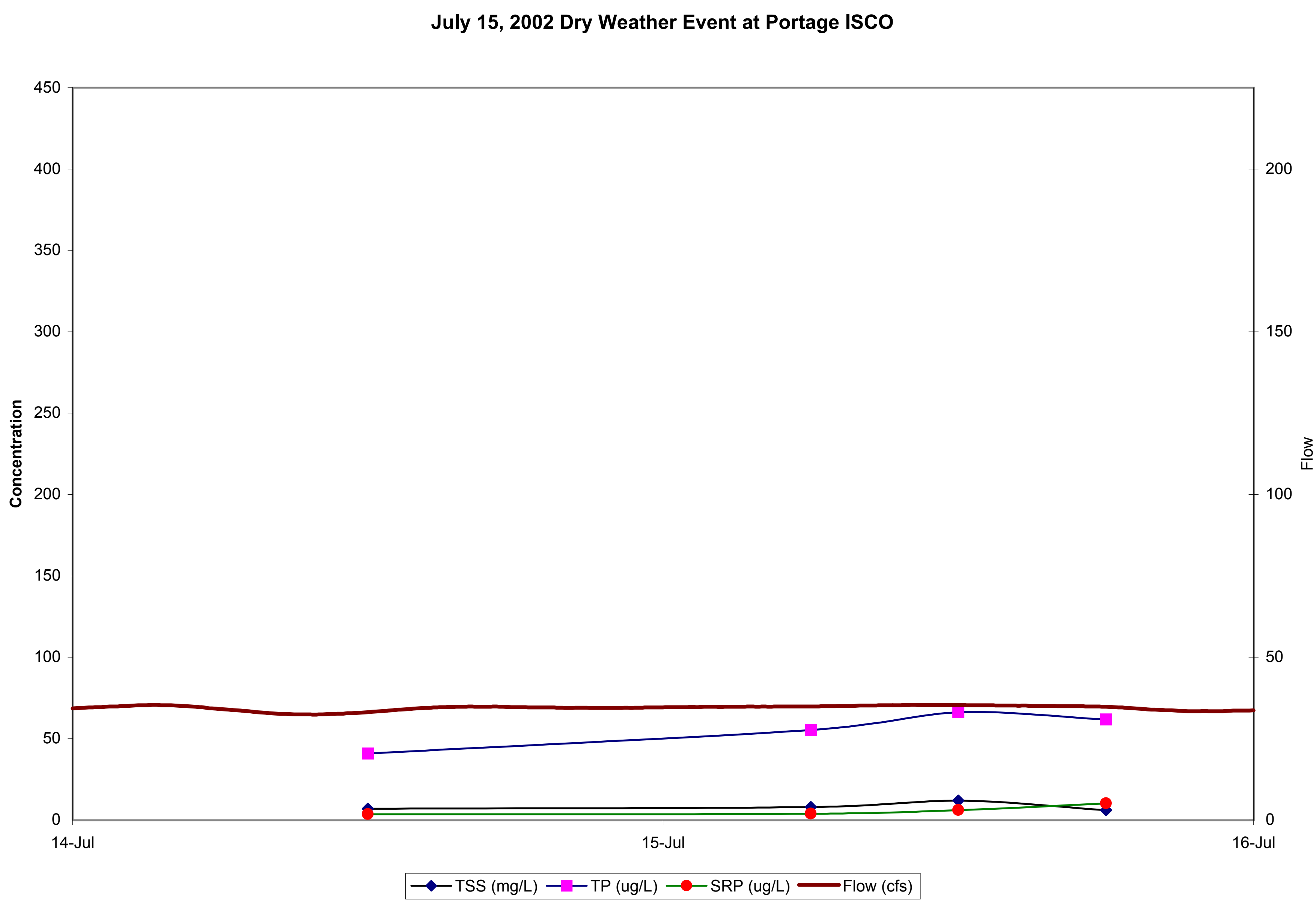


January 17, 2002 Dry Weather Event at Portage ISCO
Concentration
Flow
450
400
350
300
250
200
150
100
50
0
200
150
100
50
0
16-Jan
16-Jan
16-Jan
17-Jan
17-Jan
17-Jan
17-Jan
17-Jan
18-Jan
18-Jan
18-Jan
TSS (mg/L)
TP (ug/L)
Flow (cfs)

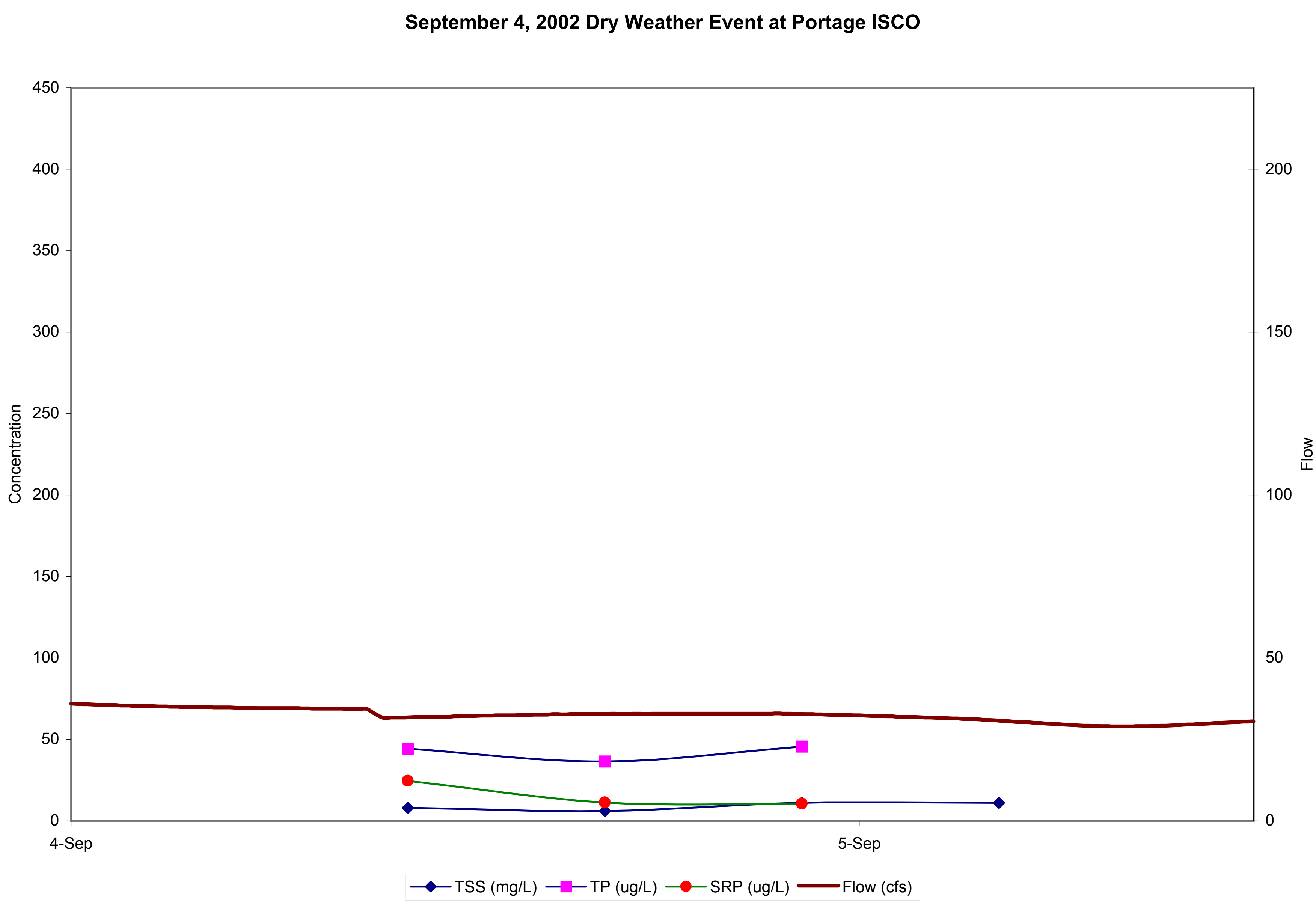

February 25, 2002 Dry Weather Event at Portage ISCO
Concentration
Flow
450
400
350
300
250
200
150
100
50
0
200
150
100
50
0
24-Feb
25-Feb
26-Feb
TSS (mg/L)
TP (ug/L)
Flow (cfs)


May 21, 2002 Dry Weather Event at Portage ISCO
Concentration
Flow
450
400
350
300
250
200
150
100
50
0
200
150
100
50
0
21-May
21-May
21-May
21-May
21-May
22-May
22-May
22-May
22-May
22-May
23-May
TSS (mg/L)
TP (ug/L)
Flow (cfs)

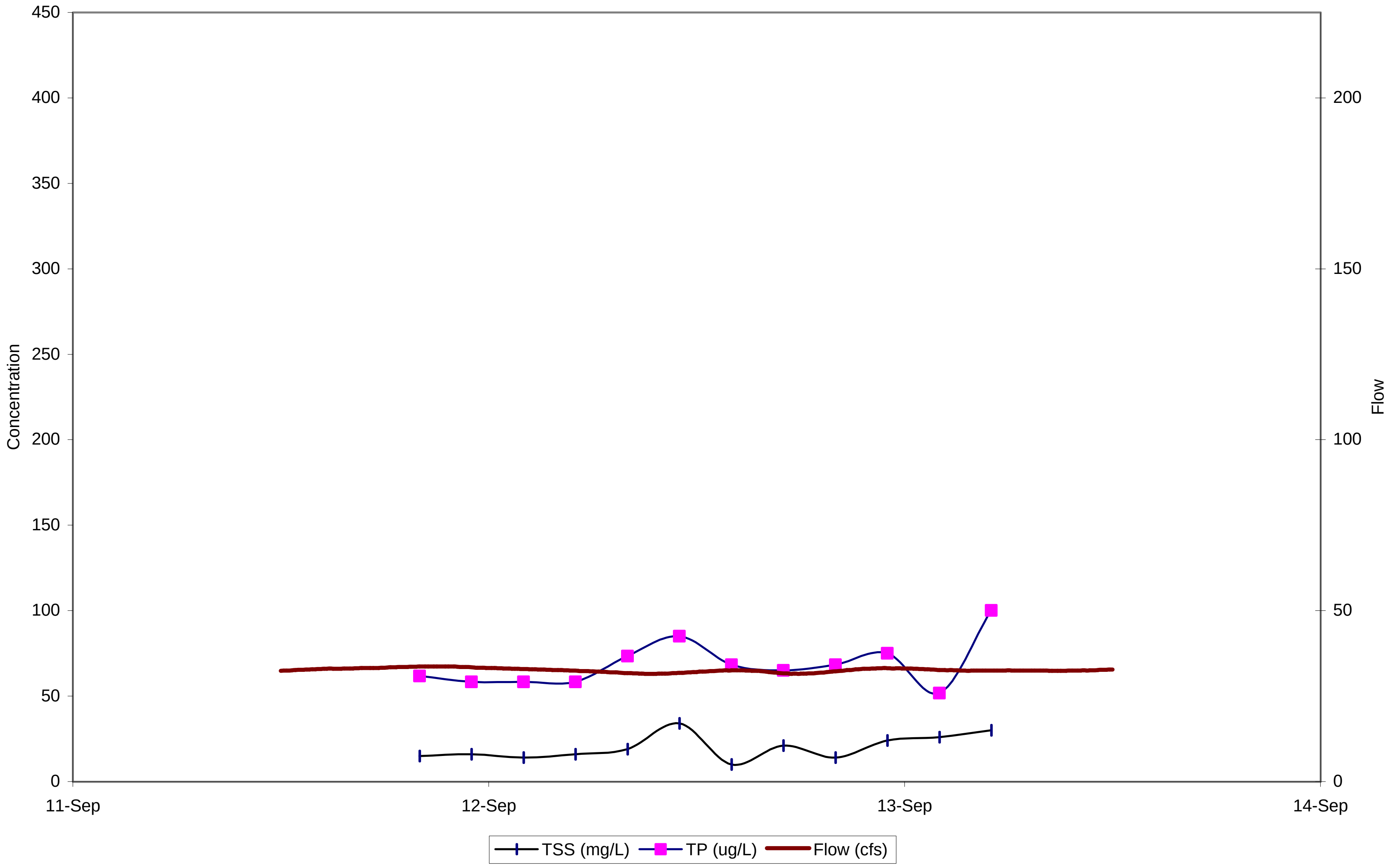

June 14-18, 2002 Dry Weather Event at Portage ISCO
Concentration
450
400
350
300
250
200
150
100
50
0
Flow
200
150
100
50
0
14-Jun
15-Jun
16-Jun
17-Jun
18-Jun
19-Jun
TSS (mg/L)
TP (ug/L)
Flow (cfs)

