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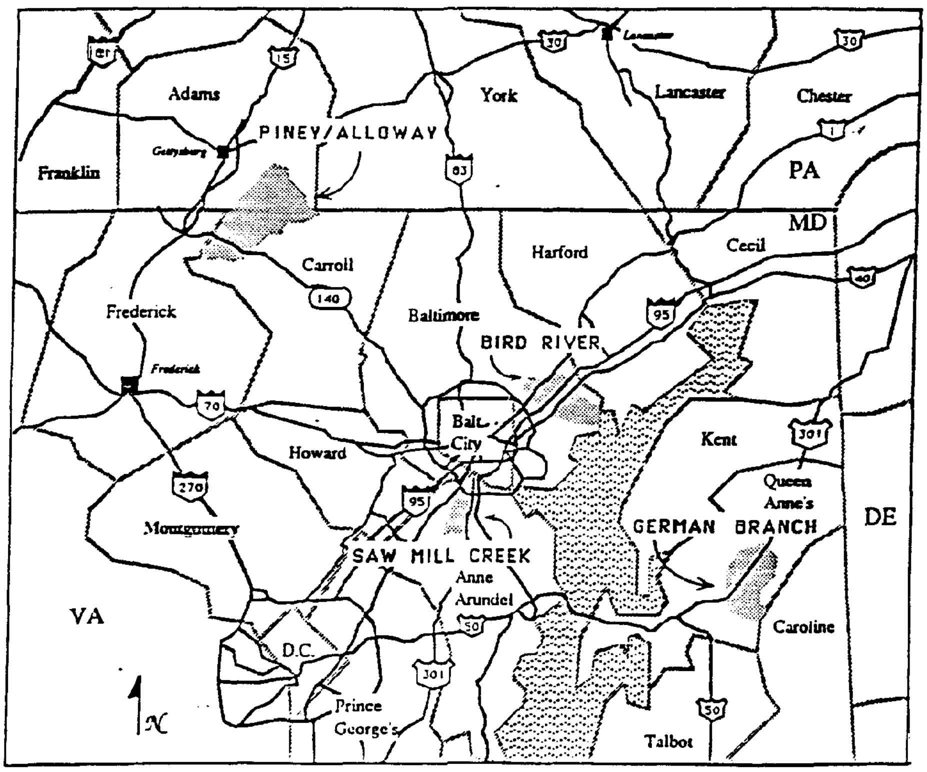
Task 14

Targeted Watershed Project: Implementation Monitoring

FINAL DATA REPORT

(A Report to the Maryland Coastal Zone Management Program
in accordance with Contract # C286-92-005)



Maryland Targeted Watershed Project

Tidewater Administration

July 1993

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This report was prepared by the staff of the Targeted Watershed Program at the Maryland Department of Natural Resources: Stuart Lehman, Doug Marshall, Mike Haddaway, and Michele Katz. Assistance with data collection was received from Larry Lubbers and Ken Yetman from DNR's Watershed Impact Evaluation Program. Jeff Opel, the District Manager of the Queen Anne's County Soil Conservation District, assisted the data collection effort in German Branch. Dr. Peter Lade of Salisbury State University and Fred Schenerman at DNR assisted this project with computer mapping of land use practices and water quality data. The Maryland Environmental Service's Cece Donovan and Chesapeake Biological Laboratory's Carl Zimmerman helped conduct the water chemistry analyses. Dr. Thomas Jordan of the Smithsonian Environmental Research Center and John McCoy of the Maryland Department of the Environment assisted with the development of the sampling strategy and supplied flow data for German Branch.

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INTRODUCTION

The Targeted Watershed Project is a multi-agency, state initiative to improve water quality and restore living resources in several key tributaries to the Chesapeake Bay. The Targeted Watersheds are all stream basins which are either threatened by degradation from urbanization or contribute a disproportionately high level of nutrients to the Chesapeake Bay from agricultural non-point sources. The watersheds are similar in size and small enough that measurable results are expected from implementation of an array of non-point source pollution controls actions.

The Targeted Watershed Project provides an opportunity for Chesapeake Bay managers to develop, demonstrate and evaluate a coordinated approach to improving water quality and the habitat conditions for living resources. Through the implementation of various Bay cleanup activities in the targeted watersheds, the project will demonstrate and help evaluate the effectiveness of a number of the Chesapeake Bay Agreement commitments including the 40% reduction goal for control of excess nutrients.

Four small Maryland watersheds, which drain into the Chesapeake Bay, have monitoring and restoration efforts underway. Monitoring has been conducted in these "Targeted Watersheds for over three years in German Branch and Sawmill Creek. German Branch is located in Queen Anne's County and Sawmill Creek is located Anne Arundel County. German Branch drains mostly cropland on the Eastern Shore and Sawmill Creek flows through a commercial and residential area near Baltimore. This monitoring project, called "implementation monitoring", was focussed on these two watersheds to test a several monitoring techniques. These techniques included synoptic (same day) basin-wide sampling for toxics and nutrients and fully automated storm sampling. The water quality parameters tested were chosen to help project managers target pollution control programs to specific problem sites.

Objectives of "Implementation Monitoring":

The term "implementation monitoring", in this project refers to the water testing which is done in specific locations to either identify pollutant sources or to determine whether control actions are being effective. As problems are identified, action by the implementation teams of the Targeted Watersheds will focus regulatory attention and agricultural incentive programs towards resolving them.

Three monitoring initiatives were carried out in this project:

1. Nitrate and Ammonia in German Branch - This initiative involved watershed-wide sampling of stream water for nitrogen compounds during base flow during three seasons at multiple stations throughout this watershed. Samples were collected by two teams of biologists at 31 road crossings throughout the watershed during approximately a two hour period. The purpose was to determine tributaries of the watershed which are discharging disproportionately high levels of nutrients so that control programs could be targeted in particular sub-watersheds to deal with them.

2. Toxic metals, toxic organics, and fecal coliform monitoring in Sawmill Creek - Water from some reaches and tributaries of Sawmill Creek was found to have detrimental impacts to organisms when tested in bioassay experiments in 1990 (Marshall et al. 1992) (Hartwell et al. 1993). These earlier tests also showed higher toxicity during storm events. The main purpose of this sampling initiative was to determine if identifiable toxic pollutants were present in these and other tributaries. Additional stations near potential sources of contamination were also sampled.

Fecal coliform tests in previous studies also indicated higher concentrations during storms than during dry weather in previous studies. In storms, results exceeded the quantifiable level of 1600 MPN/100 ml of the method (Marshall et al. 1991). For this initiative, samples were taken at several locations in the watershed for fecal coliforms on the day after a rain event.

3. Storm sampling in Sawmill Creek's Muddy Bridge Branch - An automated sampler was purchased to collect samples during storms in Muddy Bridge Branch. This branch is the site of several stream restoration projects. This initiative had two components: to capture any airport de-icers (glycols) that may be flowing off the grounds of Baltimore/Washington International Airport (BWI) during ice and snow storms, the other, to collect baseline data on suspended solids and nutrients prior to the construction of restoration projects designed to minimize habitat-damaging high storm flows. The information gained from this sampling will be compared to results from future sampling to track restoration progress and guide implementation.

METHODS

Sample Collection Methods

German Branch Synoptics - Sampling was conducted at 31 stations in the watershed during dry periods (at least 3 days of no rain prior to sampling) on 4/9/92, 9/11/92, and 12/15/92. Low flow samples were taken to estimate the groundwater contribution to stream flows. Samples were collected using a syringe, with a syringe-mounted, 0.45 μ pore size (Gelman GF/C) filter, and placed in 50 ml bottles. Bottles were stored on ice and transported to the laboratory on the day of collection. The filtered samples were analyzed by the Nutrient Analytical Services Laboratory at the University of Maryland's Chesapeake Biological Laboratory for dissolved inorganic nitrogen (NO_3, NO_2, NH_4).

Sawmill Creek Toxics and Fecals - Samples were collected by DNR biologists on 3/11/93 and 3/29/93. On 3/11/93 samples were taken for fecal coliforms and the group of non-halogenated aromatic compounds (ethylbenzene, total xylenes, benzene, and toluene). On this date rain occurred a couple days prior, however not on the day of sampling. On 3/29/93 samples were collected for metals, phenols, and organic priority pollutants. Samples were taken midstream to get representative samples and no rinses were made (so that preservatives for metals were retained in the bottles and to avoid concentrating organics in the surface film inside the sample bottles). Field water quality measurements were made for temperature, dissolved oxygen, pH, and conductivity with a Hydrolab Datasonde III at the time that toxic and fecal samples were taken in Sawmill Creek. A contracting laboratory, Martel Inc., conducted fecal coliform, metals and organics analyses. All analyses were conducted according to published, standard methods acceptable to the U.S. Environmental Protection Agency (EPA).

Sawmill Creek Glycols, Solids, and Nutrients - Time-composited samples were collected with an ISCO, Inc. model 3700 automated sampler coupled with a model 3230 flow meter. The automated sampler was programmed and bottles were iced when the chance of precipitation was forecasted at 50% or greater. At the conclusion of a storm event samples were collected. Storm samples for solids and nutrients included both whole water and filtered samples. Filtered samples were taken using a syringe-mounted, 0.45 μ pore size (Gelman GF/C) filter. The filtered sample was analyzed by the Nutrient Analytical Services Laboratory at the University of Maryland's Chesapeake Biological Laboratory (CBL) for dissolved inorganic nitrogen (NO_3, NO_2, NH_4), and dissolved inorganic phosphorus (PO_4). An unfiltered aliquot was analyzed for total suspended solids, total nitrogen, and total phosphorus by the same laboratory. Samples of suspended solids and nutrients were collected in 250 ml and 500 ml, polyethylene bottles, transported on ice, frozen in the DNR lab and McPherson Ct. and taken to CBL with routine samples. Samples of glycols and other toxics were iced and sent to Martel Inc. on the day of collection.

Laboratory Methods

The Chesapeake Biological Laboratory provided the chemical analysis of nutrients and conventional pollutants (for method descriptions, see Table 1). The Maryland Environmental Service (MES) provided contractual support for the analysis of toxic metals and organics and fecal coliforms through Martel Inc. (Table 2). Both of these laboratories use EPA-approved analytical procedures and CBL's methods for nutrients also are approved by the EPA Chesapeake Bay Program to measure concentrations typically found in the Bay and its tributaries. Both contractors have detailed QA/QC plans and have logging procedures which track the handling of the water samples.

Chesapeake Biological Laboratory (Nutrients and Suspended Solids)

- Nutrient Analytical Services Laboratory (NASL) at the Chesapeake Biological Laboratory - Contact: Carl Zimmerman - (410) 326-7252.

Table 1. Methods - Nutrient Analytical Services Laboratory (CBL)

Variable name	Method Reference
Nitrate	Technicon Industrial Method: 158-71 W/A EPA. 1979. Chemical Analysis of Water and Wastes. USEPA-600/4-79-020. Method #353.2.
Nitrite	Technicon Industrial Method: 158-71 W/A EPA. 1979. Chemical Analysis of Water and Wastes. USEPA-600/4-79-020. Method #353.2.
Ammonium	Industrial Method 804-86T (Technicon TrAAcs-800. Berthelot Reaction)
Orthophosphate	Technicon Method No. 155-71 W/A EPA 1979. USEPA-600/4-79-020. Method #365.1
Total Suspended Solids	Method #160.2, USEPA, 1979 EPA 600/4-79-020
Total Nitrogen	Persulfate Oxidation Technique D'Elia et al. (1977), Valderama (1981); EPA method 353.2, (1979)
Total Phosphorus	Persulfate Oxidation Technique D'Elia et al. (1977), Valderama (1981); EPA method 353.2, (1979)

Martel Labs/Maryland Environmental Service (Coliforms, Glycols and other Toxics)

- Martel Laboratory Services, Inc. (MLS) - Contact: Paul Jackson - (301) 825-7790.

Table 2. Methods - Martel Laboratory Services, Inc.

Variable	Method Reference
Volatile Organic Compounds (aromatics)	EPA Methods 8020, 602, 502.2 Gas Chromatograph (GC) Purge and Trap with PID (photo-ionization detector)
Volatile Organic Compounds (non-halogenated)	EPA Methods 8240,624 - Purge and Trap with GC/Mass Spectrometer (MS)
Volatile Organic Compounds (Acid and Base/Neutral Extractable)	EPA Methods 8250, 8270, 625 Purge and trap with GC/MS
Total Metals	EPA 200.7, 206.2, 239.1, 245.1, 270.2
Total Phenolics	EPA 420.2
Ethylene and Propylene Glycols	Gas Chromatograph with FID (flame-ionization detector) - method pending approval by EPA
Fecal Coliforms	Standard Methods 908, Multiple-tube incubation

Station Locations

German Branch - Figure 1 shows the location of stations sampled for nitrate + nitrite and ammonia. Stations were chosen to provide a broad coverage of the watershed and to provide coverage of different types of land use.

Sawmill Creek - Figure 2 shows the station location for the toxics and fecal coliform samples. Station T was the site of the ISCO sampler used as part of the project to sample nutrients, glycols, and suspended solids. A flow meter and automated depth gage were used by the Watershed Impact Evaluation Program of DNR to collect stream discharge data at Station F.

Table 3 gives precise locations of the sampling stations in Sawmill Creek and the type of chemical analyses performed at each on 3/11/93 and 3/29/93.