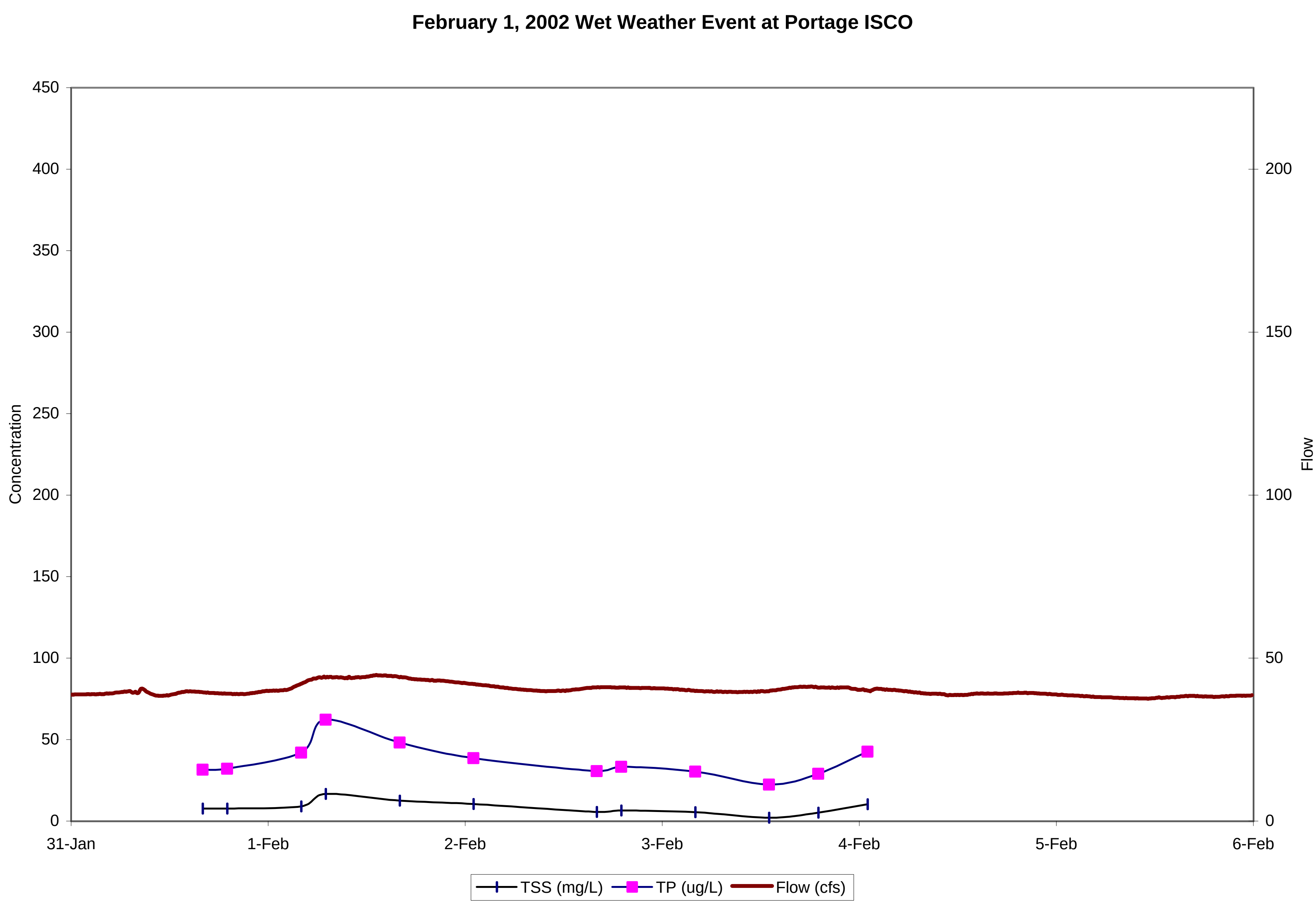


July 15, 2002 Dry Weather Event at Portage ISCO
Concentration
Flow
450
400
350
300
250
200
150
100
50
0
200
150
100
50
0
14-Jul
15-Jul
16-Jul
TSS (mg/L)
TP (ug/L)
SRP (ug/L)
Flow (cfs)


September 4, 2002 Dry Weather Event at Portage ISCO
Concentration
Flow
450
400
350
300
250
200
150
100
50
0
200
150
100
50
0
4-Sep
5-Sep
TSS (mg/L)
TP (ug/L)
SRP (ug/L)
Flow (cfs)

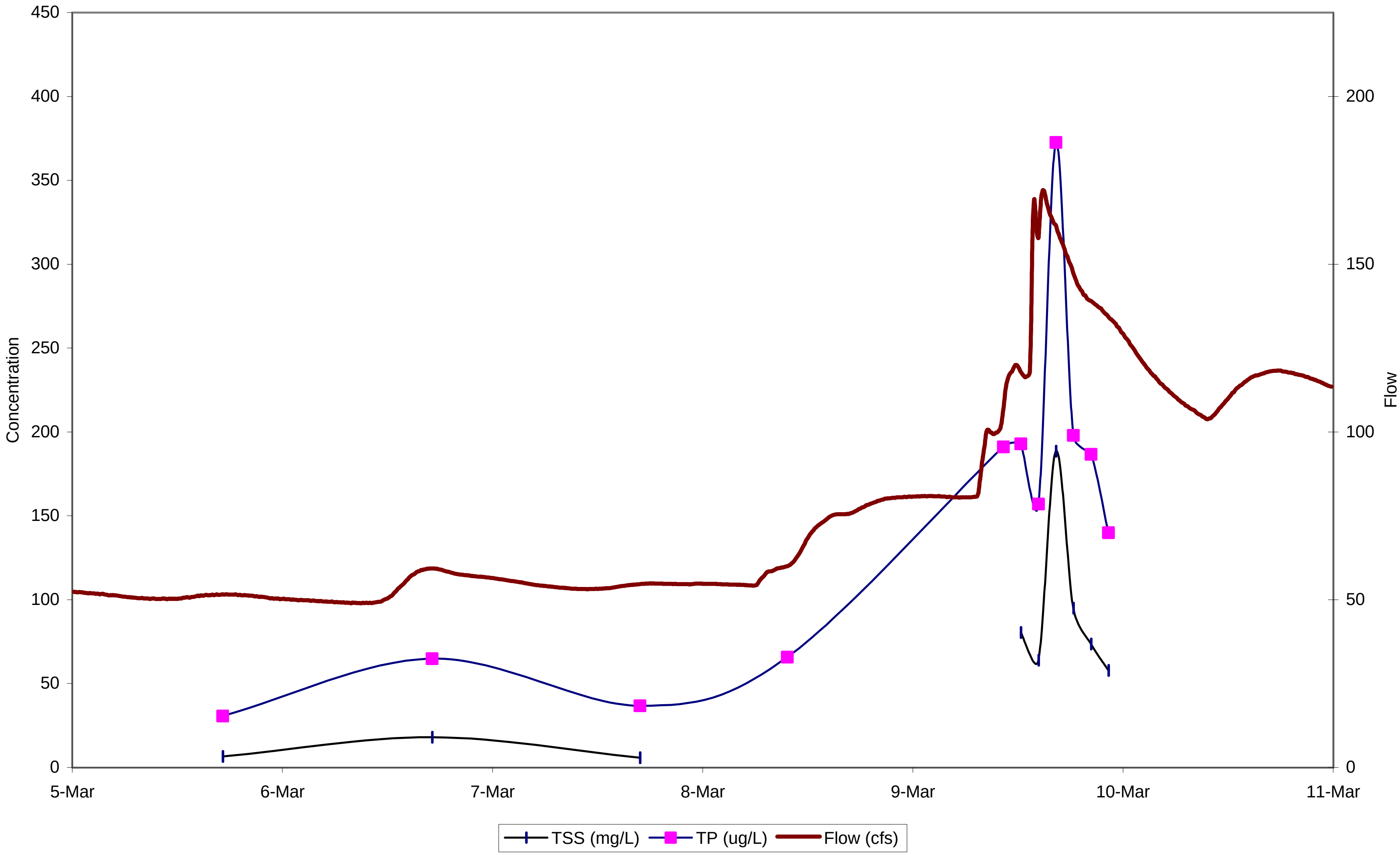
September 11-13, 2002 Dry Weather Event at Portage ISCO

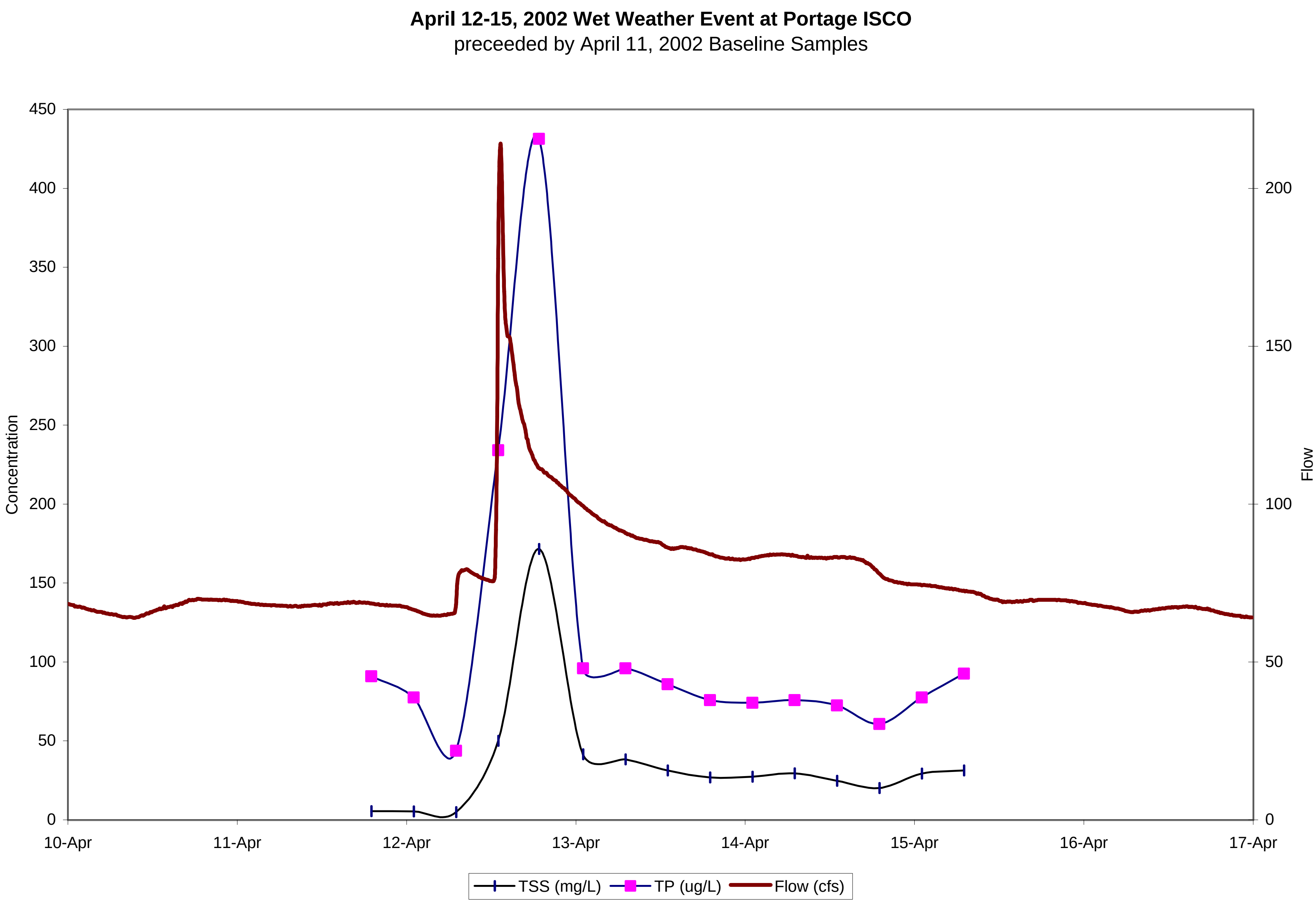




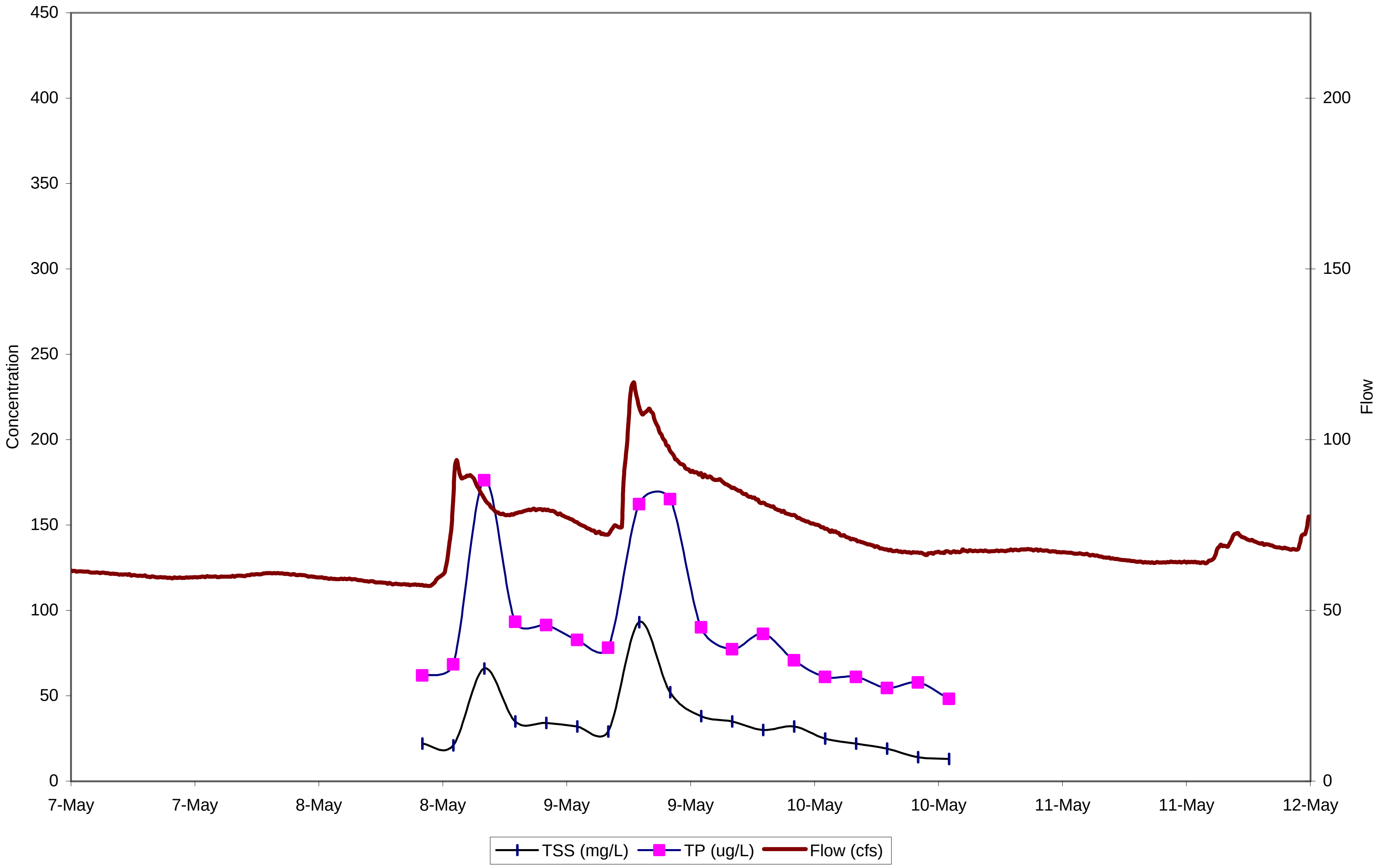
February 1, 2002 Wet Weather Event at Portage ISCO
Concentration
Flow
450
400
350
300
250
200
150
100
50
0
200
150
100
50
0
31-Jan
1-Feb
2-Feb
3-Feb
4-Feb
5-Feb
6-Feb
TSS (mg/L)
TP (ug/L)
Flow (cfs)

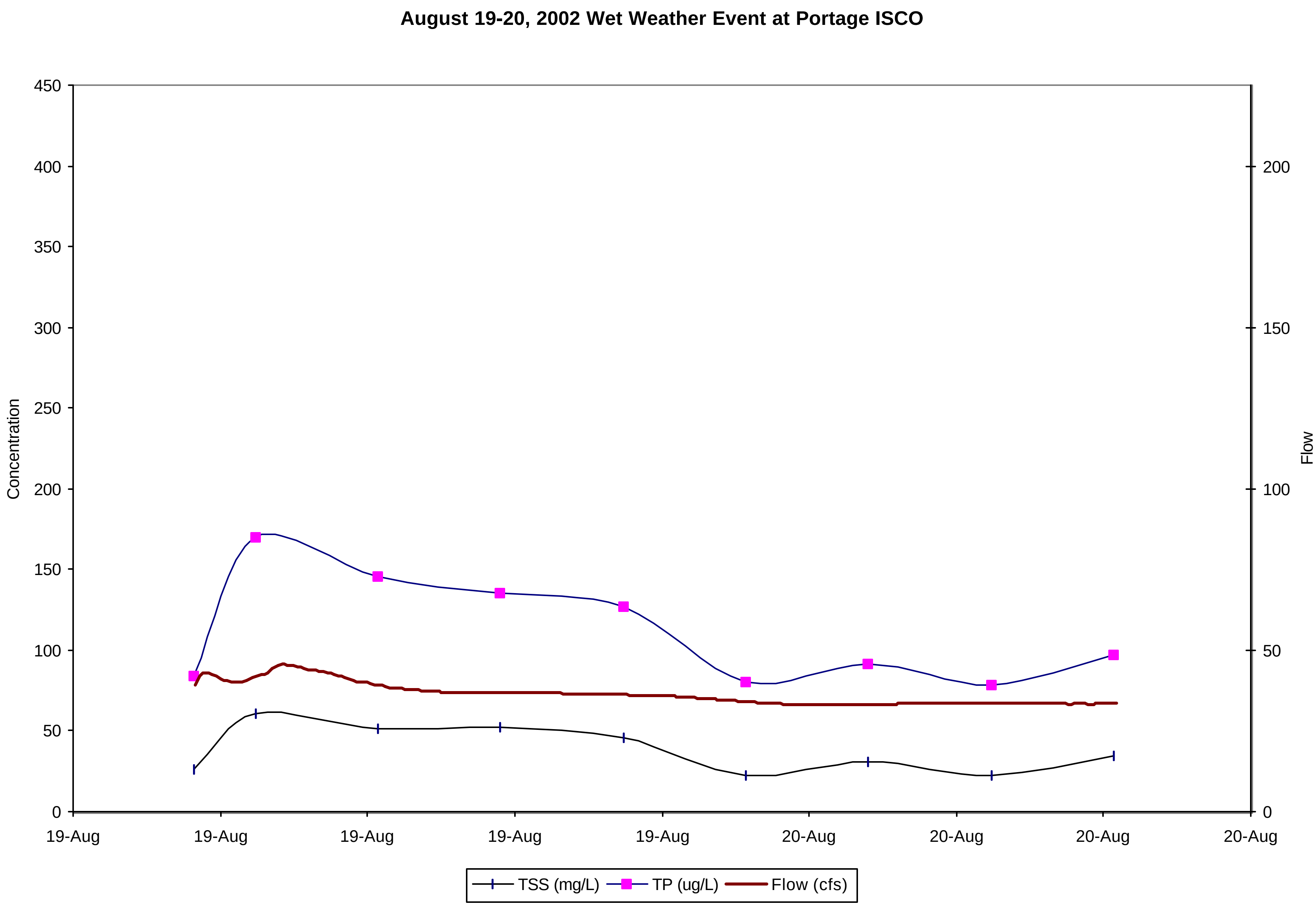
March 9, 2002 Wet Weather Event at Portage ISCO
preceeded by March 5-7, 2002 Baseline Sampling



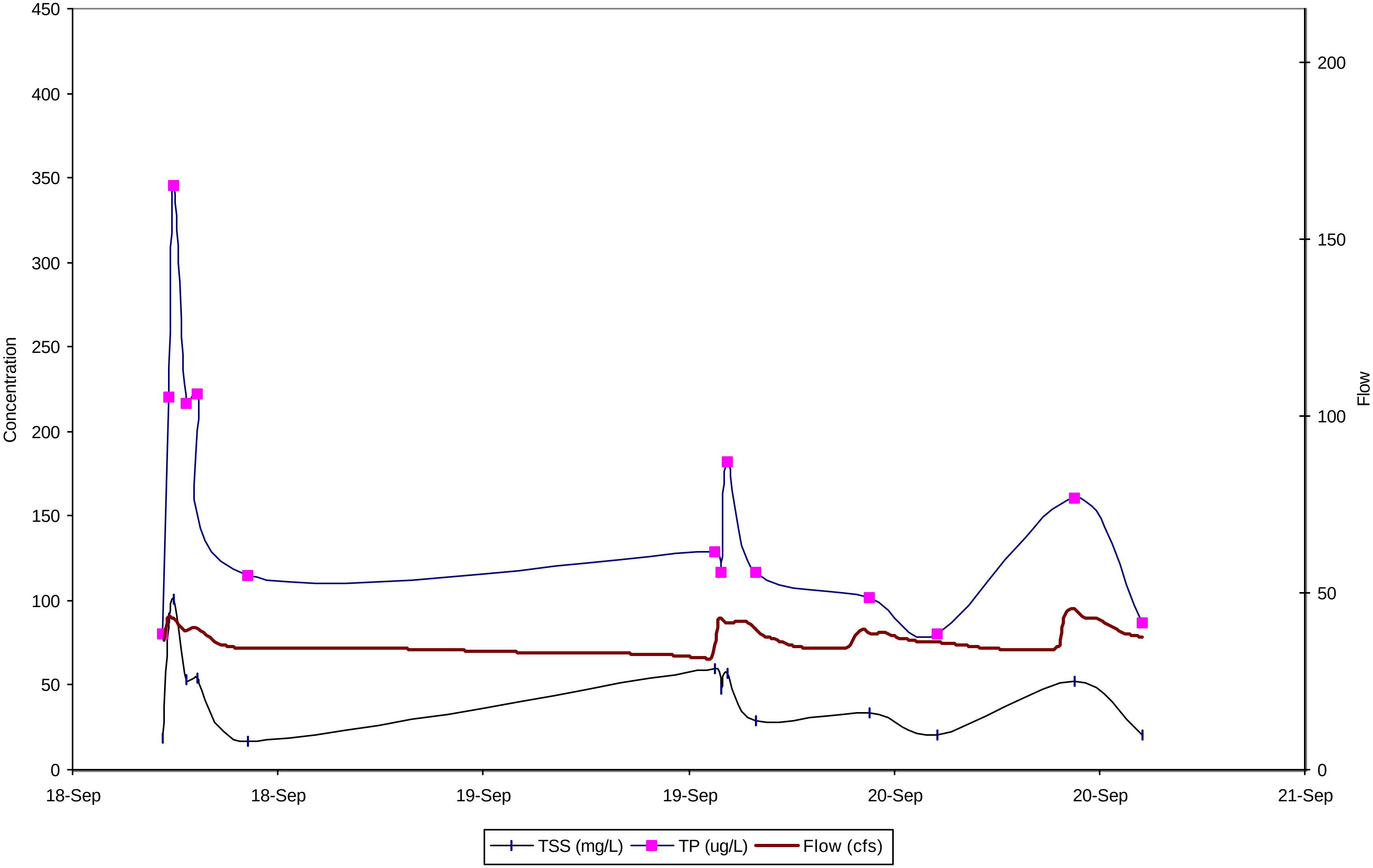

April 12-15, 2002 Wet Weather Event at Portage ISCO
preceeded by April 11, 2002 Baseline Samples
Concentration
Flow
450
400
350
300
250
200
150
100
50
0
200
150
100
50
0
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
16-Apr
17-Apr
TSS (mg/L)
TP (ug/L)
Flow (cfs)