GERMAN BRANCH SYNOPTIC STATIONS - DNR

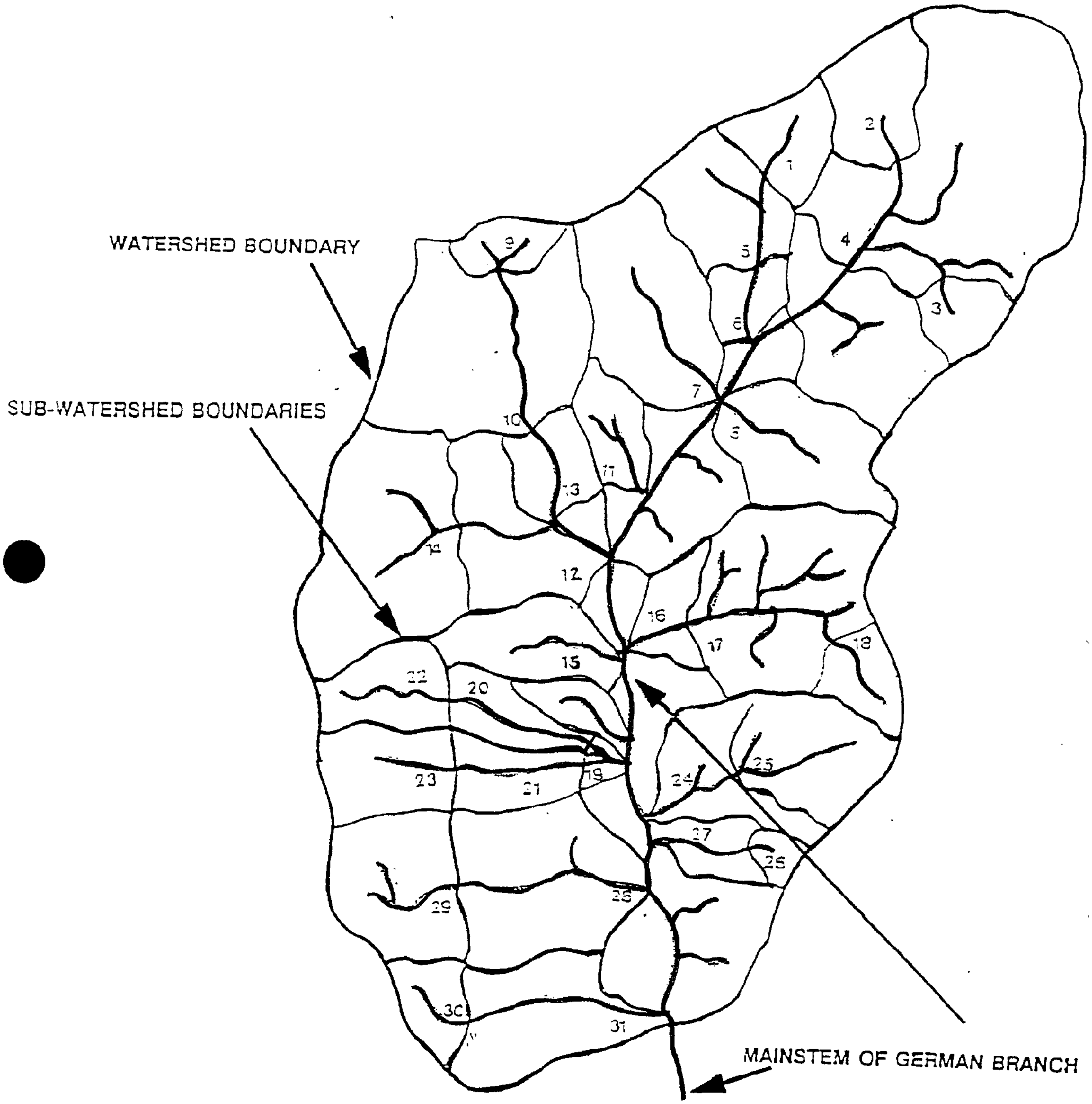

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Figure 1. Synoptic Survey Stations in German Branch watershed

Figure 2. Sampling stations in the Sawmill Creek watershed

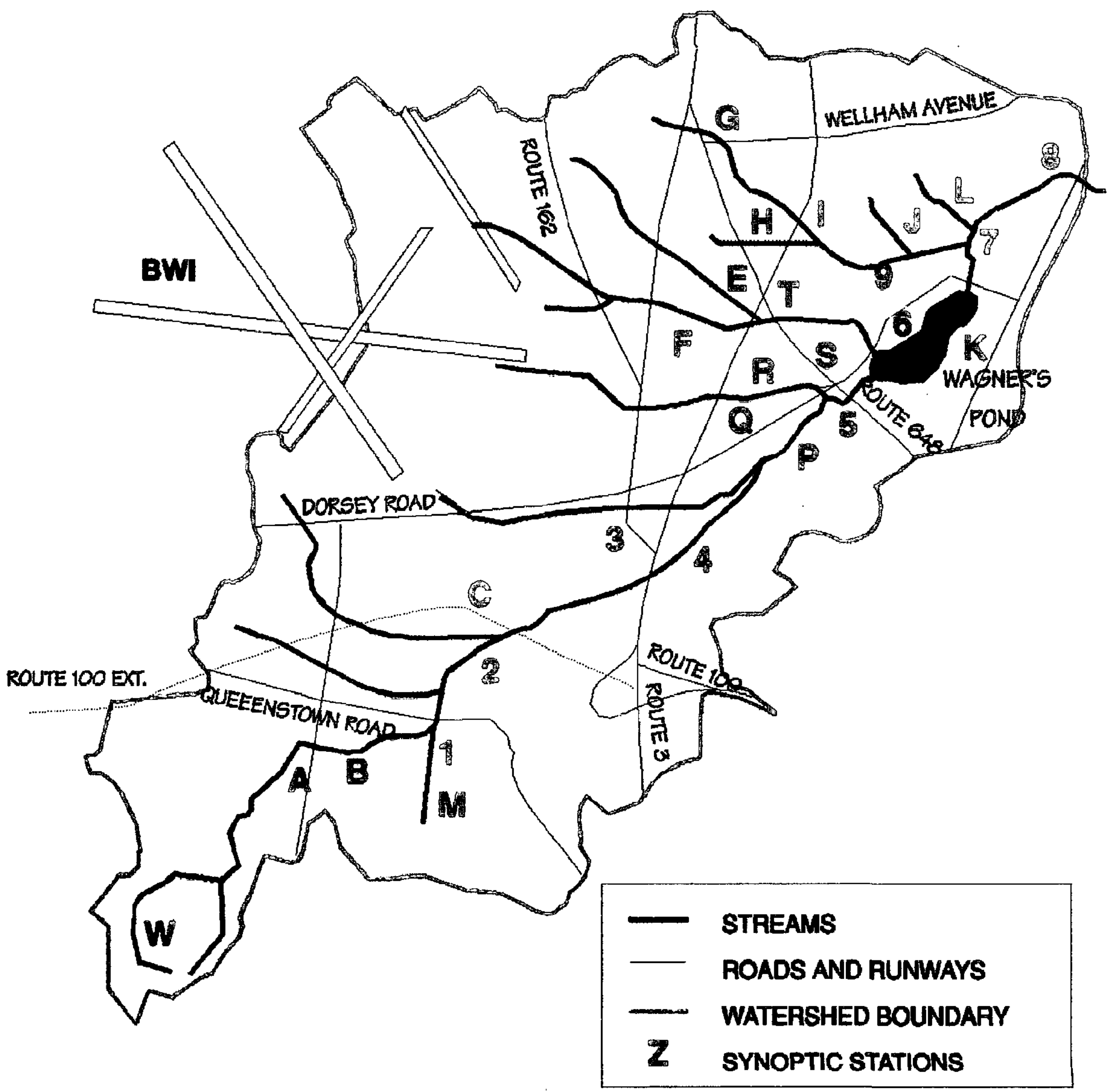

Table 3. Sawmill Creek Synoptic Survey Stations

Station	Location	Fecal Coliforms	Metals(+Phen)	PPO(v)	VOH
A	Mainstem, upstream of WB&A Blvd. and hog farm.	x			
B	Mainstem, @ WB&A Blvd.	x			
SC1	Mainstem, @ Queenstown Rd.	x			
C	Trib. @ confluence with mainstem @ SC2.	x			
SC2	Mainstem on Airport property.	x			
SC4	Mainstem @ Stewart Ave.	x			
P	Mainstem @ Central Ave.		x	x	
Q	Trib. behind Armory @ source.				x
R	Trib. behind Armory @ storm pond outfall.				x
S	Trib. behind Armory @ Rt. 648.	x	x	x	x
SC5	Mainstem @ Rt. 648.	x	x	x	
N	Storm drain @ SC5.	x	x		
SC6	Trib., Muddy Bridge Branch @ 8th Ave.	x	x	x	
T	Trib. MBB @ Eastern St.				x
F	Trib., MBB @ Rt. 3.	x	x		x
E	MBB trib between Rt. 3 & 648.	x	x		
G	Trib 9 @ Oakleigh Ave.		x		
H	Trib 9 @ Olen Dr. left trib (from road)	x	x		
I	Trib 9 @ Olen Dr. right trib from road	x	x		
J	Trib near sta. 9 draining residential area on northside of trib. 9.		x		
K	Storm drain @ Wagners Pond (largest drain outlet on east side of pond).		x	x	
SC7	Mainstem, @ 8th Ave.	x			
L	Cresthaven trib. @ Cresthaven Dr.	x	x		
SC9	Trib. behind Penrod Ct.	x	x	x	
SC8	Mainstem, between Crain Hwy. & Rt. 2.	x			
W	Mainstem, @ Severn Danza Park.				
SC3	Stewart Ave crossing, tributary		x		

RESULTS AND DISCUSSION

Nitrate + Nitrite and Ammonia in German Branch

Many tributaries that were high in NO3+2 during the first sample period were also high during following sample dates indicating that the source of these pollutants were relatively steady (Table 4). This might be expected since most of the water feeding the streams at these times was mostly of groundwater origin.

NH4 showed greater changes from season to season than NO3+2, for instance, in August the concentrations of ammonia nitrogen increased two orders of magnitude at Station 13 (highest value recorded) and more than one order at Stations 3, 9, 12, 16, and 28 from the level measured in April. Station 13 also had the highest recorded NO3+2 in the survey. This sub-watershed contains a large ornamental plant nursery which has several ponds to collect runoff.

Figure 3 shows the sub-watersheds of German Branch and the average concentrations of NO3+2 for the three sampling periods. Tributary stations 11, 27, and 31 had the highest NO3+2 concentrations.

Figure 4 indicates the estimated concentration of NO3+2 at various sub-watersheds in German Branch after it is adjusted to account for the effect of dilution from any upstream area also sampled. This adjustment produces an area-weighted estimate of the NO3+2 concentration. Weighting by watershed area assumes that the contribution of the watershed to the stream flow is the same throughout - which may not be the case. The adjustment is made only to those sub-watersheds which have an upstream station (an example of this estimate method is found in Appendix A). These estimates allow a more uniform comparison of the contribution of various parts of the watershed to the total nitrate + nitrite discharge. This figure illustrates that large areas of the lower part of German Branch watershed contribute high level of nitrate + nitrite during base

Table 4. Concentration of nitrogen compounds found in German Branch in synoptic surveys

NO2 + NO3 and NH4 DATA FROM SYNOPTIC SAMPLING IN GERMAN BRANCH

Station	NH4			NO2 +NO3		
	4/9/92	8/11/92	12/15/92	4/9/92	8/11/92	12/15/92
1	0.49		0.084	4.8		3.1
2	0.178		0.084	0.16		0.36
3	0.023	0.74	0.059	3.6	0.02	1.31
4	0.05	0.07	0.067	2.38	1.62	2.08
5	0.017	0.05	0.044	5.52	5.39	5.76
6	0.005	0.041	0.032	5.43	5.1	6
7	0.005		0.028	5.29		3.95
9	0.013	0.881	0.035	2.33	0.1	1.2
10	0.013	0.053	0.044	2.5	2.36	2.38
11	0.017	0.015	0.02	7.73	6.22	7.49
12	0.003	0.274	0.04	4.39	8.18	4.23
13	0.007	0.727	0.059	3.09	9.17	2.88
14	0.006	0.039	0.032	4.81	5.39	4.82
15	0.01		0.032	6.31		6.05
16	0.005	0.054	0.098	2.86	4.42	2.23
17	0.019	0.088	0.118	1.82	1.85	1.51
19	0.121	0.534	0.222	2.27	0.87	1.84
20	0.028	0.071	0.228	2.61	4.52	2.76
21	0.013		0.034	4.45		1.64
22	0.018		0.074	0.04		0.53
23	0.11			0.04		
24	0.004	0.021	0.014	3.99	3.92	3.86
25	0.009	0.068	0.022	3.03	3.97	2.9
26	0.048			0.05		
27	0.016	0.063	0.037	8.46	5.83	7.17
28	0.005	0.09	0.044	5.45	4.08	4.82
29	0.019	0.043	0.026	0.69	0.11	0.46
30	0.08			2.89		
31	0.006		0.048	8.66		7.28

GERMAN BRANCH SYNOPTIC STATIONS - DNR

NITRATE AND NITRITE NITROGEN

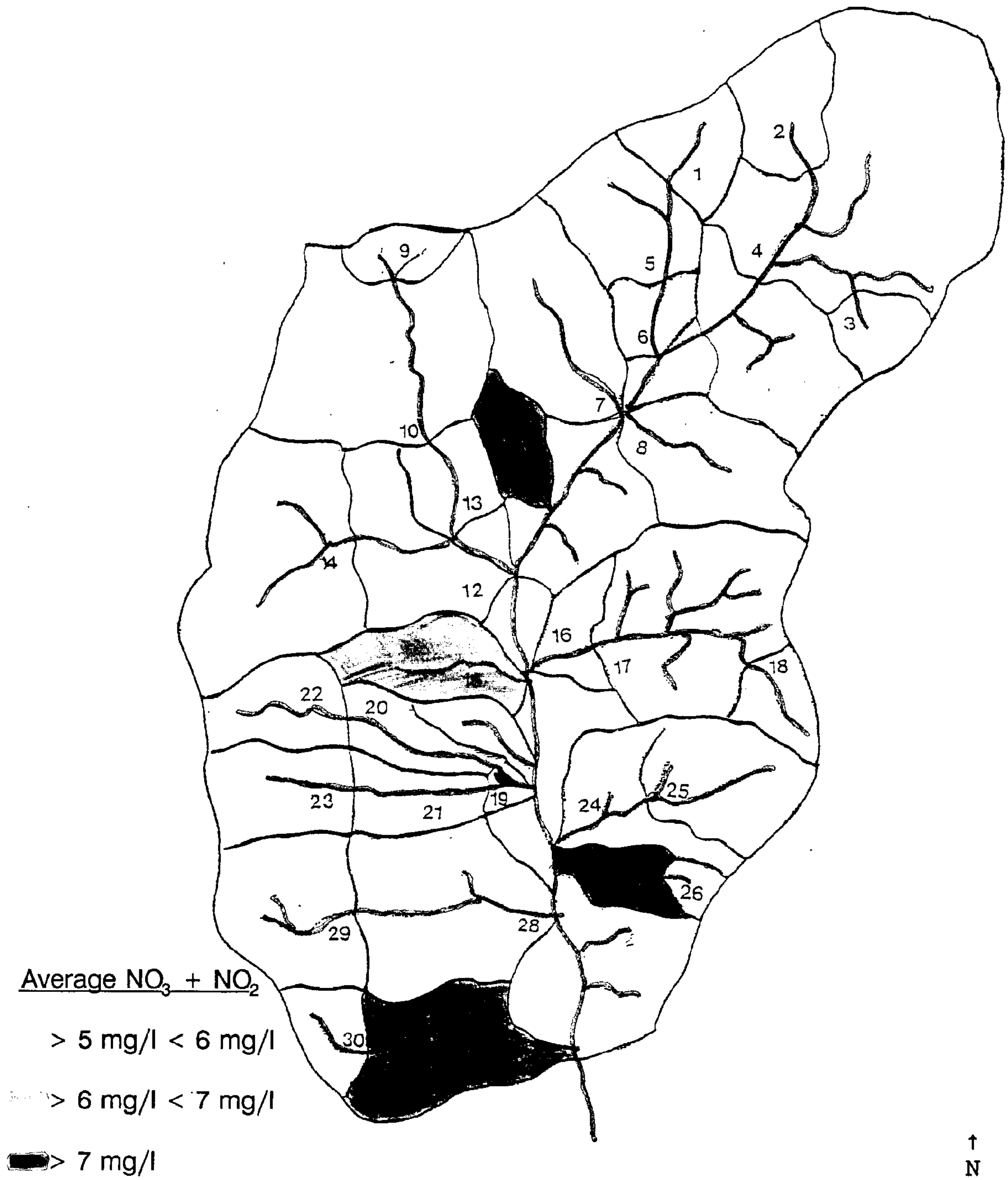

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Figure 4. German Branch: average concentration of nitrate + nitrite nitrogen

GERMAN BRANCH SYNOPTIC STATIONS - DNR

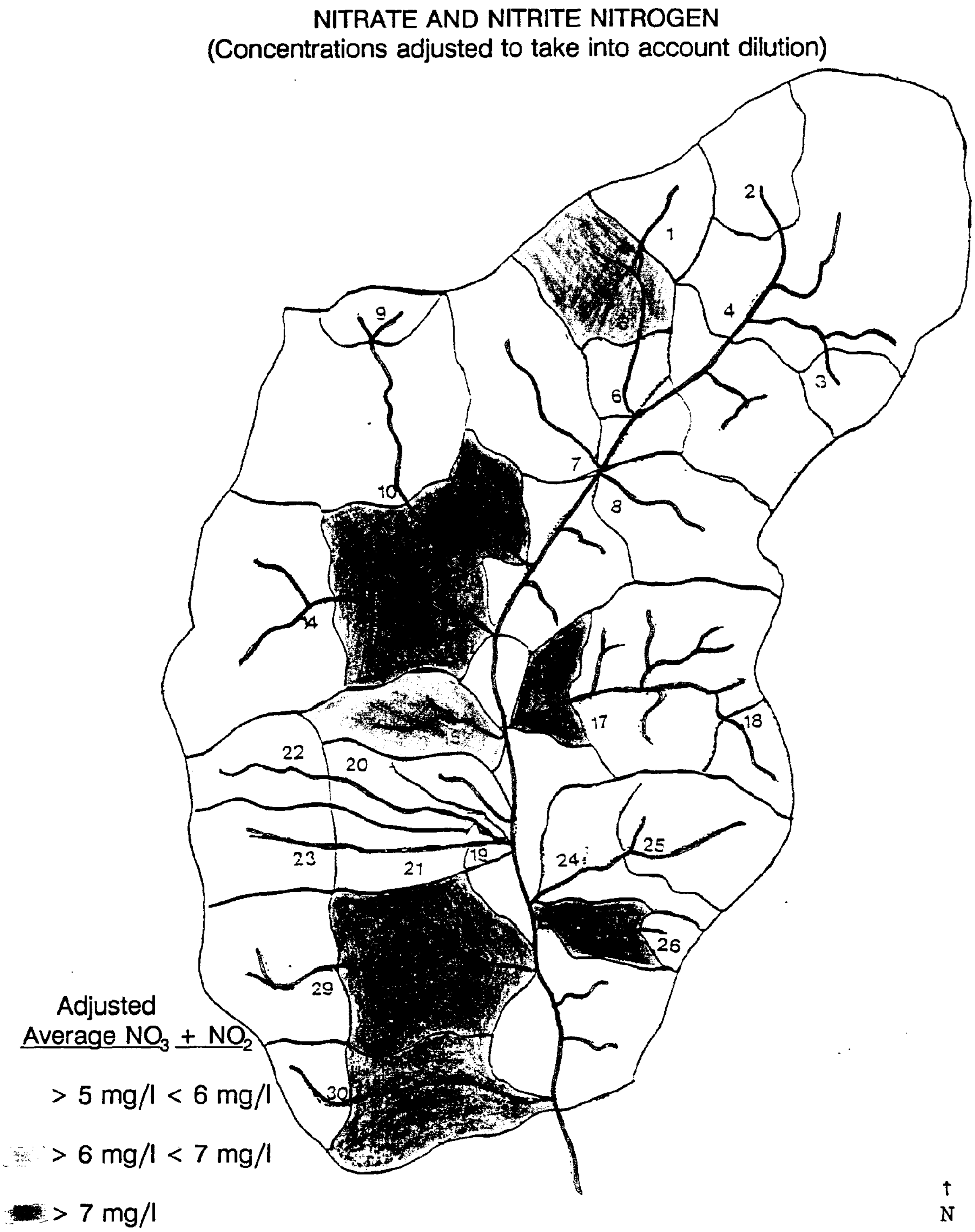

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Figure 4. German Branch: adjusted concentration of nitrate + nitrite nitrogen

flow. Station 13 produced the highest adjusted level of nitrate + nitrite per watershed area at 36.4 mg/l. This level is much higher than that expected from agricultural land.

Previous monitoring in German Branch's mainstem indicated a mean concentration of 3.27 mg/l at base flow (Haddaway et al. 1992). This new monitoring shows that of parts the watershed (about 1/5 of the area) are producing concentrations of nitrate and nitrite (the predominant form of nitrogen compounds) which are more than double the concentrations of the mainstem.

In January 1993, sludge disposal was identified by a state delegate as a potential source of concentrated nitrate-nitrogen to area streams which warranted further regulation. Our sampling results were compared to the location of sludge application sites. Figure 5 shows areas in the German Branch watershed where sludge had been applied in 1990-92 (note that these areas do not match up well with the previous figure showing high NO3+2 in the watershed). These findings were presented to the delegate with the explanation that sludge application alone could not account for the nitrogen levels which were found in these surveys during low flow periods. Some of these areas were primarily agricultural land using commercial fertilizers.

At Station 19, NO3+2 was lower than its upstream stations on all three sampling events. This may be due to the effect of two ponds that lie directly upstream of this station. Ammonia nitrogen levels are higher at this station, which one might expect if oxygen levels are low in these ponds, however they do not account for all of the missing nitrate. One possible explanation is that some denitrification of ammonia is occurring and releasing gaseous nitrogen compounds to the atmosphere. These ponds also may be losing some of the inorganic nitrogen to groundwater. Monitoring of this pond system could produce useful information on the nitrogen removal potential of farm ponds.

GERMAN BRANCH SYNOPTIC STATIONS - DNR

SLUDGE SITES (Applied 1990-1992)

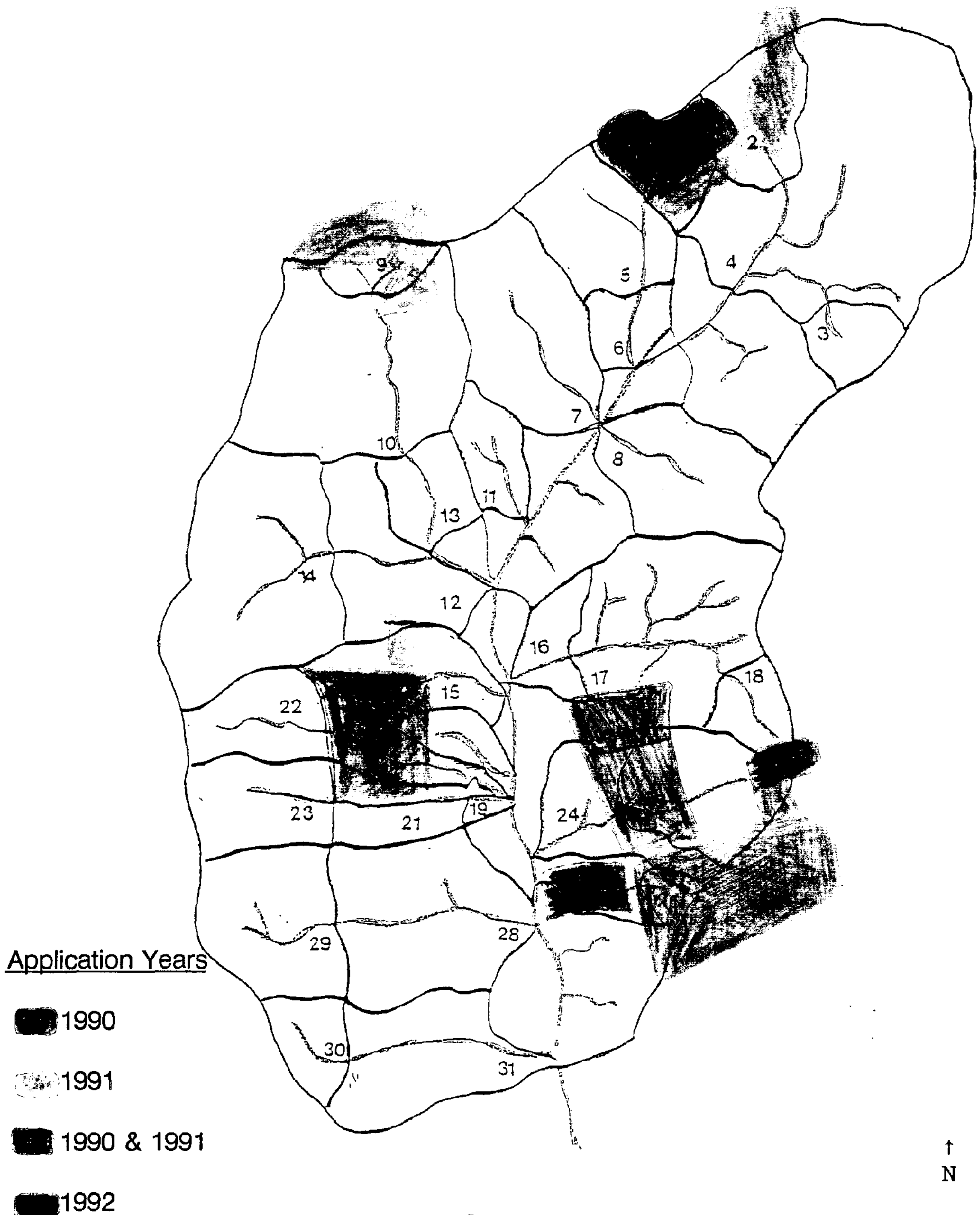

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Figure 5. Location of sewage sludge application sites active in 1990-92

Toxic Metals and Organics Monitoring in Sawmill Creek

Tables 5 through 14 show the concentrations of metals collected in our survey of 3/29/93 and the results of previous analyses collected by the Targeted Watershed Program staff in 1991 for comparison. Previous samples were taken during baseflow conditions. Samples collected on 3/29/93 were taken during the beginning of a rainfall event. Although higher concentrations would be expected during such an event, the results were not appreciably higher. In general, most of the stations sampled did not have many metals at detectable levels. Included in these tables are criteria levels for metals from various sources including Maryland's water quality standards from the Code of Maryland Regulations, proposed EPA water quality criteria, and promulgated EPA water quality criteria. Determining whether these guidelines are actually being met would require more intensive sampling, however, they can be used as a general indicator of the relative magnitude of our results. In general, only zinc and copper exceeded criteria levels on several occasions. Both of these metals are used extensively in commercial and residential areas. Both are also found as a fossil fuel combustion byproducts and are ubiquitous in their distribution due to transportation emissions and atmospheric fall out. Station K had the highest level of zinc and the greatest number of detected metals. This station also had the greatest number of detectable organics. The area above Station K is part of an extensively developed transportation corridor (Route 2 - Ritchie Highway).

Tables 15 through 17 show the concentration of organic compounds collected in the survey of March 11, 1993. Only Station K had compounds at detectable levels. Station K, mentioned above, is located at a storm drain on the east side of Wagner's Pond. The water trickling out of this storm drain was dark and scummy at the time of sampling. Nine separate organic chemicals were found at this station at levels above the detection limits. Total phenols were also detected at 0.030 mg/l.

Of these compounds, phenanthrene exceeded a known criterion value. The proposed

Table 5. Concentration of total metals found in Sawmill Creek on 3/29/93

METALS DATA

SAWMILL CREEK

(in mg/l)

March 29, 1993

Total Metals	Detection Limit	Stations S	P	K	N	E	G	F	J	H	L	I	Acute	Chronic
Antimony	0.1	*	*	*	*	*	*	*	*	*	*	*	0. a	0. a
Arsenic	0.01	*	*	*	*	*	*	*	*	*	*	*	0.36	0.19
Beryllium	0.01	*	*	*	*	*	*	*	*	*	*	*	0. b	0. b
Cadmiu	0.01	*	*	*	*	*	*	*	*	*	*	*	0.0039	0. c
Chromiu	0.01	*	*	0.02	*	*	*	*	*	*	*	*	0. d	0. d
Copper	0.01	*	*	0.03	*	*	*	*	*	0.02	*	0.01	0.018	0.012
Lead	0.02	*	*	0.11	*	*	0.04	*	*	*	*	*	0.082	0.0032
Mercury	0.0005	0.0002	*	0.0003	0.0002	*	0.0002	0.0002	*	0.0003	*	*	0.0024	0.000012
Nickel	0.02	*	*	*	*	*	*	*	*	*	*	*	1.4	0.16
Selenium	0.01	*	*	*	*	*	*	*	*	*	*	*	0.020	0.005
Silver	0.01	*	*	*	*	*	*	*	*	*	*	*	0.0041	0.00012
Thallium	0.1	*	*	*	*	*	*	*	*	*	*	*	1. b	0. b
Zinc	0.01	0.07	0.05	0.36	0.04	0.06	0.14	0.06	0.19	0.10	0.12	0.08	0.12	0.11

Table 6-7. Concentration of total metals found in Sawmill Creek stations 1 & 2

Station 1 (in mg/l)

Total Metals	Detection Limit	4/22/91 Results	5/16/91 Results	6/13/91 Results	3/29/93 Results	Acute	Chronic
Antimony	0.1	*	*	*	---	0.088 a	0.030 a
Arsenic	0.01	*	*	*	---	0.36	0.19
Beryllium	0.01	0.01	0.01	0.01	---	0.13 b	0.0053 b
Cadmium	0.01	*	*	*	---	0.0039	0.0011 c
Chromium	0.01	0.05	0.04	0.02	---	0.05 d	0.05 d
Copper	0.01	0.02	0.01	0.02	---	0.018	0.012
Lead	0.02	0.03	*	0.05	---	0.082	0.0032
Mercury	0.0005	*	*	0.0007	---	0.0024	0.000012
Nickel	0.02	*	*	0.02	---	1.4	0.16
Selenium	0.01	*	*	*	---	0.020	0.005
Silver	0.01	*	*	0.02	---	0.0041	0.00012
Thallium	0.1	*	*	*	---	1.4 b	0.040 b
Zinc	0.01	0.05	0.03	0.03	---	0.12	0.11

Station 2 (in mg/l)