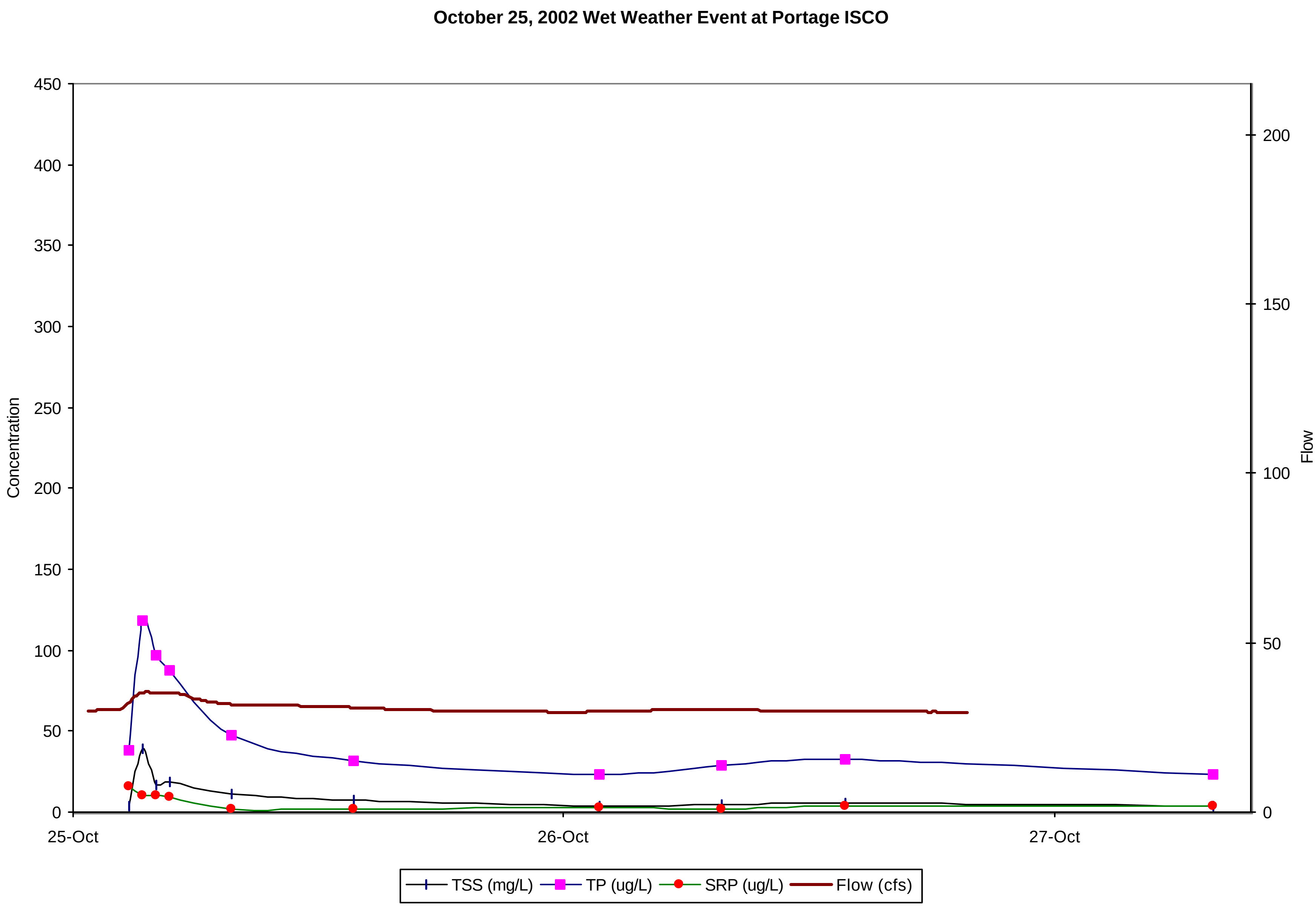
May 8-10, 2002 Wet Weather Event at Portage ISCO



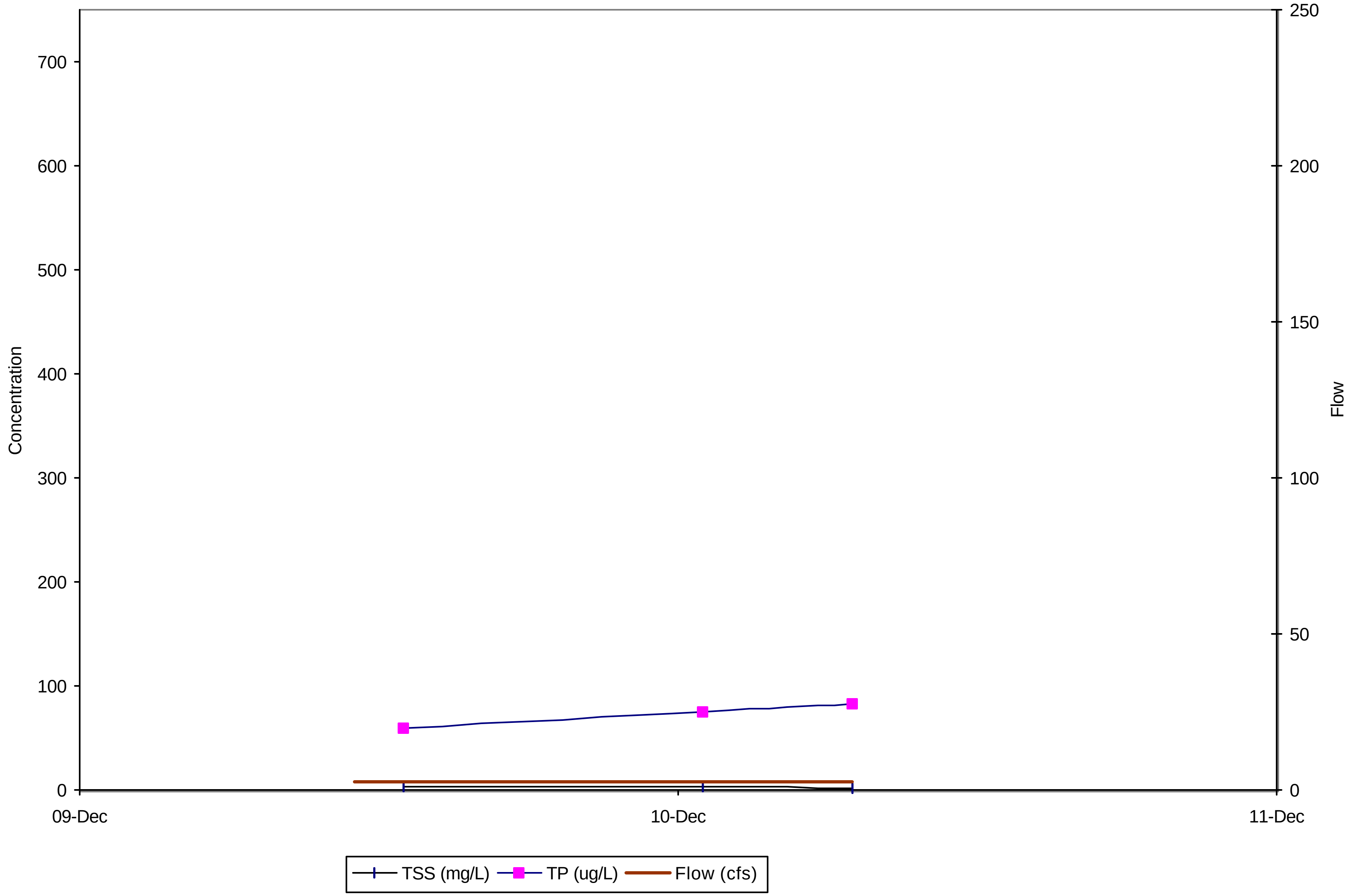

August 19-20, 2002 Wet Weather Event at Portage ISCO
Concentration
Flow
450
400
350
300
250
200
150
100
50
0
200
150
100
50
0
19-Aug
19-Aug
19-Aug
19-Aug
19-Aug
20-Aug
20-Aug
20-Aug
20-Aug
TSS (mg/L)
TP (ug/L)
Flow (cfs)

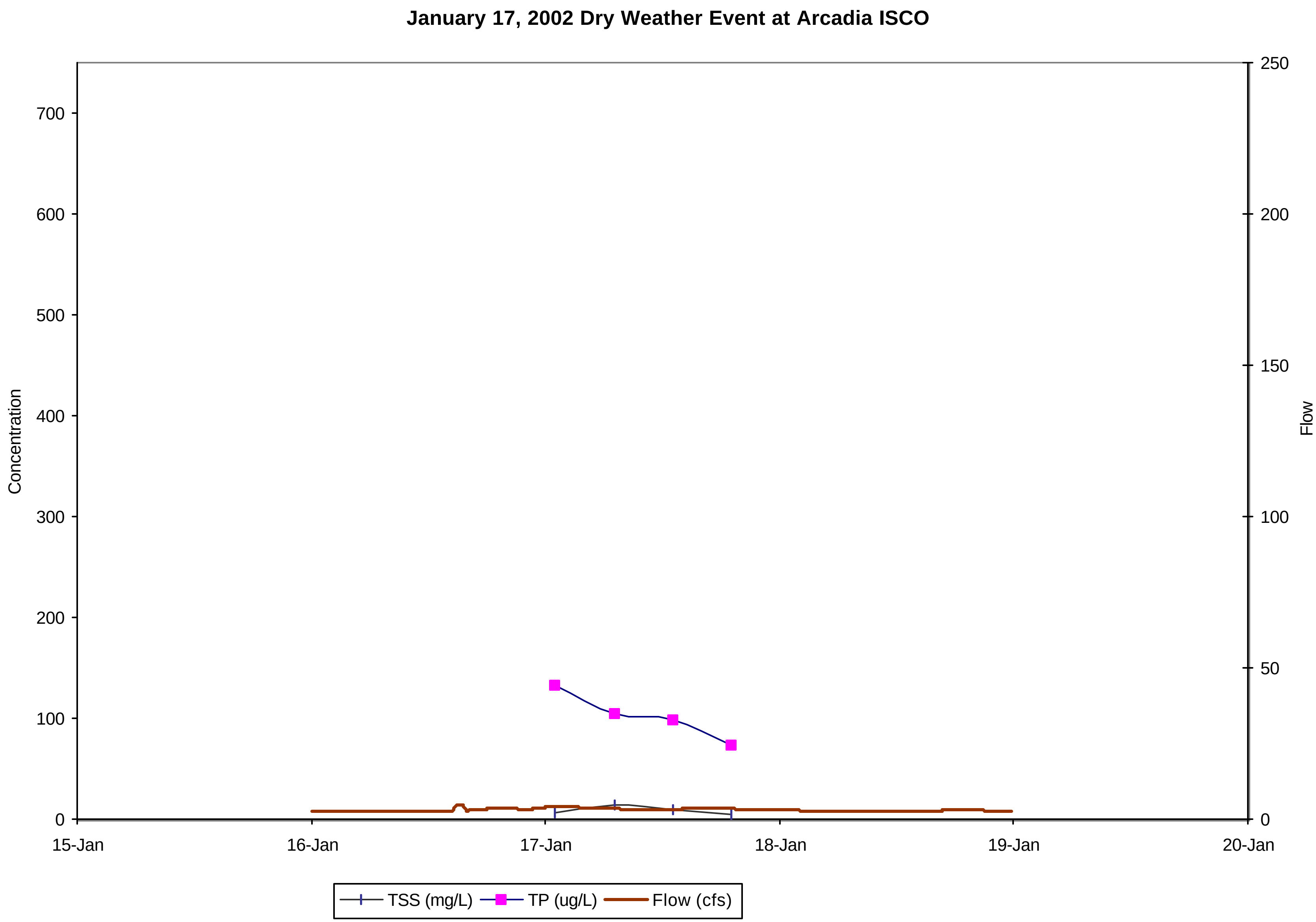
September 18-20, 2002 Wet Weather Events at Portage ISCO



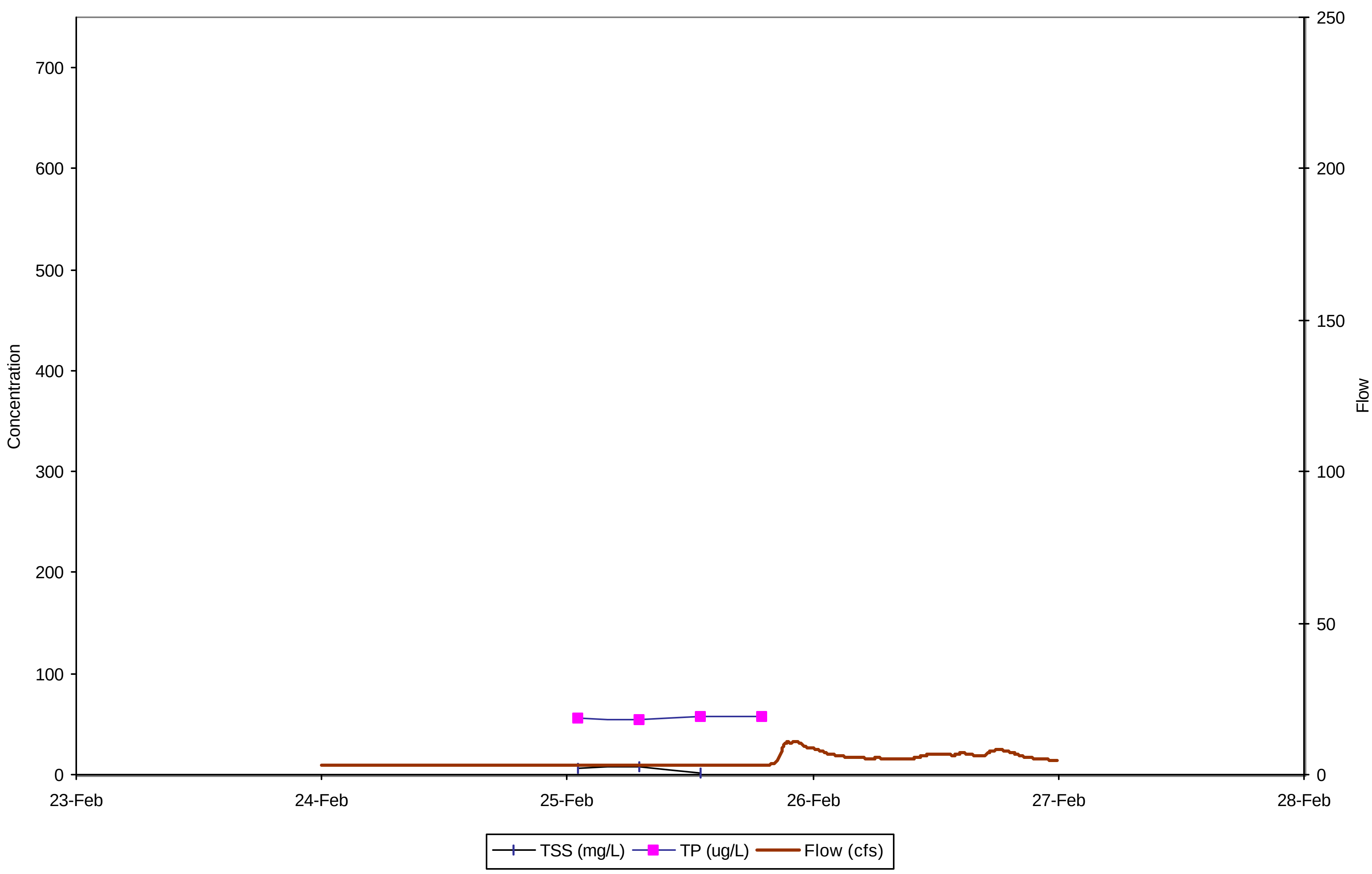

October 25, 2002 Wet Weather Event at Portage ISCO
Concentration
Flow
0
50
100
150
200
250
300
350
400
450
0
50
100
150
200
25-Oct
26-Oct
27-Oct
TSS (mg/L)
TP (ug/L)
SRP (ug/L)
Flow (cfs)

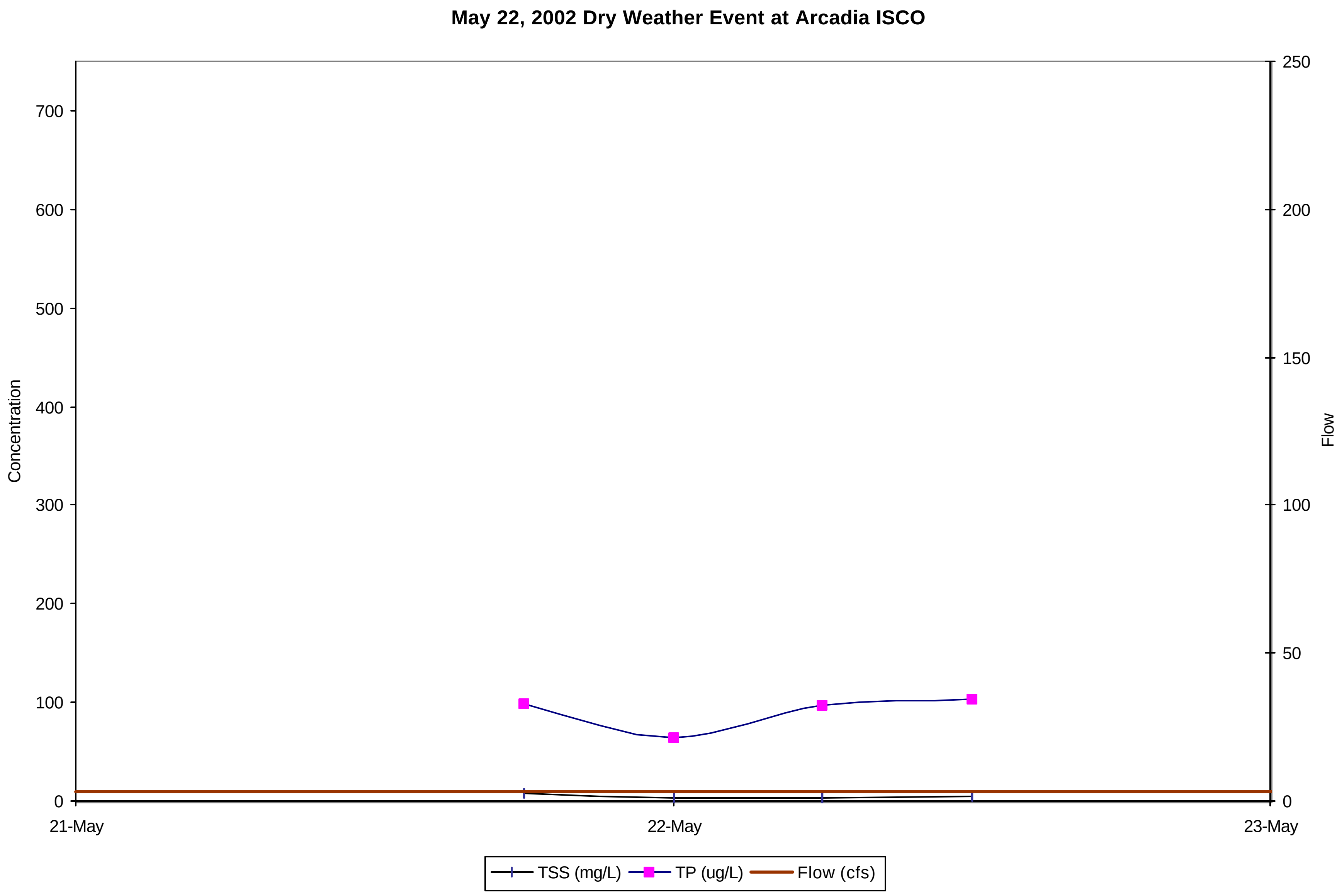
December 10, 2001 Dry Weather Event at Arcadia ISCO



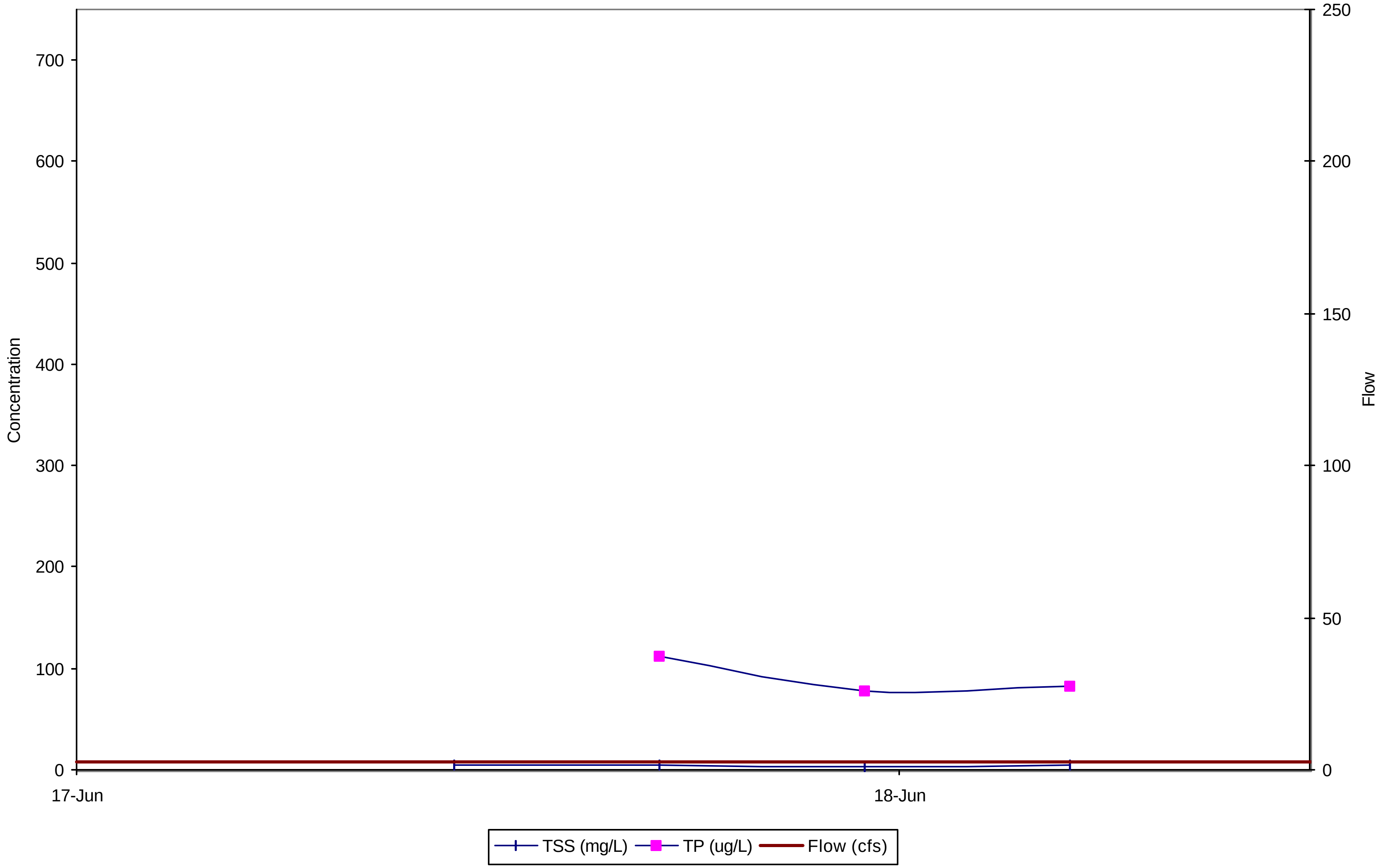

January 17, 2002 Dry Weather Event at Arcadia ISCO
Concentration
Flow
0
100
200
300
400
500
600
700
0
50
100
150
200
250
15-Jan
16-Jan
17-Jan
18-Jan
19-Jan
20-Jan
TSS (mg/L)
TP (ug/L)
Flow (cfs)