Total Metals	Detection Limit	4/22/91 Results	5/16/91 Results	6/13/91 Results	3/29/93 Results	Acute	Chronic
Antimony	0.1	*	*	*	---	0.088 a	0.030 a
Arsenic	0.01	*	*	*	---	0.36	0.19
Beryllium	0.01	0.01	0.01	0.01	---	0.13 b	0.0053 b
Cadmium	0.01	0.01	*	*	---	0.0039	0.0011 c
Chromium	0.01	0.05	0.07	0.02	---	0.05 d	0.05 d
Copper	0.01	0.02	*	0.01	---	0.018	0.012
Lead	0.02	*	*	*	---	0.082	0.0032
Mercury	0.0005	*	*	0.001	---	0.0024	0.000012
Nickel	0.02	0.02	0.05	*	---	1.4	0.16
Selenium	0.01	*	*	*	---	0.020	0.005
Silver	0.01	*	*	*	---	0.0041	0.00012
Thallium	0.1	*	*	*	---	1.4 b	0.040 b
Zinc	0.01	0.04	0.03	0.02	---	0.12	0.11

Table 8-9. Concentration of total metals found in Sawmill Creek stations 3 & 4

Station 3 (in mg/l)

Total Metals	Detection Limit	4/22/91 Results	5/16/91 Results	6/13/91 Results	3/29/93 Results	Acute	Chronic
Antimony	0.1	*	*	---	*	0.088 a	0.030 a
Arsenic	0.01	*	*	---	*	0.36	0.19
Beryllium	0.01	*	0.01	---	*	0.13 b	0.0053 b
Cadmium	0.01	*	*	---	*	0.0039	0.0011 c
Chromium	0.01	0.06	0.05	---	*	0.05 d	0.05 d
Copper	0.01	0.02	*	---	0.04	0.018	0.012
Lead	0.02	*	*	---	*	0.082	0.0032
Mercury	0.0005	*	0.008	---	*	0.0024	0.000012
Nickel	0.02	0.02	*	---	*	1.4	0.16
Selenium	0.01	*	*	---	*	0.020	0.005
Silver	0.01	0.01	*	---	*	0.0041	0.00012
Thallium	0.1	*	*	---	*	1.4 b	0.040 b
Zinc	0.01	0.03	0.03	---	0.08	0.12	0.11

Station 4 (in mg/l)

Total Metals	Detection Limit	4/22/91 Results	5/16/91 Results	6/13/91 Results	3/29/93 Results	Acute	Chronic
Antimony	0.1	*	*	*	---	0.088 a	0.030 a
Arsenic	0.01	*	*	*	---	0.36	0.19
Beryllium	0.01	0.01	0.01	0.01	---	0.13 b	0.0053 b
Cadmium	0.01	*	*	*	---	0.0039	0.0011 c
Chromium	0.01	0.06	0.05	0.02	---	0.05 d	0.05 d
Copper	0.01	0.01	*	0.01	---	0.018	0.012
Lead	0.02	0.03	*	*	---	0.082	0.0032
Mercury	0.0005	*	*	0.0012	---	0.0024	0.000012
Nickel	0.02	0.03	*	*	---	1.4	0.16
Selenium	0.01	*	*	*	---	0.020	0.005
Silver	0.01	*	*	*	---	0.0041	0.00012
Thallium	0.1	*	*	*	---	1.4 b	0.040 b
Zinc	0.01	0.06	0.09	0.06	---	0.12	0.11

Table 10-11. Concentration of total metals found in Sawmill Creek stations 5 & 6

Station 5 (In mg/l)

Total Metals	Detection Limit	4/22/91 Results	5/16/91 Results	6/13/91 Results	3/29/93 Results	Acute	Chronic
Antimony	0.1	*	*	*	*	0.088 a	0.030 a
Arsenic	0.01	*	*	*	*	0.36	0.19
Beryllium	0.01	0.01	0.01	0.01	*	0.13 b	0.0053 b
Cadmium	0.01	*	*	*	*	0.0039	0.0011 c
Chromium	0.01	0.05	0.04	0.03	*	0.05 d	0.05 d
Copper	0.01	0.01	*	0.02	*	0.018	0.012
Lead	0.02	0.05	*	0.02	*	0.082	0.0032
Mercury	0.0005	*	0.005	0.0008	0.0002	0.0024	0.000012
Nickel	0.02	*	*	*	*	1.4	0.16
Selenium	0.01	*	*	*	*	0.020	0.005
Silver	0.01	*	*	0.02	*	0.0041	0.00012
Thallium	0.1	*	*	*	*	1.4 b	0.040 b
Zinc	0.01	0.03	0.02	0.02	0.05	0.12	0.11

Station 6 (In mg/l)

Total Metals	Detection Limit	4/22/91 Results	5/16/91 Results	6/13/91 Results	3/29/93 Results	Acute	Chronic
Antimony	0.1	*	*	*	*	0.088 a	0.030 a
Arsenic	0.01	*	*	*	*	0.36	0.19
Beryllium	0.01	0.01	0.01	0.01	*	0.13 b	0.0053 b
Cadmium	0.01	0.01	*	*	*	0.0039	0.0011 c
Chromium	0.01	0.06	0.04	0.02	*	0.05 d	0.05 d
Copper	0.01	0.02	*	0.01	*	0.018	0.012
Lead	0.02	0.04	*	*	*	0.082	0.0032
Mercury	0.0005	*	*	0.0009	0.0002	0.0024	0.000012
Nickel	0.02	*	*	*	*	1.4	0.16
Selenium	0.01	*	*	*	*	0.020	0.005
Silver	0.01	*	*	*	*	0.0041	0.00012
Thallium	0.1	*	*	*	*	1.4 b	0.040 b
Zinc	0.01	0.04	0.01	0.02	0.05	0.12	0.11

Table 12-13. Concentration of total metals found in Sawmill Creek stations 7 & 8

Station 7 (in mg/l)

Total Metals	Detection Limit	4/22/91 Results	5/16/91 Results	6/13/91 Results	3/29/93 Results	Acute	Chronic
Antimony	0.1	*	*	*	---	0.088 a	0.030 a
Arsenic	0.01	*	*	*	---	0.36	0.19
Beryllium	0.01	*	0.01	0.01	---	0.13 b	0.0053 b
Cadmium	0.01	*	*	*	---	0.0039	0.0011 c
Chromium	0.01	0.06	0.05	0.03	---	0.05 d	0.05 d
Copper	0.01	0.01	*	0.02	---	0.018	0.012
Lead	0.02	*	*	*	---	0.082	0.0032
Mercury	0.0005	*	*	0.0007	---	0.0024	0.000012
Nickel	0.02	*	*	*	---	1.4	0.16
Selenium	0.01	*	*	*	---	0.020	0.005
Silver	0.01	*	*	0.03	---	0.0041	0.00012
Thallium	0.1	*	*	*	---	1.4 b	0.040 b
Zinc	0.01	0.01	0.01	0.01	---	0.12	0.11

Station 8 (in mg/l)

Total Metals	Detection Limit	4/22/91 Results	5/16/91 Results	6/13/91 Results	3/29/93 Results	Acute	Chronic
Antimony	0.1	*	*	*	---	0.088 a	0.030 a
Arsenic	0.01	*	*	*	---	0.36	0.19
Beryllium	0.01	0.01	0.01	0.01	---	0.13 b	0.0053 b
Cadmium	0.01	*	*	*	---	0.0039	0.0011 c
Chromium	0.01	0.06	0.04	0.02	---	0.05 d	0.05 d
Copper	0.01	0.01	*	0.01	---	0.018	0.012
Lead	0.02	*	*	0.13	---	0.082	0.0032
Mercury	0.0005	*	0.009	0.0012	---	0.0024	0.000012
Nickel	0.02	0.02	*	*	---	1.4	0.16
Selenium	0.01	*	*	*	---	0.020	0.005
Silver	0.01	*	*	0.02	---	0.0041	0.00012
Thallium	0.1	*	*	*	---	1.4 b	0.040 b
Zinc	0.01	0.03	0.02	0.02	---	0.12	0.11

Table 14. Concentration of total metals found in Sawmill Creek stations 9

Station 9 (in mg/l)

Total Metals	Detection Limit	4/22/91 Results	5/16/91 Results	6/13/91 Results	3/29/93 Results	Acute	Chronic
Antimony	0.1	*	*	*	*	0.088 a	0.030 a
Arsenic	0.01	*	*	*	*	0.36	0.19
Beryllium	0.01	0.01	0.01	0.01	*	0.13 b	0.0053 b
Cadmium	0.01	0.01	*	*	*	0.0039	0.0011 c
Chromium	0.01	0.06	0.06	0.01	*	0.05 d	0.05 d
Copper	0.01	0.01	*	0.01	0.04	0.018	0.012
Lead	0.02	*	*	*	*	0.082	0.0032
Mercury	0.0005	*	0.005	0.0005	0.0002	0.0024	0.000012
Nickel	0.02	0.02	0.02	*	*	1.4	0.16
Selenium	0.01	*	*	*	*	0.020	0.005
Silver	0.01	*	*	*	*	0.0041	0.00012
Thallium	0.1	*	*	*	*	1.4 b	0.040 b
Zinc	0.01	0.05	0.02	0.03	0.12	0.12	0.11

* Below Detection Limit
a Proposed EPA Standards from Quality Criteria for Water 1992
b Lowest Observed Effect Level (LOEL) from Quality Criteria for Water 1992
c Hardness Dependent 100 $CaCO_3$
d Maryland Drinking Water Standards 26.08.02
--- Not sampled on this date

Entries which are not footnoted are MD WQS 26.08.02

Table 15. Concentrations of toxic organic compounds found in Sawmill Creek

Organic Analysis Results for Sawmill Creek
March 11, 1993

Compound	Detection Limit(p	Stations K	9	5	S	P	6	3	N	E	G	F	J	H	L	I
Chloromethane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Bromomethane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Vinyl Chloride	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Chloroethane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Methylene Chloride	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Acetone	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Carbon Disulfide	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
1,1-Dichloroethene	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
1,1-Dichloroethane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Trans-1,2-Dichloroethene	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Chloroform	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
1,2-Dichloroethane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
2-Butanone (MEK)	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
1,1,1-Trichloroethane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Carbon Tetrachloride	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Bromodichloromethane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
1,2-Dichloropropane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Cis-1,3-Dichloropropene	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Trichloroethene	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Benzene	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Chlorodibromomethane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
1,1,2-Trichloroethane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Bromoform	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
4-Methyl-2-pentanone	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
2-Hexanone	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
1,1,2,2-Tetrachloroethane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---

Table 16. Concentrations of toxic organic compounds found in Sawmill Creek

Organic Analysis cont.

Compound	Detection Limit(p	Stations K	9	5	S	P	8	3	N	E	G	F	J	H	L	I
Tetrachloroethane	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Toluene	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Chlorobenzene	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Ethylbenzene	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Styrene	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
m-Xylene	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
(p + o)-Xylene	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
N-Nitrosodimethylamine	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Bis(2-chloroethyl) ether	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
1,3-Dichlorobenzene	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Phenolics	10	0.03	*	*	*	*	*	*	*	*	*	*	*	*	*	*
1,4-Dichlorobenzene	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
1,2-Dichlorobenzene	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Bis(2-chloroisopropyl) ether	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
N-Nitroso-di-N-propylamine	2	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Hexachloroethane	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Nitrobenzene	2	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Isophorone	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Bis(2-chloroethoxy) methane	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
1,2,4-Trichlorobenzene	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Hexachlorocyclopentadiene	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
2-Chloronapthalene	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Dimethyl phthalate	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
2,6-Dinitrotoluene	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Acenaphthylene	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Acenaphthene	1	3	*	*	*	*	*	---	---	---	---	---	---	---	---	---
2,4-Dinitrotoluene	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Diethyl phthalate	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---

Table 17. Concentrations of toxic organic compounds found in Sawmill Creek

Organic Analysis cont.

Compound	Detection Limit(p	K	9	5	S	P	6	3	N	E	G	F	J	H	L	I
		Stations														
4-Chlorophenyl phenyl ether	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Flourene	1	4	*	*	*	*	*	---	---	---	---	---	---	---	---	---
N-Nitrosodiphenylamine	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
1,2-Diphenylhydrazine	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
4-Bromophenyl phenyl ether	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Hexachlorobenzene	2	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Di–N-Butyl phthalate	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Phenanthrene	1	42	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Anthracene	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Flouranthene	1	83	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Benzidine	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Pyrene	1	44	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Butyl benzyl phthalate	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Bis(2-ethylhexyl) phthalate	10	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Benzo(a) anthracene	1	5	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Chrysene	1	27	*	*	*	*	*	---	---	---	---	---	---	---	---	---
3,3'-Dichlorobenzidine	2	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Di-n-octylphthalate	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Benzo(b)flouranthene	1	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Benzo(k)flouranthene	1	95	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Benzo(a)pyrene	1	19	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Indeno(123cd)pyrene	2	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Dibenz(ah)anthracene	2	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---
Benzo(ghi)perylene	2	*	*	*	*	*	*	---	---	---	---	---	---	---	---	---

* Below Detection Limit

--- Not tested for these parameters

EPA criterion for protection of freshwater aquatic life is 0.030 mg/l. The measurement at Station K was 0.042 mg/l. Four of these compounds are considered carcinogenic and have criteria values designed to assure protection of humans from contaminated fish which are eaten and water which is drunk. Wagner's Pond is rarely fished and is not used for water supply, so it is not clear whether such criteria would apply to storm drains entering it. These compounds are of a class called polynuclear aromatic hydrocarbons (PAH's) which are widespread in the environment. PAH's originate from fossil fuel combustion and natural sources, such as forest fires, and are of concern in developed regions of the world.

Table 18 shows a group of compounds which were identified as possibly present in Sawmill Creek surface waters (in parts per billion-ppb), based on the existence of a known groundwater contamination site. Solvents, including these compounds, were found in the groundwater below an industrial site on B & A Boulevard, next to Route 3, in earlier investigations by the Maryland Department of the Environment. The monitoring results at Stations R and T for these compounds may indicate that the solvents from this spill are reaching the surface waters of Sawmill Creek.

Table 18.

Concentration of aromatic hydrocarbons near industrial site

Compound	d.l.*	Sta. S	Sta. R	Sta.T	Sta. Q
Benzene	1ppb	-**	-	-	-
Toulene	1ppb	-	460	2.2	-
Ethylbenzene	1ppb	-	-	-	-
Total Xylenes	1/ppb	-	120	-	-

* - detection limit
** - (-) denotes below detection limit)

Fecal coliforms were sampled on 3/11/93 at 18 stations in Sawmill Creek (Table 19). Only Station B has a concentration which, if measured routinely over several weeks,

Table 19. Fecal coliform concentrations on March 11, 1993

Fecal Coliform Analysis

March 11, 1993

(MPN/100ml)

Stations	Result
1	36
2	<30
4	<30
5	<30
6	36
7	<30
8	36
9	91
A	36
B	230
C	<30
E	<30
F	<30
H	<30
I	<30
L	<30
N	36
S	<30

would be above State criteria. This station was chosen because it is downstream of a small hog farming operation. The upstream station (A) and Station 1 nearby had detectable fecal coliforms but at lower levels. Station 8 and 9 (see Figure 3) also had fecal coliforms at low levels (< 200 MPN/100ml). These stations are in the lower Sawmill Creek watershed which is influenced by urban runoff and possibly pet wastes or leaky sewer systems.

Table 20 contains the results of Hydrolab measurements taken at the time of collection of the samples for the organic compounds and fecal coliforms on March 29, 1993. Table 21 contains similar results March 11, 1993 at the time that metals samples were taken.

Table 20.

Sawmill Creek Synoptic Survey
March 29, 1993

Station	Time	Temp	pH	DO	Cond
P	1310	11.42	6.50	10.63	227
S	1320	10.89	6.29	8.65	209
SC5	1330	11.38	6.47	10.78	232
N	1337	9.81	6.63	10.33	486
SC6	1345	11.65	6.68	9.23	270
F	1530	10.86	6.63	8.62	259
E	1525	11.66	7.41	11.07	215
G	1510	11.27	6.44	9.46	335
H	1458	11.47	6.65	9.32	320
I	1500	12.25	6.54	9.36	205
J	1448	9.47	6.46	10.34	338
K	1415	9.75	7.01	8.42	686
L	1438	11.29	5.76	10.51	217
SC9	1400	12.12	6.76	9.97	182
SC3	1255	10.16	6.75	9.85	314

Table 21. Results of hydrolab measurements on March 11, 1993

Sawmill Creek Synoptic Survey
March 11, 1993

Station	Time	Temp	pH	DO	Cond
W	1250	7.18	4.81	7.91	129
A	807	5.23	4.35	10.08	166
B	815	4.24	5.83	6.82	208
SC1	825	3.29	6.35	9.83	197
C	845	4.95	6.42	10.89	178
SC2	855	4.62	6.24	10.59	170
SC4	905	5.3	6.17	10.96	167
P	917	4.16	6.53	11.18	304
SC5	925	4.04	6.58	11.5	228
N	930	9.44	6.83	9.35	470
Q	1000	5.27	6.4	8.63	283
R	1005	5.25	6.6	8.38	187
S	1011	5.98	6.36	8.36	218
E	1225	9.96	5.92	2.92	366
F	1215	8.03	6.52	8	266
T	1150	9.11	6.33	6.98	294
SC6	1035	9.38	6.53	8.05	278
I	1140	10.16	6.36	9.74	323
H	1142	9.85	6.42	9.46	478
SC9	1050	8.69	6.58	9.95	314
SC7	1055	6.13	6.62	9.55	260
L	1125	10.22	5.82	9.98	237
SC8	1105	6.46	6.49	9.51	255

Station E (Table 21) showed the lowest D.O. concentration on 3/11/93 - which would be stressful to aquatic organisms. This tributary flows through an urbanized reach of the Muddy Bridge Branch watershed and by an industrial outfall. On 3/29/93 the same tributary had the highest oxygen level of the stations monitored.

The storm drain at Station K had the highest conductivity measured in the 3/29 surveys. As mentioned before, this station also had the greatest concentration of organic and metal pollutants. Stations W and A in the upper watershed had pH levels below 5 mg/l (state water quality criterion) on the 3/11 survey, however, this could be due to natural degradation of leaf matter in the stream or to other factors such as acid deposition.

Storm sampling in Sawmill Creek's Muddy Bridge Branch

Nutrients and Solids - Table 22 shows the dates and times of various storm samples collected at Eastern Street (labelled MBB - The location of this station corresponds to Station T on Figure 3) and the concentration of various pollutants measured during storms.

During the time span of covered in Table 22, stream level measurements in Muddy Bridge Branch were taken at Station T and at Route 3 - just upstream, using two different recorders. Because the upstream measurements at Route 3 were taken for the longer period of time, this data was used to develop a flow record. These flows were compared to the measured concentrations of nutrients and solids in the following figures.

Total nitrogen, total phosphorus, and total suspended solids results were taken most frequently in this baseline period because of their importance as Chesapeake Bay pollutants. Total suspended solids are of greatest concern to local aquatic life and to the well-being of the wetlands downstream at Wagner's Pond. Figures 6, 7, and 8 show the water quality measurements taken during the storm which occurred on 11/11-12/92. In general, they show increases in suspended solids and total phosphorus concentrations during rain events and dilution of total nitrogen concentrations. These data are being

Table 22. Results of suspended solids and nutrient analyses at Eastern Street

Muddy Bridge Branch, Storm Data

DATE	SAMPLE #	TIME	PO4-P mg P/l	NO2+NO3 mg N/l	NH4-N mg N/l	NO2-N mg N/l	NO3-N	TSS mg/l	TVS mg/l	BI mg/l	TP	TN
09/26/92	B1	00:15						80.0			0.120	1.77
09/26/92	B2	02:15						231.7			0.292	1.13
09/26/92	B3	04:15						130.0			0.295	0.77
09/26/92	B4	06:15						129.2			0.334	0.73
09/26/92	B5	08:15						80.6			0.304	0.77
09/26/92	B6	10:15						82.4			0.242	0.73
09/26/92	B7	12:15						106.5			0.243	0.98
10/09/92	MBB	1045	0.0116	1.2400	0.262	0.0267	1.2133	670.0			0.182	2.92
10/09/92	MBB	1245	0.0122	0.5100	0.046	0.0228	0.4872	190.9			0.165	1.31
10/09/92	MBB	1445	0.0233	0.3300	0.043	0.0110	0.3190	217.1			0.100	0.89
10/09/92	MBB	1645	0.0363	0.3200	0.029	0.0114	0.3086	76.8			0.113	0.85
10/30/92	MBB1	2244									0.311	3.71
10/31/92	MBB2	44						95.5			0.211	3.27
10/31/92	MBB3	244						138.6			0.214	2.25
10/31/92	MBB4	444	0.0094		0.281	0.0318		48.5			0.118	1.77
10/31/92	MBB5	644						20.6			0.082	1.52
10/31/92	MBB6	844						18.8			0.065	1.57
10/31/92	MBB7	1044	0.0213		0.042	0.0162		15.5			0.064	1.65
11/02/92	MBB1	854	0.0040	1.610	0.113	0.0279	1.5821	45.4			0.078	2.44
11/02/92	MBB2	1054					0.0000	100.7			0.149	2.26
11/02/92	MBB3	1254					0.0000	92.2			0.119	1.95
11/02/92	MBB4	1454					0.0000	40.0			0.081	1.60
11/02/92	MBB5	1654					0.0000	32.3			0.091	1.60
11/02/92	MBB6	1854					0.0000	24.0			0.071	1.50
11/02/92	MBB7	2054					0.0000	25.5			0.061	1.58
11/02/92	MBB8	2254					0.0000	116.5			0.136	1.36
11/03/92	MBB9	54					0.0000	106.4			0.080	1.09
11/03/92	MBB10	254					0.0000	194.5			0.307	1.40
11/03/92	MBB11	454					0.0000	303.6			0.509	2.54
11/03/92	MBB12	654					0.0000	121.0			2.670	16.00
11/03/92	MBB13	854	0.0547	0.360	0.035	0.0062	0.3538	98.0			0.203	1.30
11/12/92	MBB1	1948	0.0111	1.020	0.126	0.0178	1.0022	144.5			0.159	2.07
11/12/92	MBB2	2148	0.0050	0.270	0.029	0.0011	0.2689	115.6			*	*
11/12/92	MBB3	2348	0.0927	0.210	0.052	0.0060	0.2040	246.4			0.408	1.60
11/13/92	MBB4	148	0.1143	0.200	0.078	0.0061	0.1939	108.9			0.379	1.57
11/13/92	MBB5	348	0.0812	0.290	0.061	0.0073	0.2827	96.4			0.208	1.23
11/26/92	MBB	1413	0.0080	0.740	0.036	0.0161	0.7239	73.3			0.146	1.55
12/10/92	MBB1	1110	0.0110	1.530	0.587	0.0381	1.4919	115.0			0.119	2.95
12/10/92	MBB2	1510					0.0000	141.0			0.308	11.70
12/10/92	MBB3	2010	0.1340	0.180	0.473	0.0156	0.1644	91.0			0.242	2.66
12/11/92	MBB4	110					0.0000	66.0			0.181	1.29
12/11/92	MBB5	610					0.0000	38.0			0.154	1.16
12/11/92	MBB6	1337					0.0000	49.0			0.122	0.92
12/11/92	MBB7	1837					0.0000	43.0			0.215	0.88
12/11/92	MBB8	2337					0.0000	46.0			0.161	1.01
01/09/93	B1	255	0.0150	0.540	0.060	0.0162	0.5238	53.3			0.096	1.21
01/09/93	B2	455	0.0120	0.490	0.043	0.0108	0.4792	31.5			0.077	1.10
01/09/93	B3	655	0.0230	0.440	0.033	0.0094	0.4306	33.5			0.123	1.01
01/09/93	B4	855	0.0320	0.480	0.076	0.0102	0.4698	7.5			0.159	0.71
01/09/93	B5	955	0.1130	0.450	0.052	0.0077	0.4423	73.5			0.314	0.41
					Hammonds Ferry Road							
01/09/93	HF	1050					0.0000	25.0			0.215	0.36
01/09/93	HF	1245					0.0000	46.0			0.656	0.27

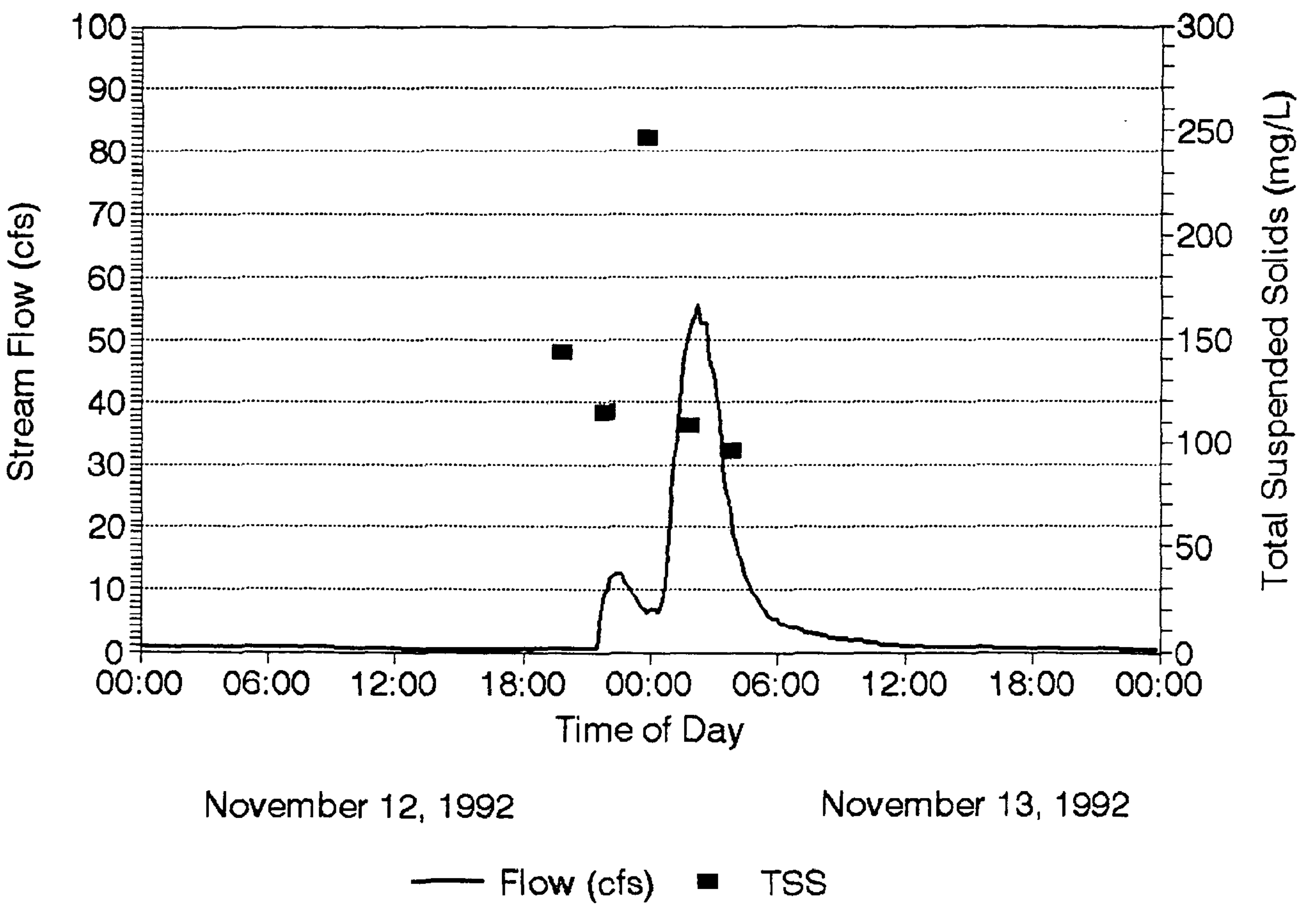

Figure 6. Total suspended solids concentration and flow record in Muddy Bridge Branch of Sawmill Creek for 11/12/92 storm