February 25, 2002 Dry Weather Event at Arcadia ISCO

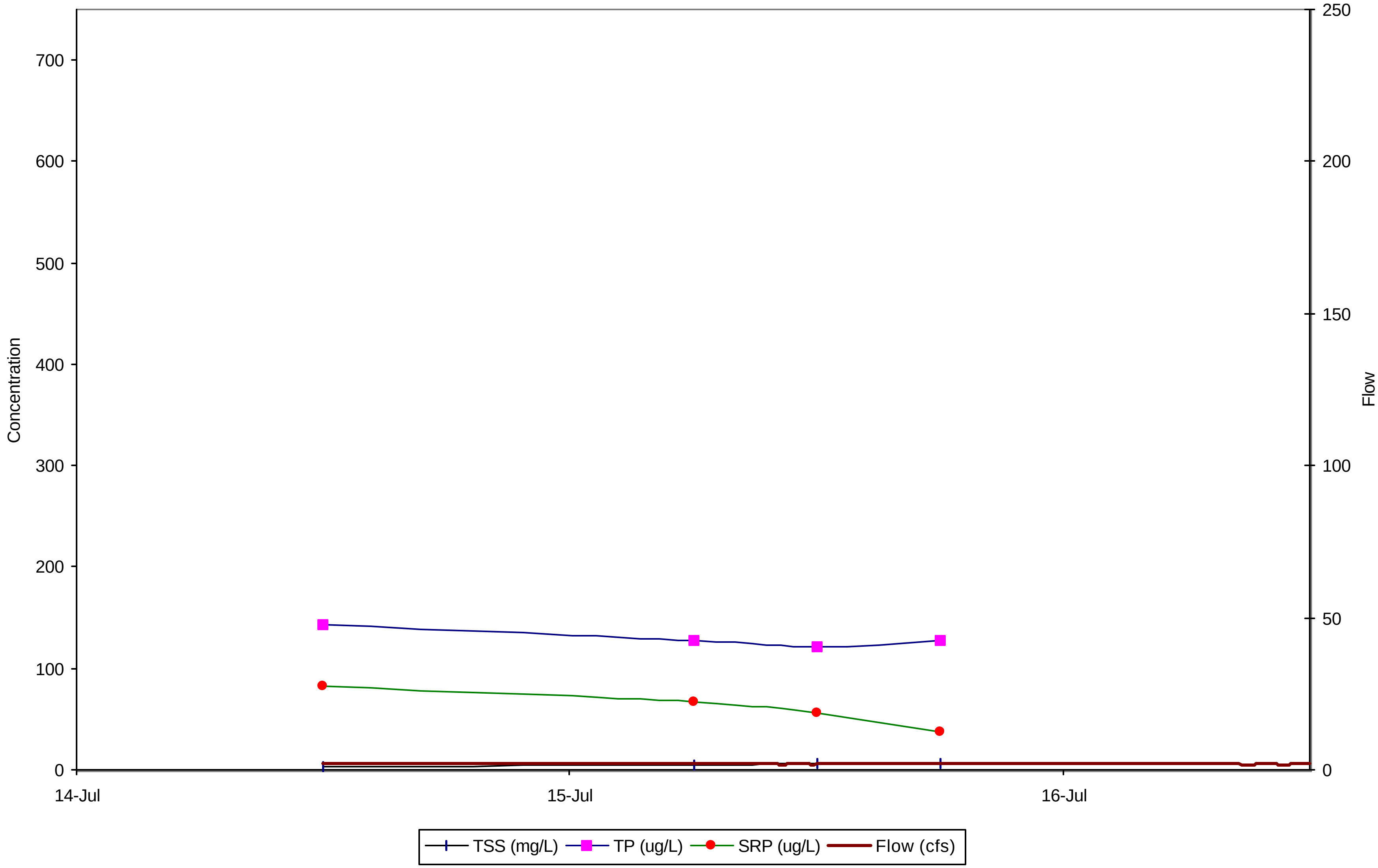


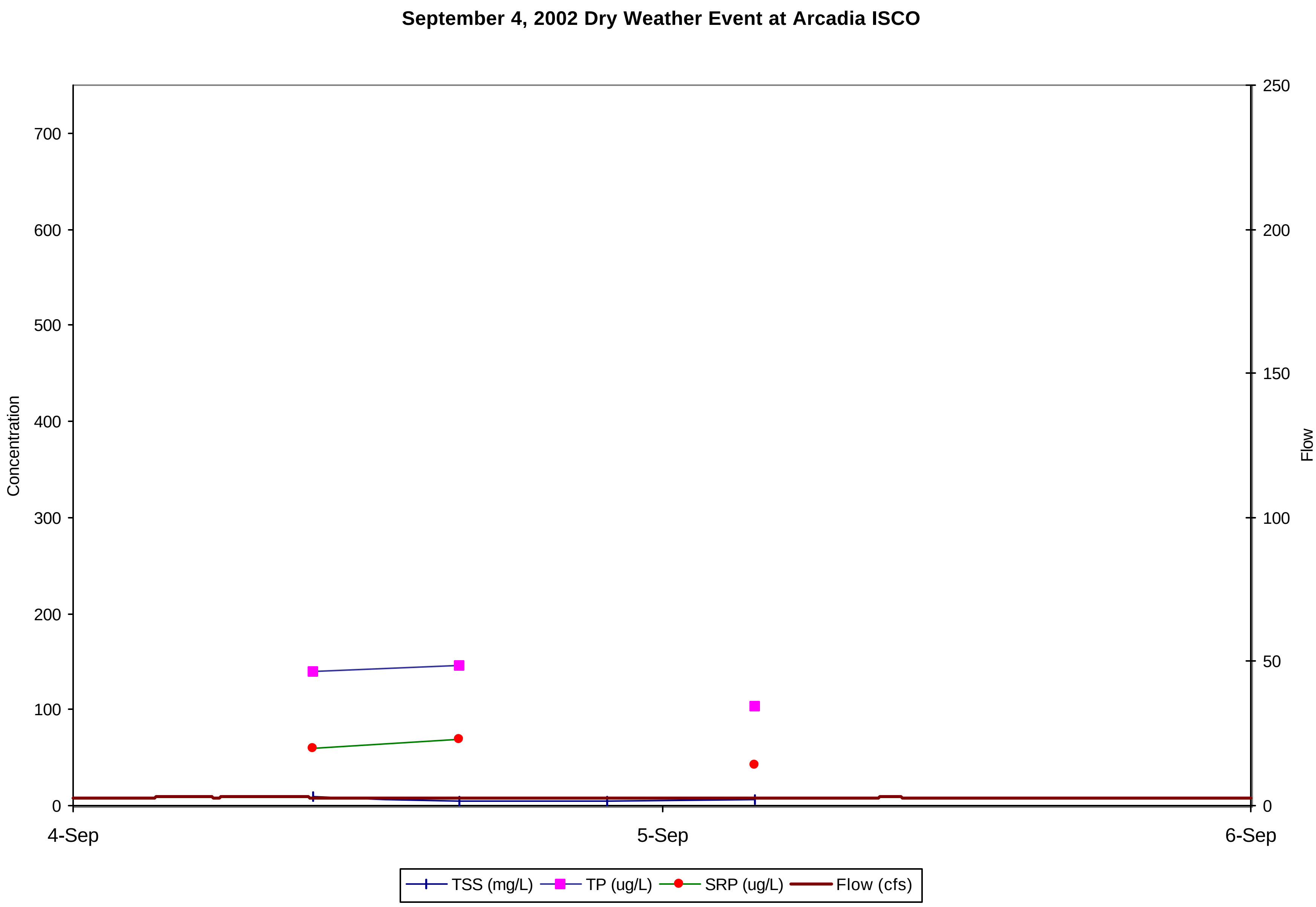

May 22, 2002 Dry Weather Event at Arcadia ISCO
Concentration
Flow
0
100
200
300
400
500
600
700
0
50
100
150
200
250
21-May
22-May
23-May
TSS (mg/L)
TP (ug/L)
Flow (cfs)

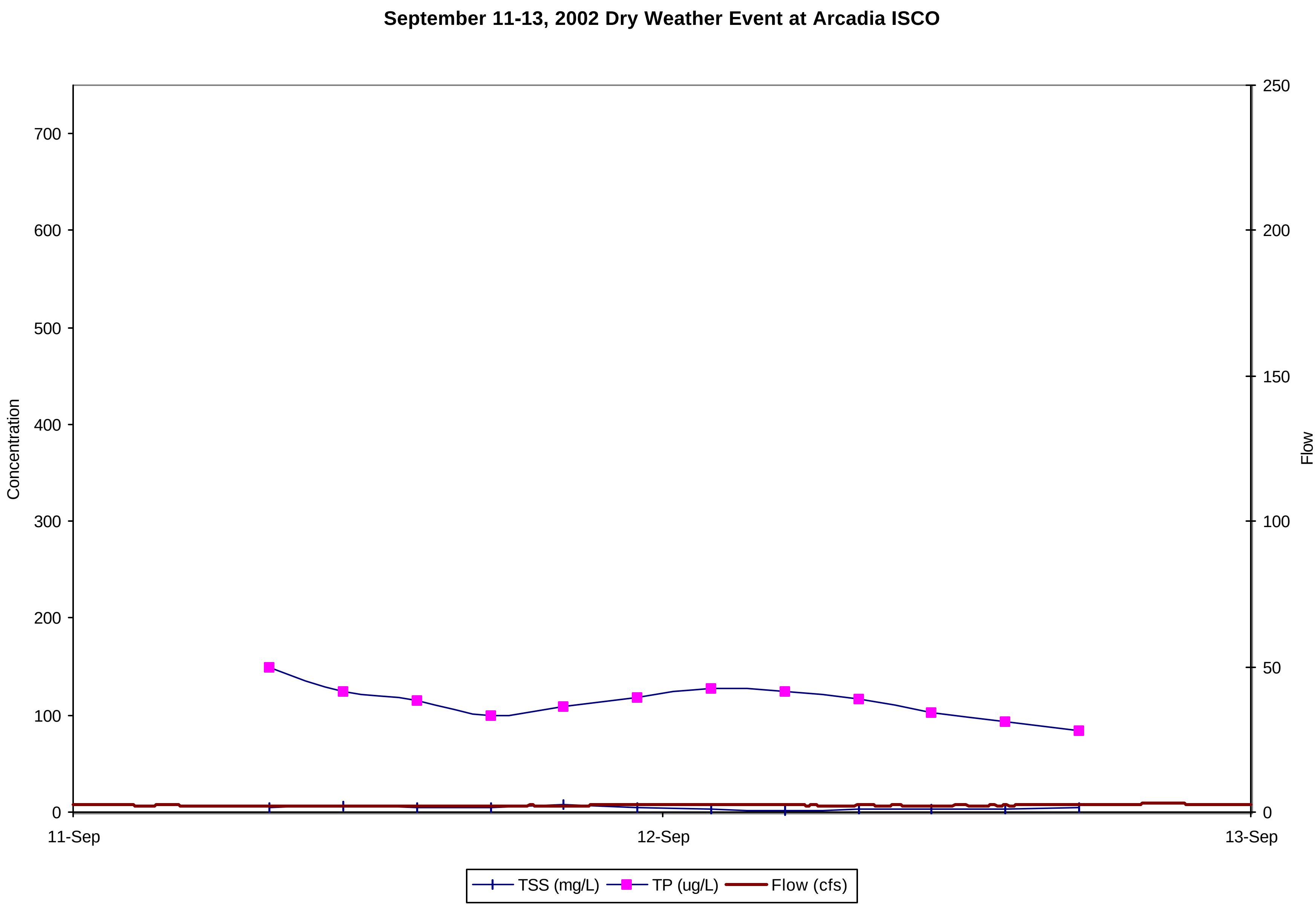
June 17, 2002 Dry Weather Event at Arcadia ISCO



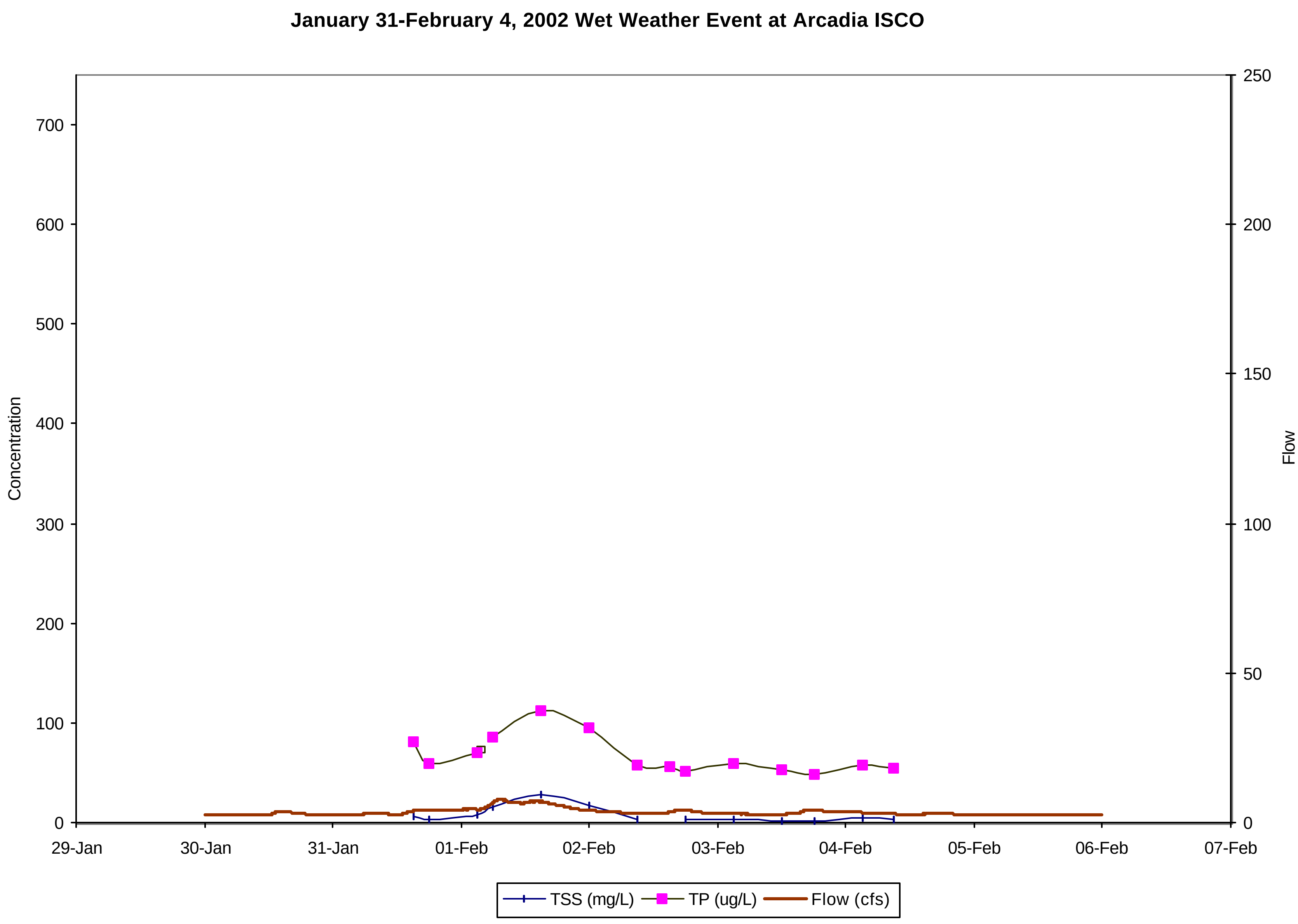
July 15, 2002 Dry Weather Event at Arcadia ISCO