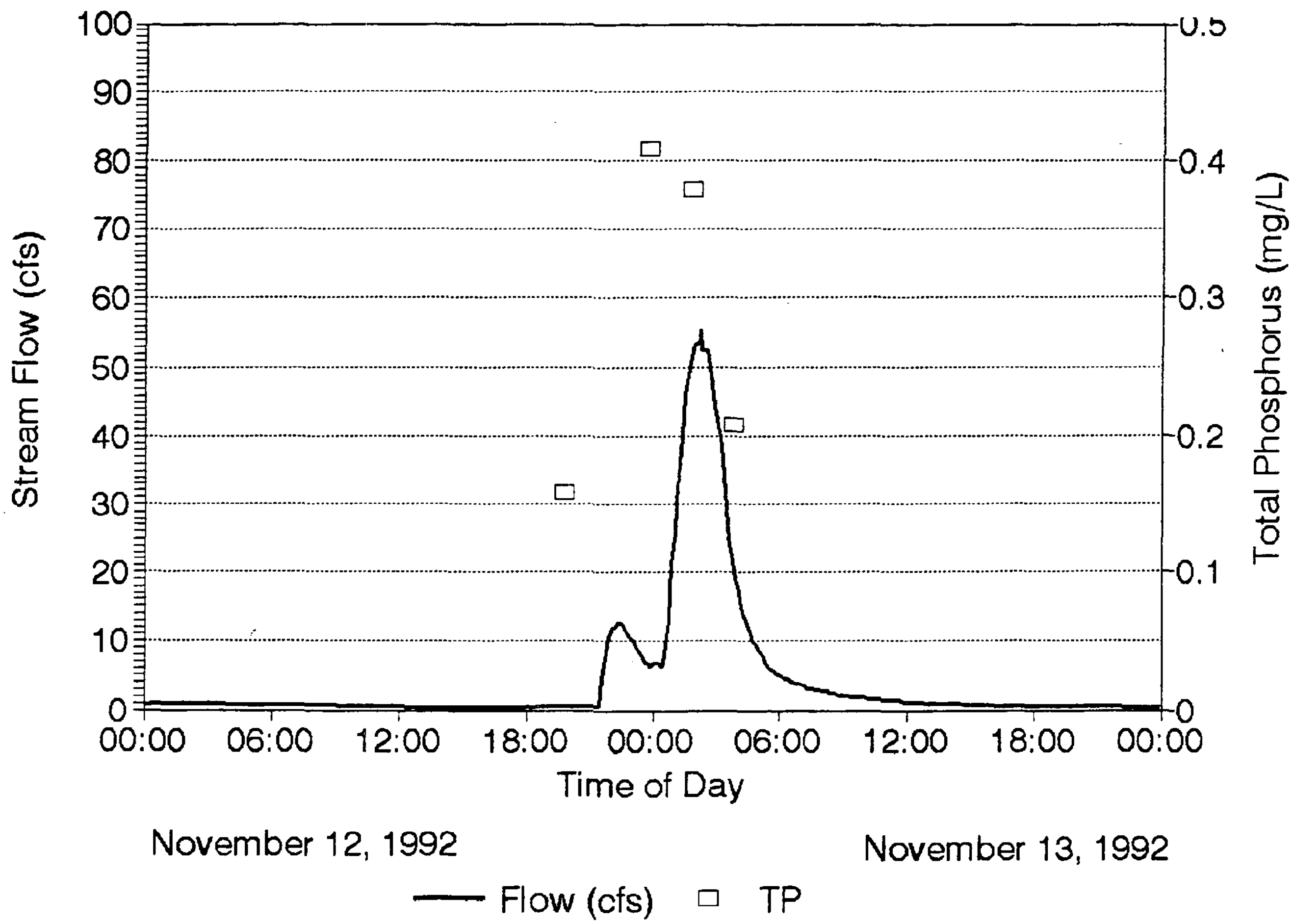

Figure 7. Total phosphorus concentration and flow record in Muddy Bridge Branch of Sawmill Creek for 11/12/92 storm

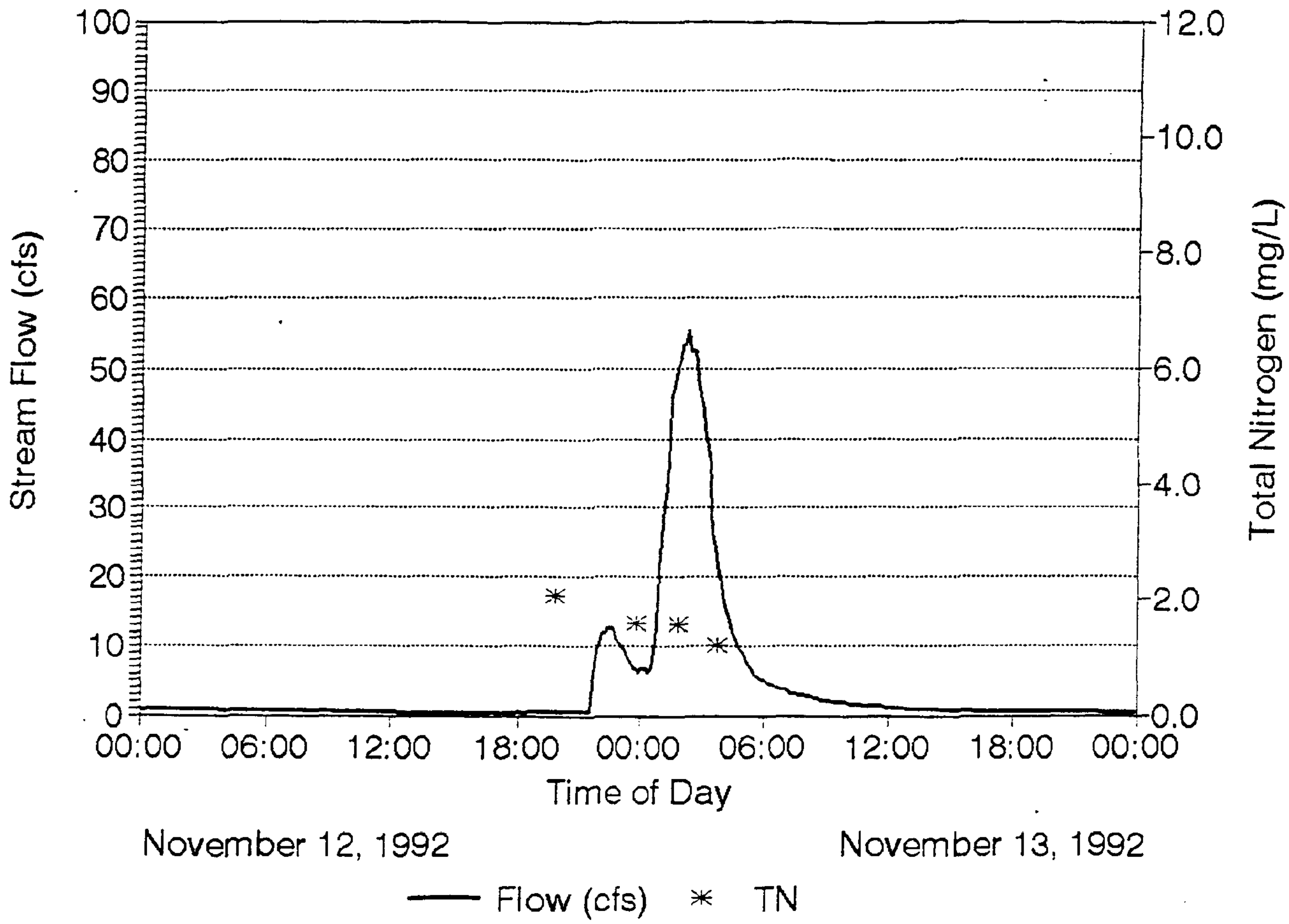

Figure 8. Total nitrogen concentration and flow record in Muddy Bridge Branch of Sawmill Creek for 11/12/92 storm

used to establish a baseline for future comparisons (see Appendix B for list of projects underway in Muddy Bridge Branch and Sawmill Creek). Flows seem to be slightly "out of synch" with measured concentrations. This points to a need for additional refinement of our data collection procedures. Figures 9, 10, 11 show the results of water quality analyses from a storm which occurred on 12/10-11/92. Figures 12, 13, and 14 show results of analyses from a storm on 1/9-10/93.

Glycols - Ethylene and propylene glycol samples for this project were taken during 4 storm events in the winter of 1992-93. The following table (Table 23) shows the concentrations of glycols present at Eastern Street on Muddy Bridge Branch during these events. Also this winter, the University of Maryland, the Maryland Department of the Environment, and the Maryland Department of Transportation conducted water quality monitoring and toxicity studies at BWI to identify levels of glycols present in several watersheds around the airport. The samples from this project were taken more frequently than those of the other agencies and will help determine the effect of concentration and time-of-exposure to organisms in the stream (Appendix C - Transcript of presentation given at a Salt Lake City conference on aircraft de-icers using data from this project).

Figure 15 shows the results in mg/l of ethylene glycol concentrations in relation to the flow on 2/12/93. Figure 16 shows the loading in pounds/hour of the two glycols during the course of the same storm event. These loadings were calculated from the concentration and flow data on the previous figure using standard conversion factors. Figure 17 is a bar graph of the precipitation measured by the National Weather Service at BWI on the edge of the watershed. The figures 18, 19, and 20 illustrate the same data and calculated values for an event occurring on 2/16/93.

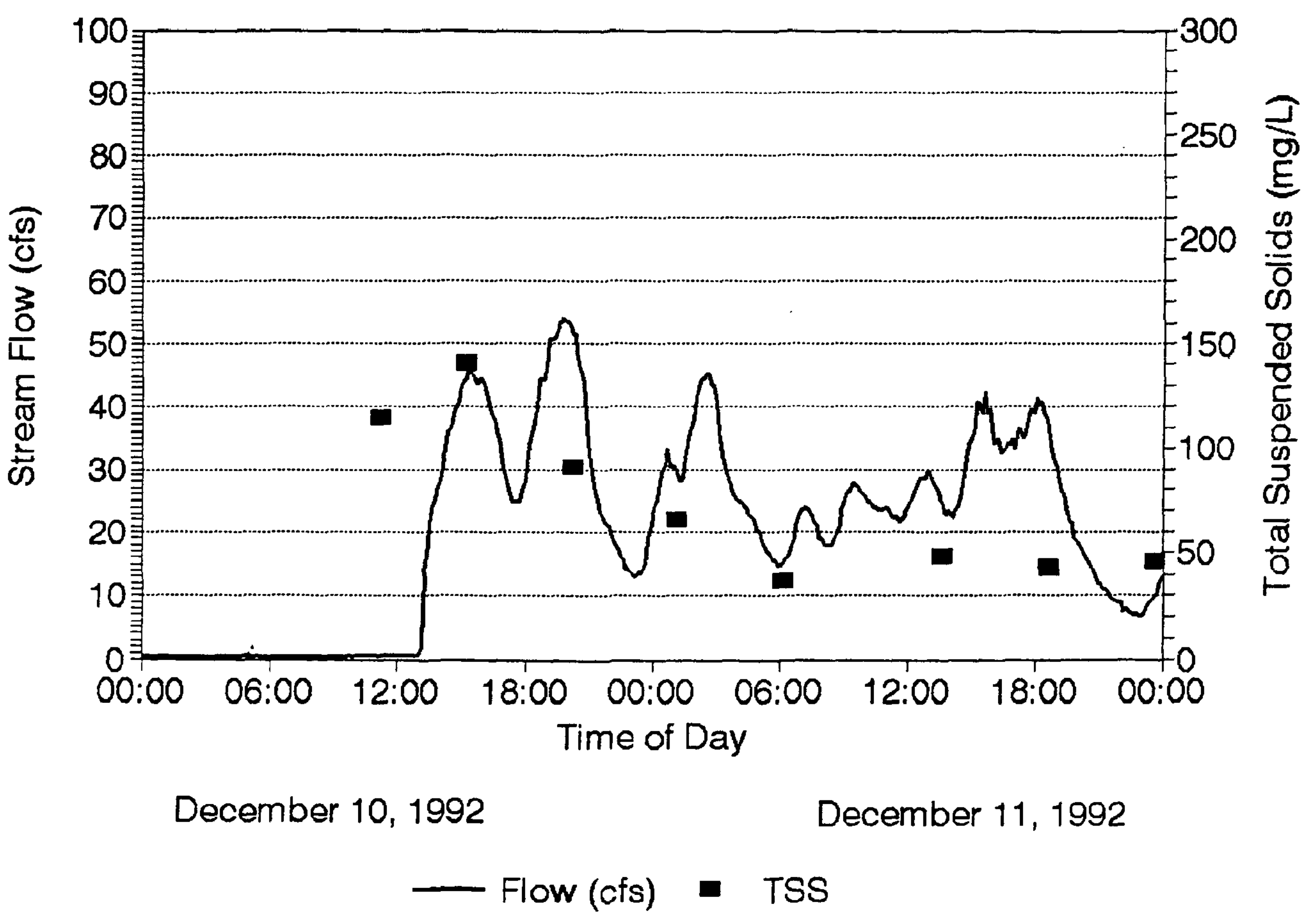

Figure 9. Total suspended solids concentration and flow record in Muddy Bridge Branch of Sawmill Creek for 12/10-11/92 storm

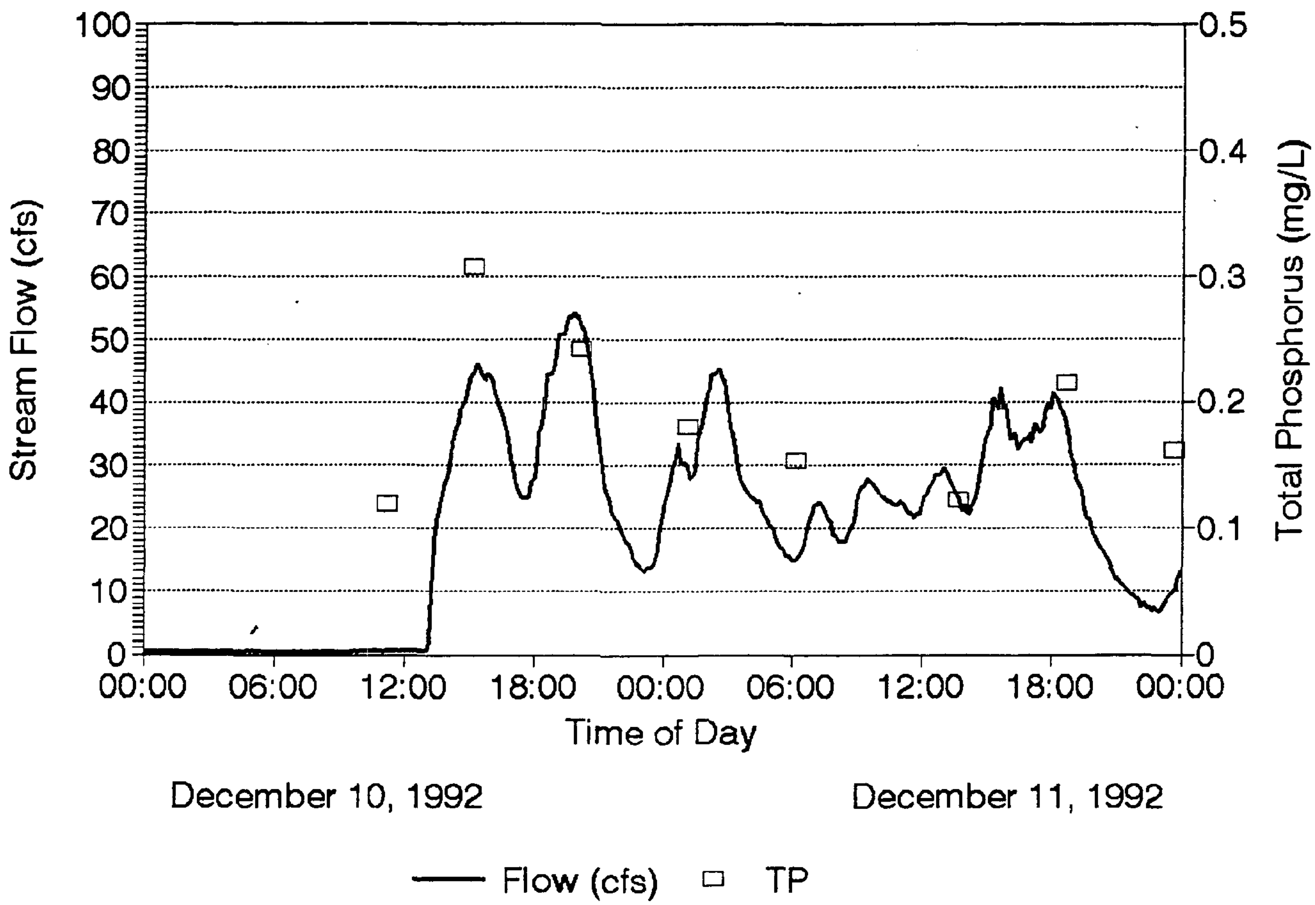

Figure 10. Total phosphorus concentration and flow record in Muddy Bridge Branch of Sawmill Creek for 12/10-11/92 storm