September 4, 2002 Dry Weather Event at Arcadia ISCO
Concentration
700
600
500
400
300
200
100
0
Flow
250
200
150
100
50
0
4-Sep
5-Sep
6-Sep
TSS (mg/L)
TP (ug/L)
SRP (ug/L)
Flow (cfs)

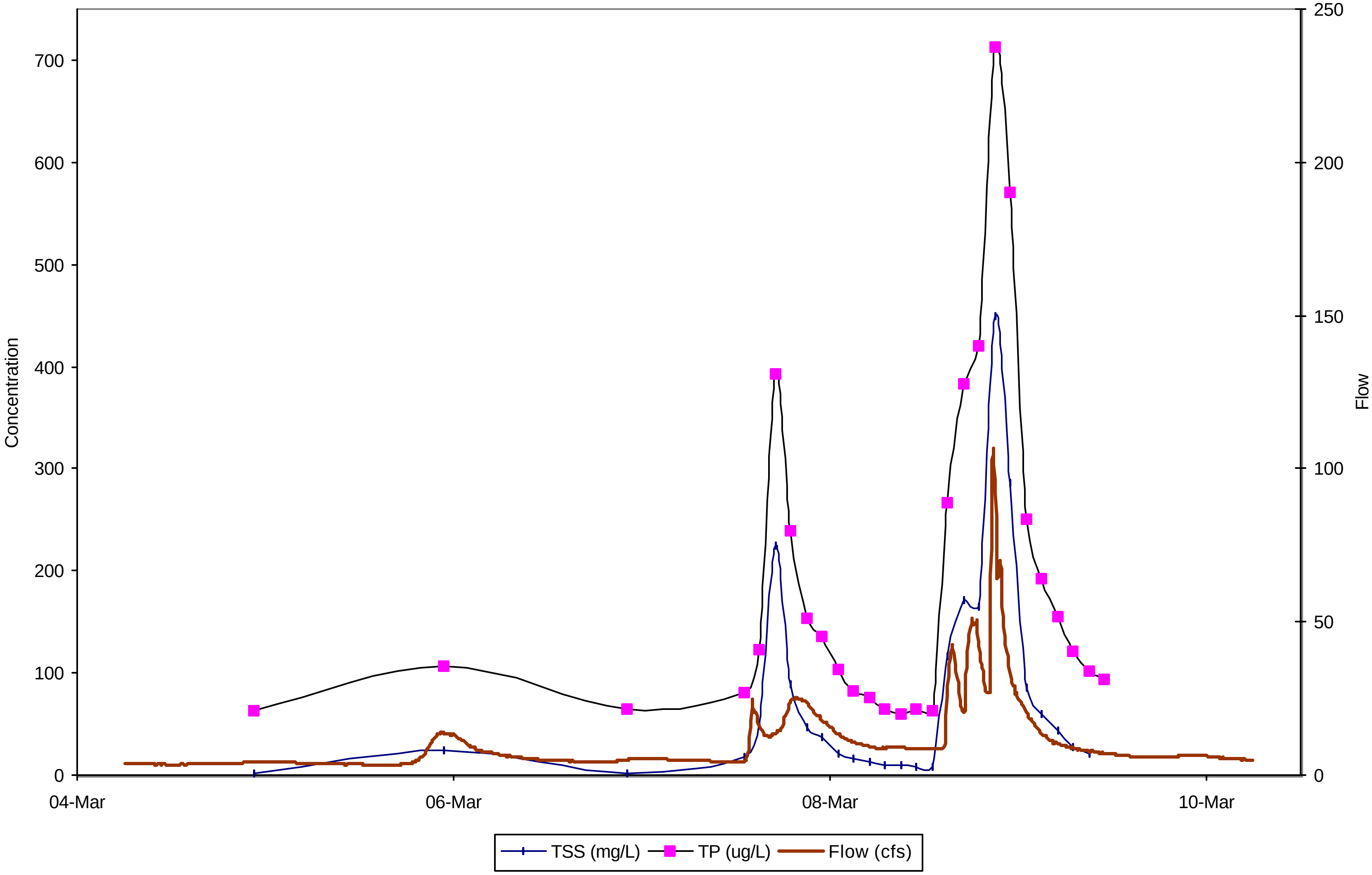


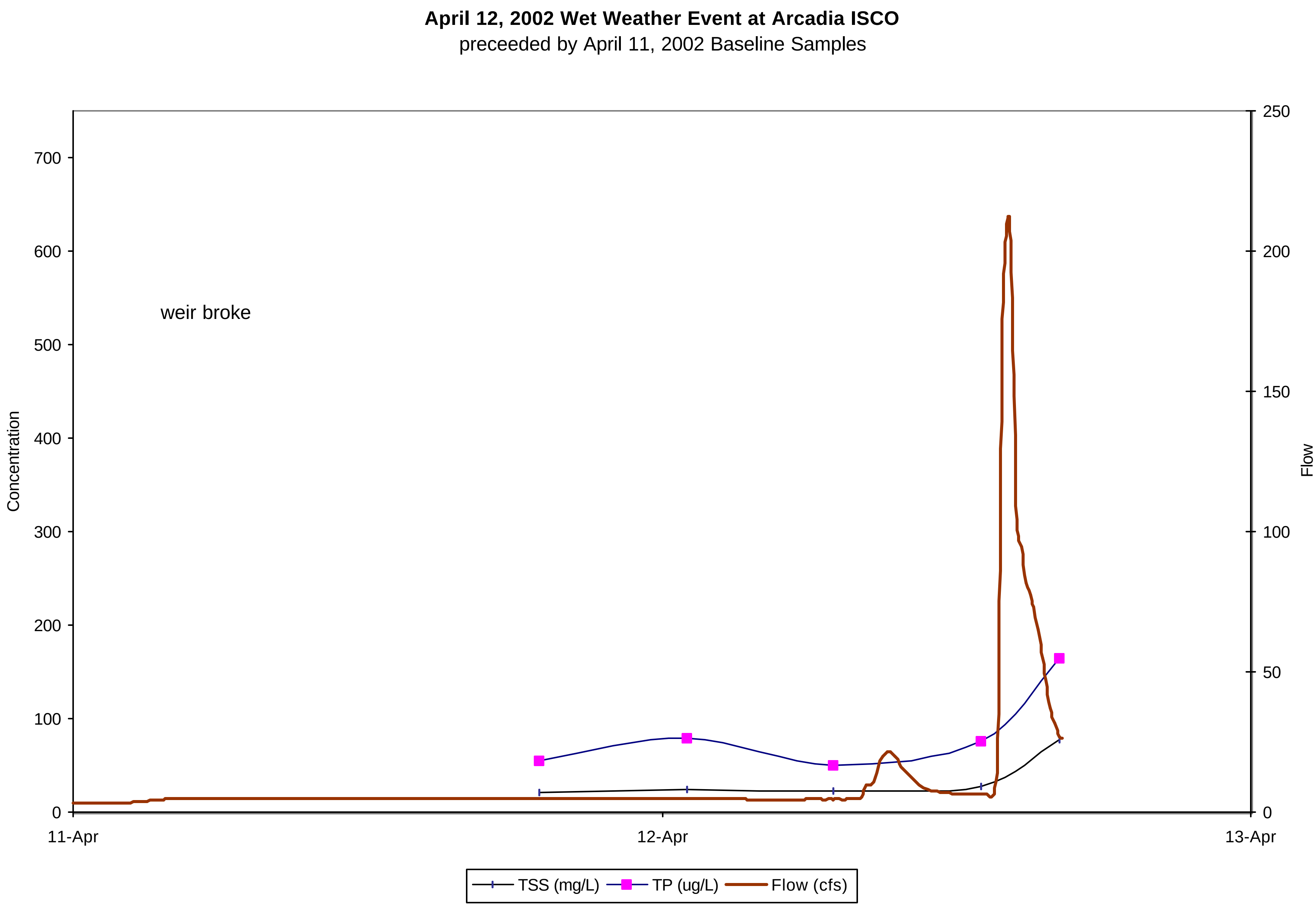
September 11-13, 2002 Dry Weather Event at Arcadia ISCO
Concentration
0
100
200
300
400
500
600
700
Flow
0
50
100
150
200
250
11-Sep
12-Sep
13-Sep
TSS (mg/L)
TP (ug/L)
Flow (cfs)



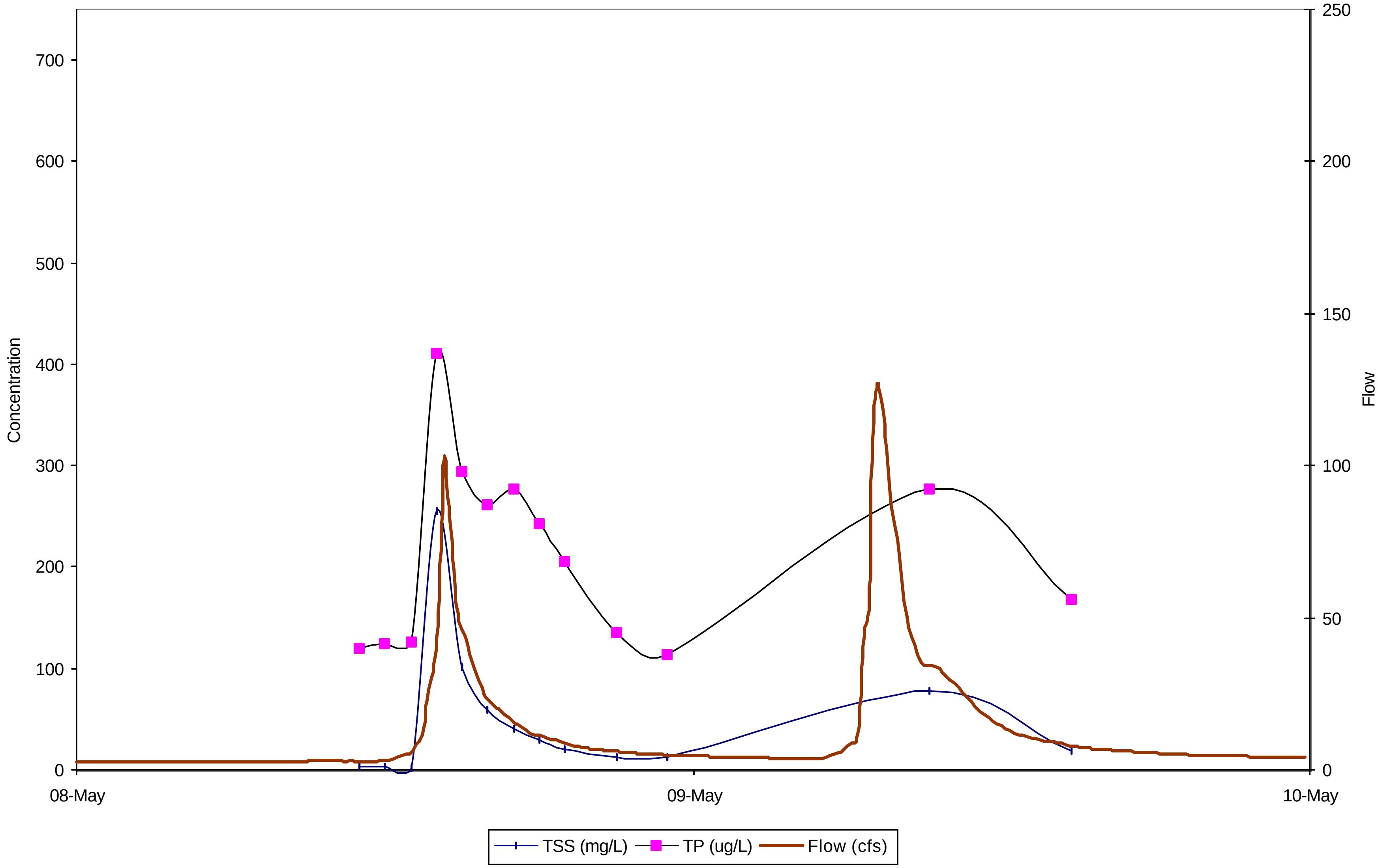
January 31-February 4, 2002 Wet Weather Event at Arcadia ISCO
Concentration
Flow
0
100
200
300
400
500
600
700
0
50
100
150
200
250
29-Jan
30-Jan
31-Jan
01-Feb
02-Feb
03-Feb
04-Feb
05-Feb
06-Feb
07-Feb
TSS (mg/L)
TP (ug/L)
Flow (cfs)