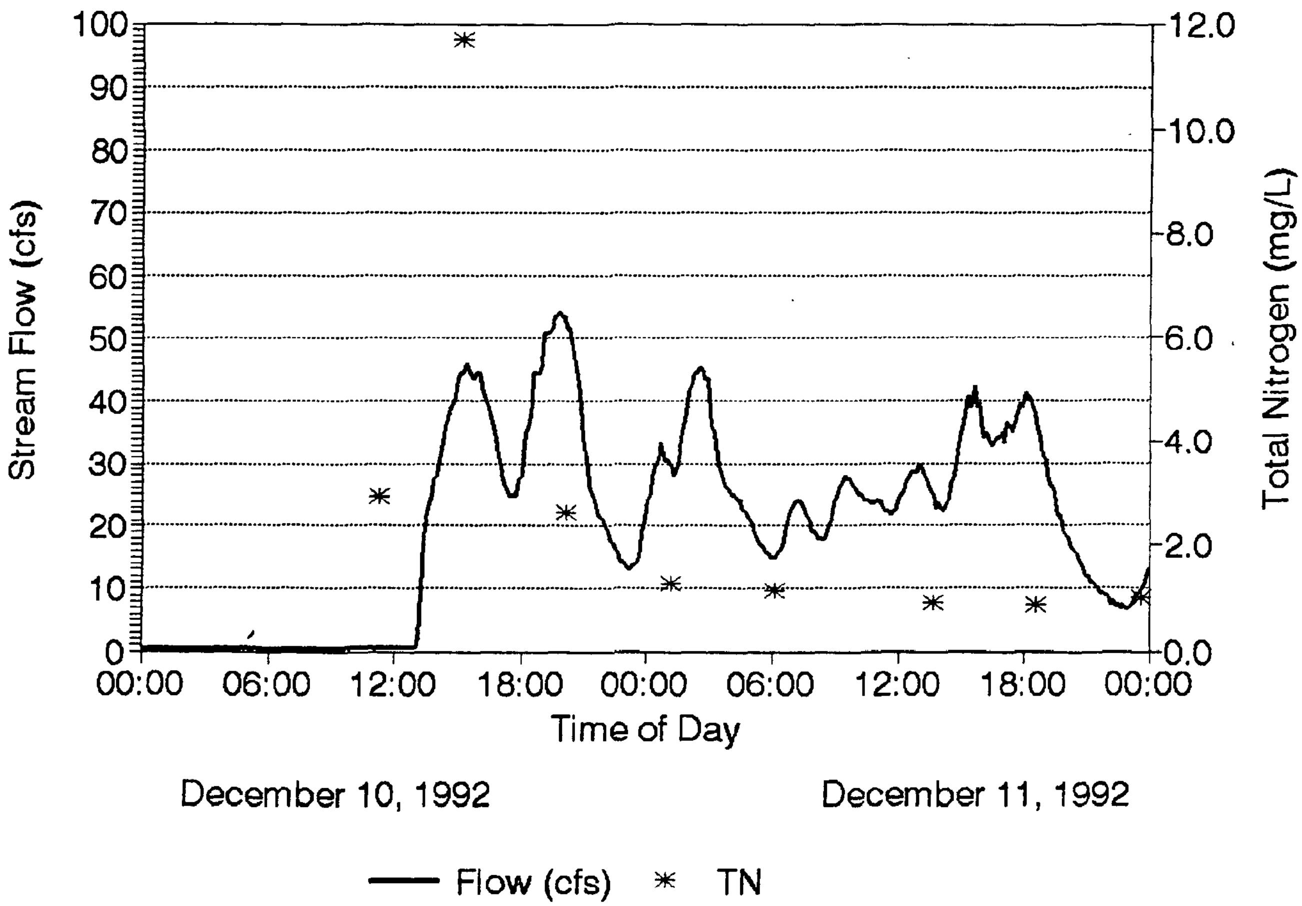

Figure 11. Total nitrogen concentration and flow record in Muddy Bridge Branch of Sawmill Creek for 12/10-11/92 storm

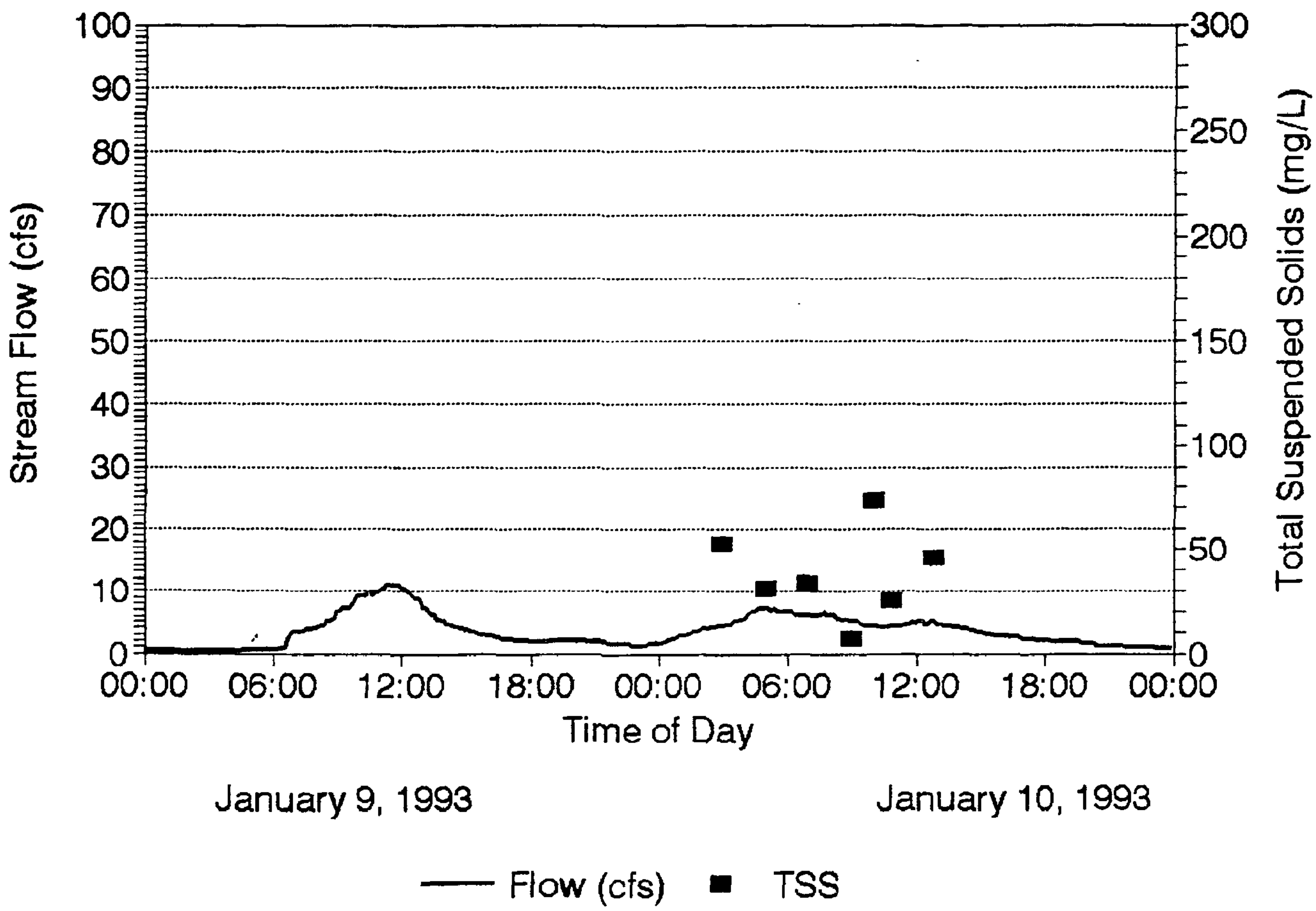

Figure 12. Total suspended solids concentration and flow record in Muddy Bridge Branch of Sawmill Creek for 1/9-10/93 storm

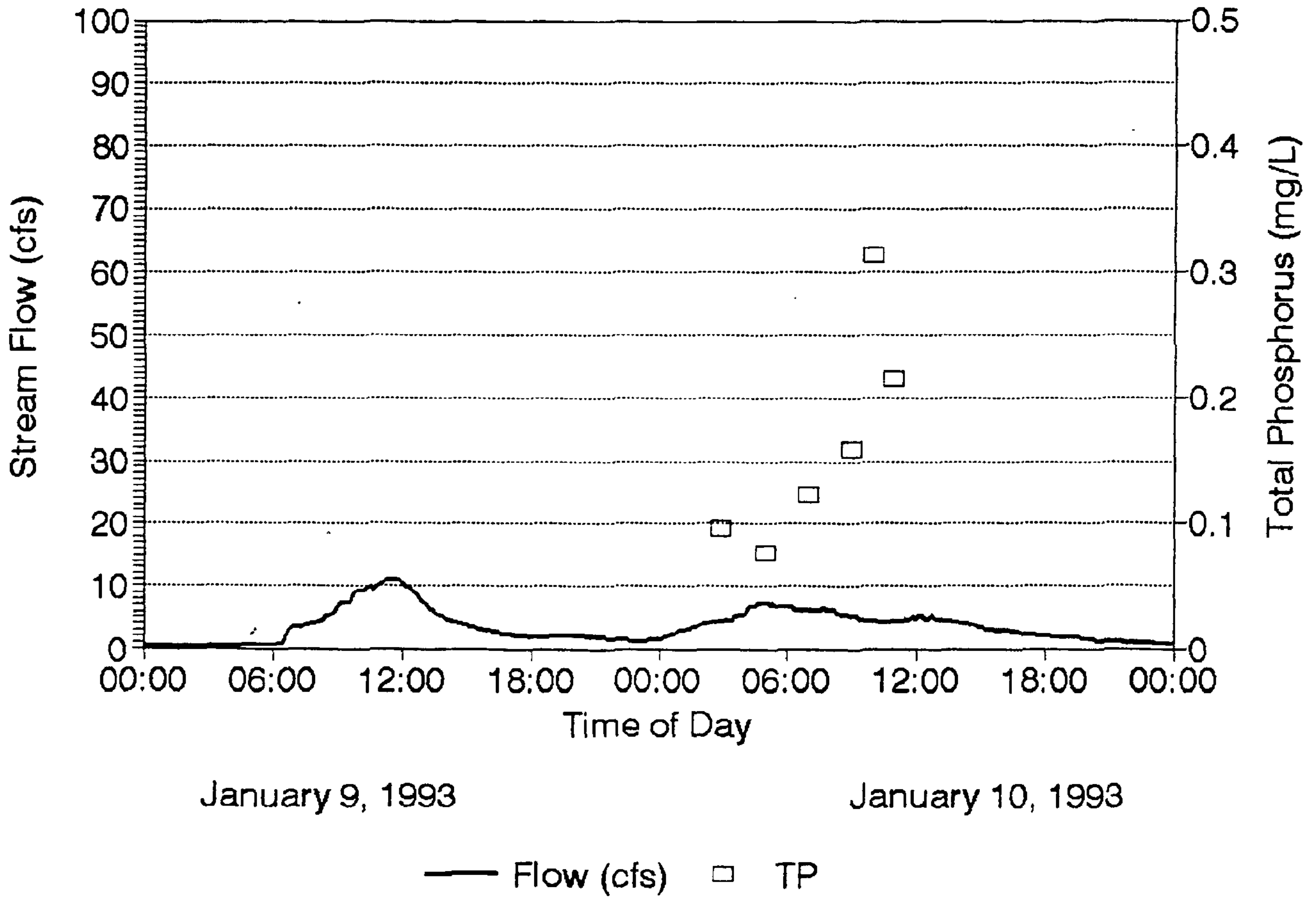

Figure 13. Total phosphorus concentration and flow record in Muddy Bridge Branch of Sawmill Creek for 1/9-10/93 storm

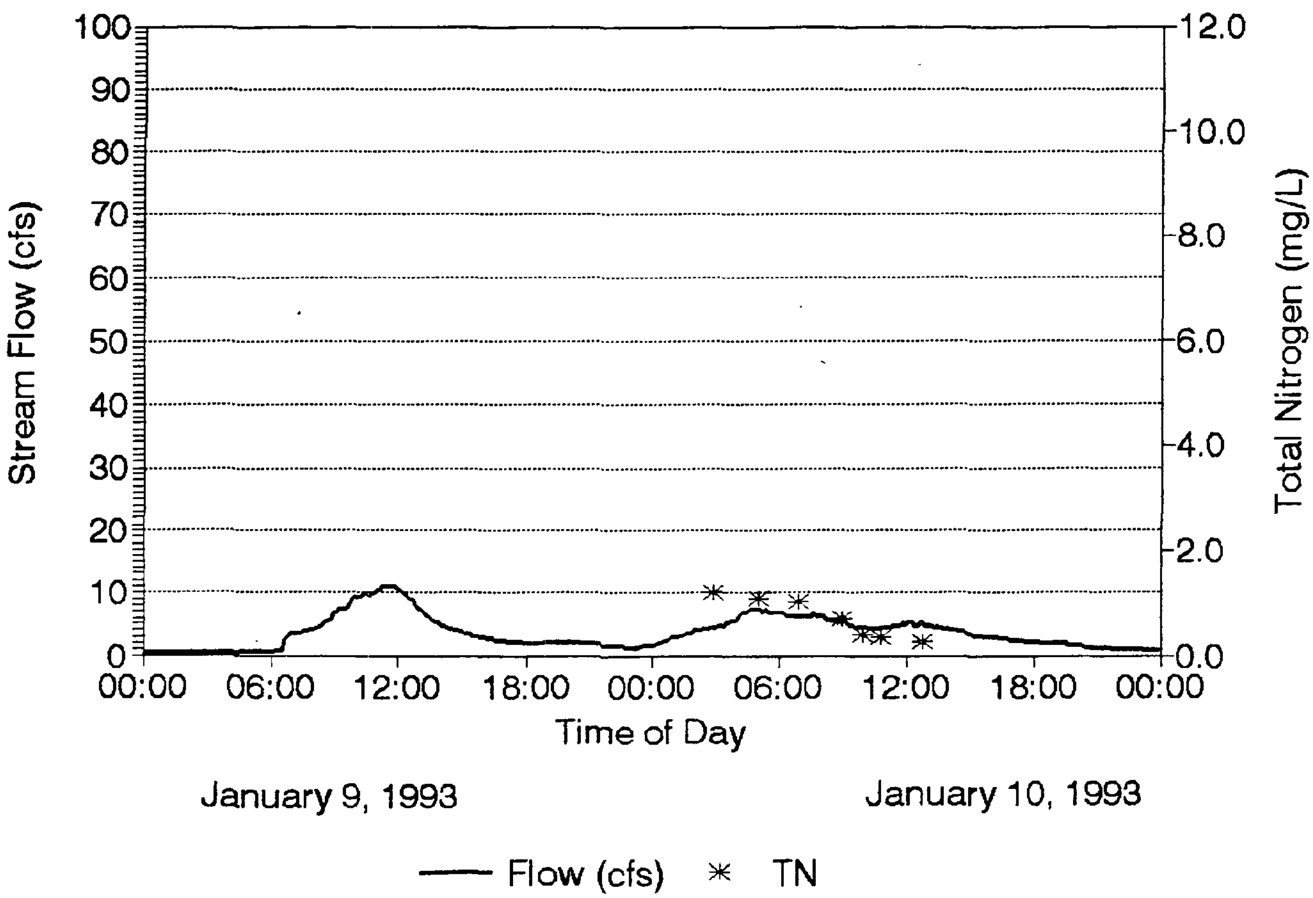

Figure 14. Total nitrogen concentration and flow record in Muddy Bridge Branch of Sawmill Creek for 1/9-10/93 storm