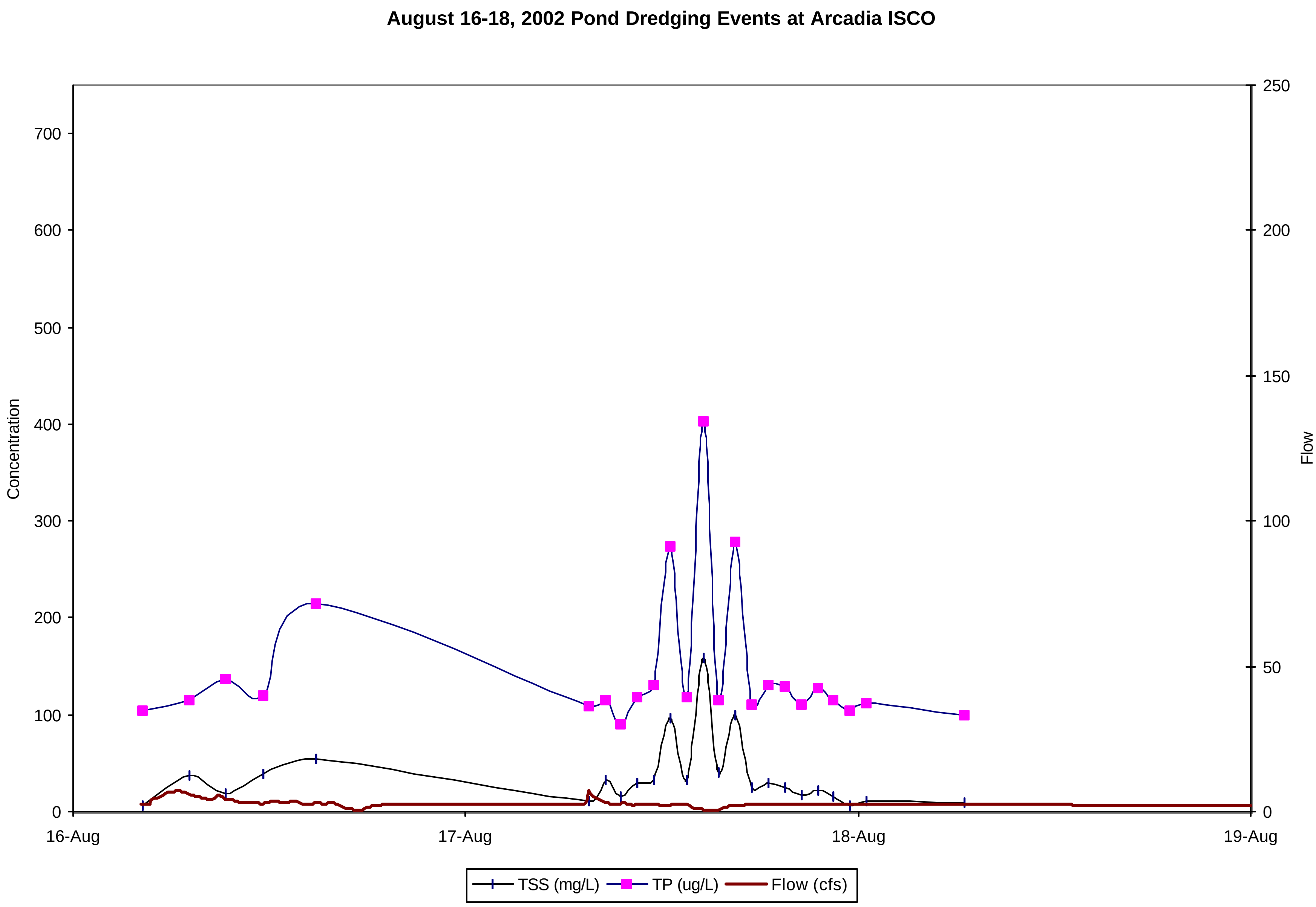
March 8-10, 2002 Wet Weather Event at Arcadia ISCO
preceeded by March 5-7, 2002 Baseline Samples




April 12, 2002 Wet Weather Event at Arcadia ISCO
preceeded by April 11, 2002 Baseline Samples
Concentration
Flow
0
100
200
300
400
500
600
700
0
50
100
150
200
250
11-Apr
12-Apr
13-Apr
weir broke
TSS (mg/L)
TP (ug/L)
Flow (cfs)

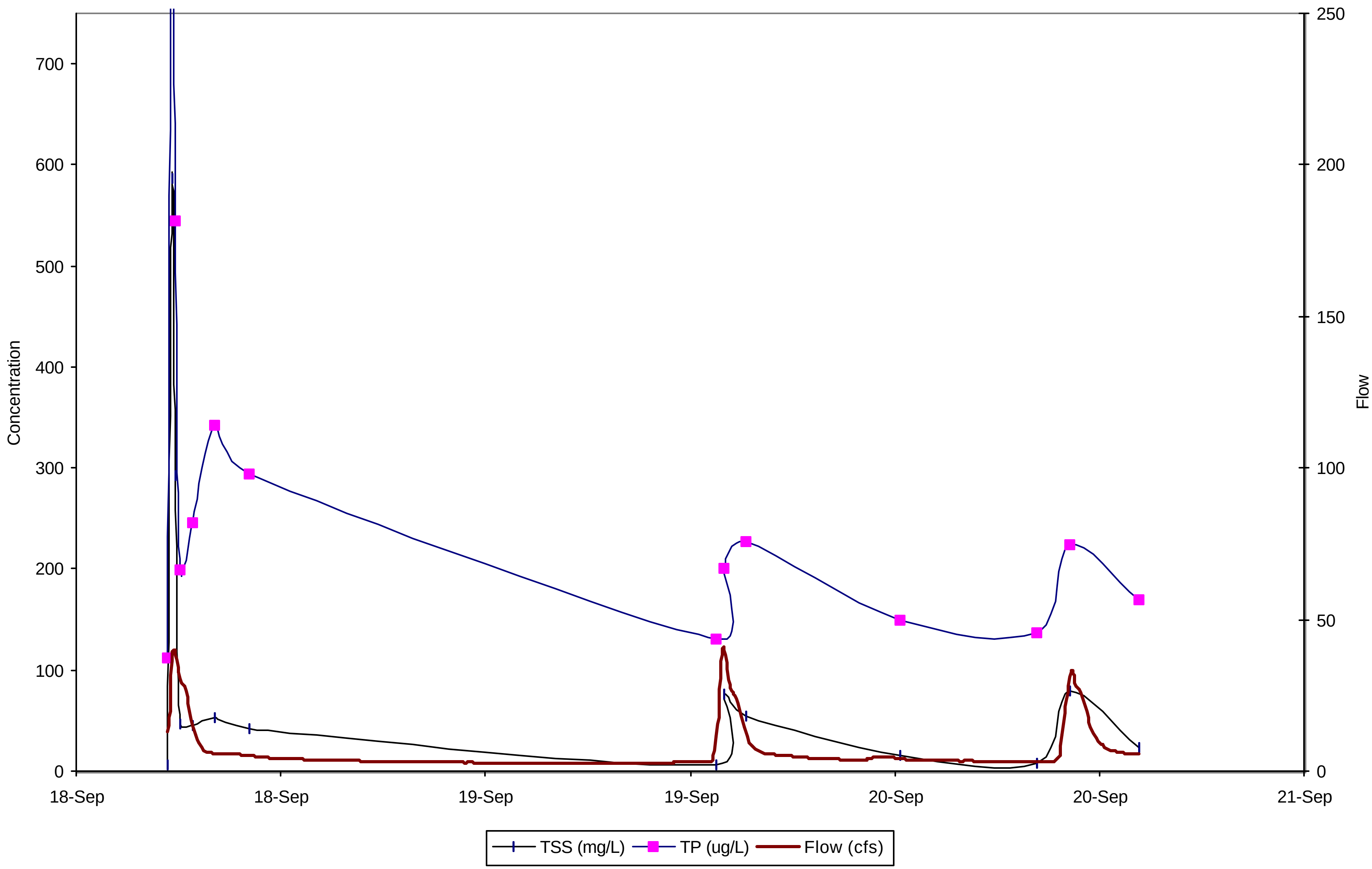
May 8-9, 2002 Wet Weather Event at Arcadia Isco

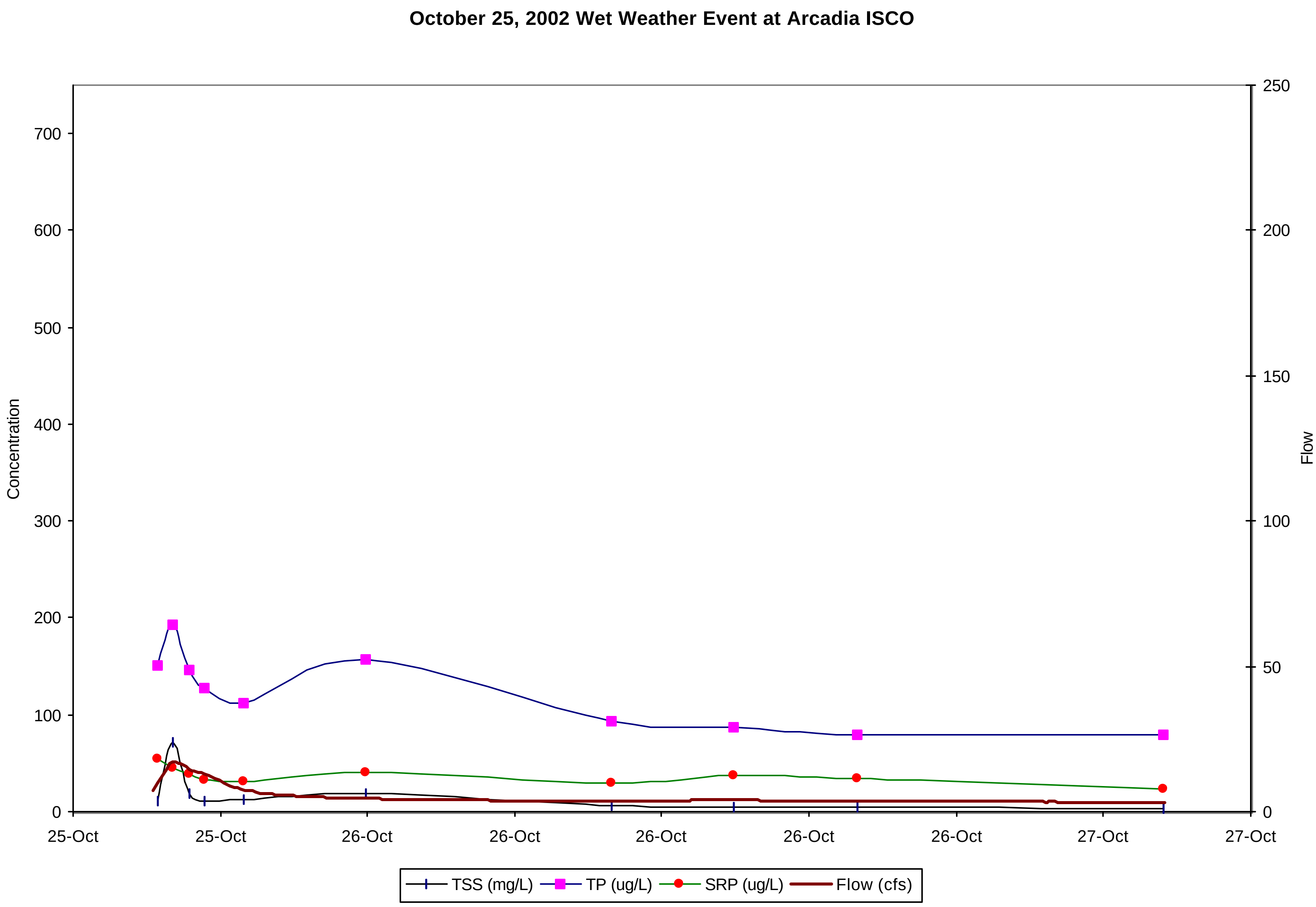




August 16-18, 2002 Pond Dredging Events at Arcadia ISCO
Concentration
Flow
0
100
200
300
400
500
600
700
0
50
100
150
200
250
16-Aug
17-Aug
18-Aug
19-Aug
TSS (mg/L)
TP (ug/L)
Flow (cfs)

September 18-20, 2002 Wet Weather Events at Arcadia ISCO




October 25, 2002 Wet Weather Event at Arcadia ISCO
Concentration
Flow
0
100
200
300
400
500
600
700
0
50
100
150
200
250
25-Oct
25-Oct
26-Oct
26-Oct
26-Oct
26-Oct
26-Oct
27-Oct
27-Oct
TSS (mg/L)
TP (ug/L)
SRP (ug/L)
Flow (cfs)

Attachment D

Analytical Laboratory Results

Available Upon Request