Table 23. Results of glycol analyses in winter of 1992-3

Ethylene/Propylene Glycol Sampling at Muddy Bridge Branch

Date	Time	E. Glycol mg/l	P. Glycol mg/l
02/12/93	04:57	0	0
	06:57	0	0
	07:57	0	0
	08:57	0	0
	09:57	92	82
	10:57	400	160
	12:54	870	260
	13:54	1400	540
	14:54	1100	630
	15:54	490	400
	16:54	640	560
	17:54	360	150
	18:54	220	50
	19:54	120	0
	20:54	58	0
	21:54	0	0

Date	Time	E. Glycol mg/l	P. Glycol mg/l
02/16/93	04:57	0	0
	05:57	0	0
	06:57	0	0
	07:57	140	99
	08:57	480	470
	09:57	680	460
	10:57	1100	1600
	11:57	400	560
	12:57	180	120
	13:57	120	74
	14:57	120	59
	15:57	92	0
	16:57	82	50
	17:57	73	0

Date	Time	E. Glycol mg/l	P. Glycol mg/l
03/13/93	04:38	0	78
	05:38	0	130
	06:38	0	180
	07:38	0	170
	08:38	0	130
	09:38	240	150
	10:38	690	240
	11:38	950	300
	12:38	940	300
	13:38	720	220
	14:38	490	160
	15:38	330	110
	16:38	210	74

Date	Time	E. Glycol mg/l	P. Glycol mg/l
03/15/93	14:20	150	2600
03/15/93	17:20	440	9100
03/15/93	21:20	280	3500
03/16/93	01:20	230	1800
03/16/93	05:20	170	990
03/16/93	09:20	160	700
03/16/93	13:20	140	530
03/16/93	22:20	210	310
03/17/93	04:20	140	290
03/17/93	10:20	50	50
03/17/93	15:20	0	0
03/17/93	19:55	0	0
03/18/93	01:55	0	0

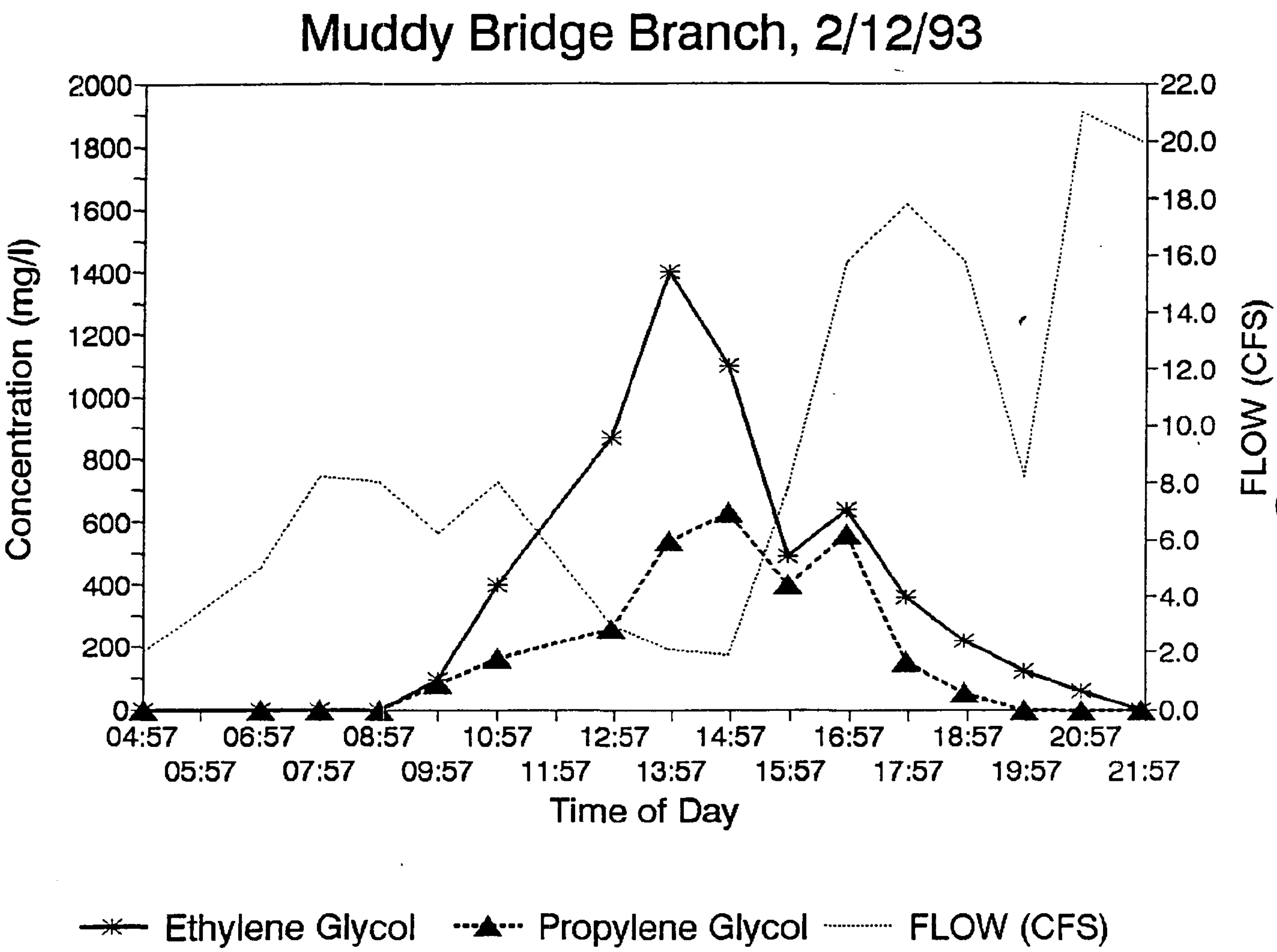

Figure 15. Ethylene and propylene glycol concentrations for the winter storm starting on 2/12/93

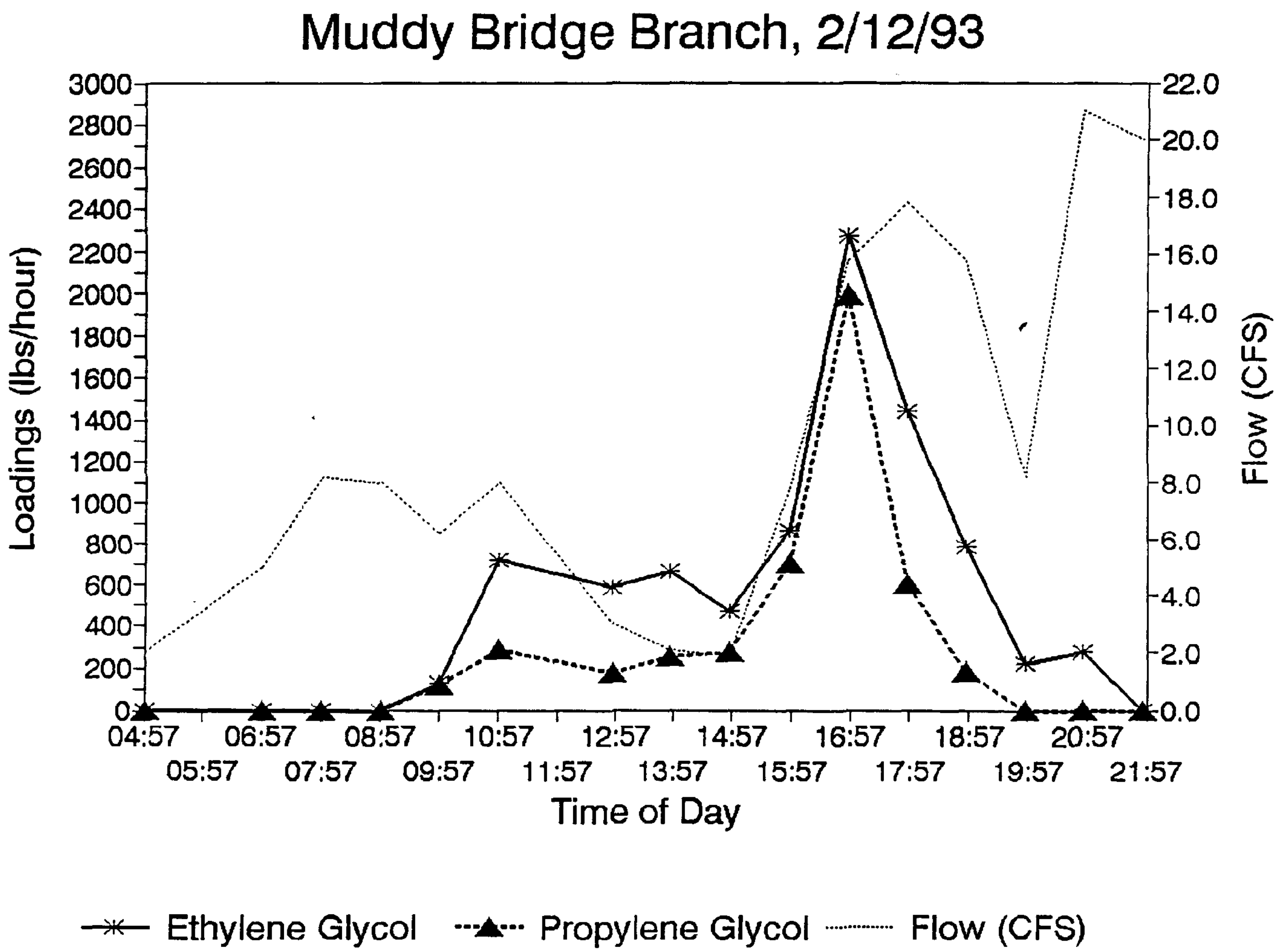

Figure 16. Ethylene and propylene glycol loadings for the winter storm starting on 2/12/93

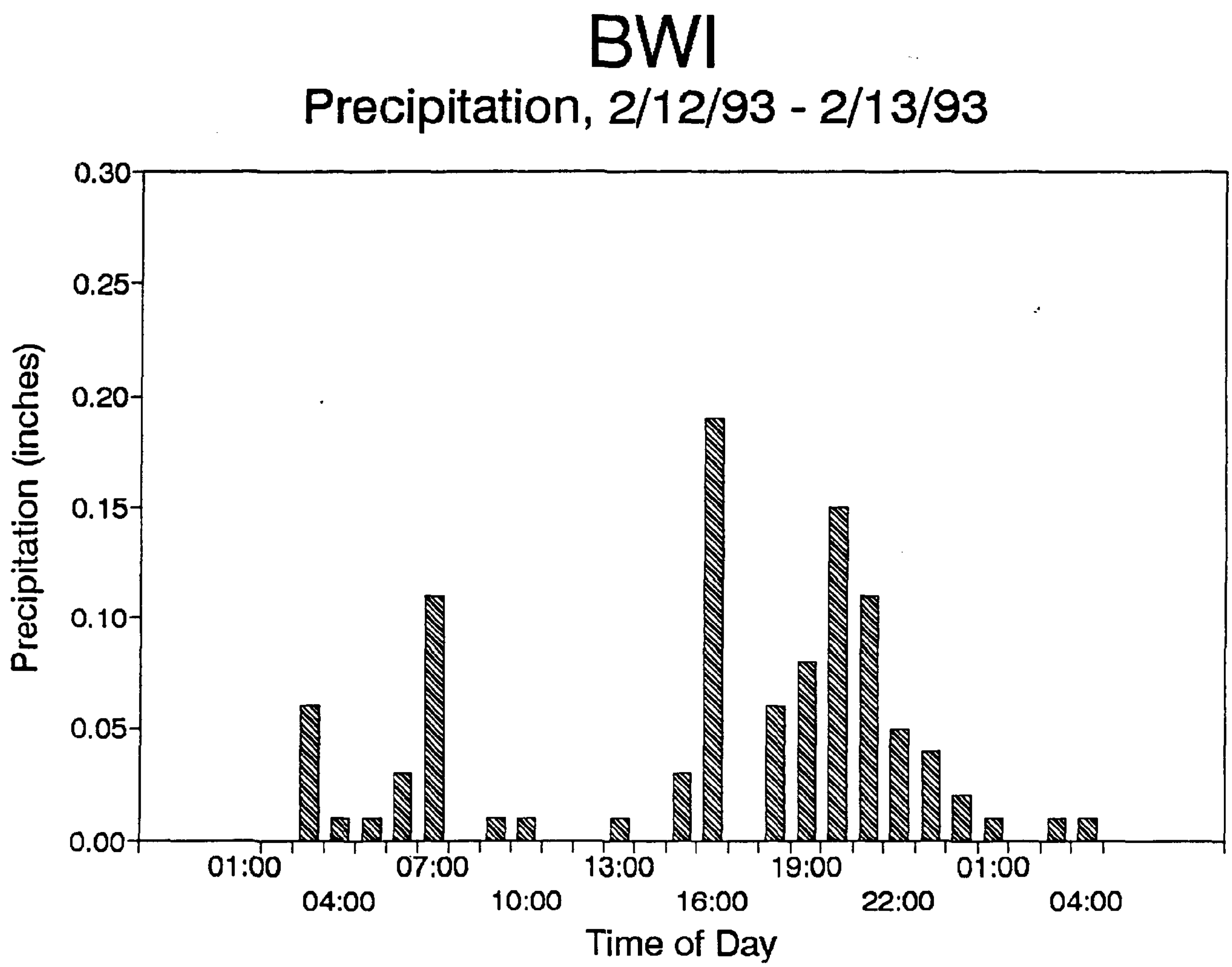

Figure 17. Precipitation at BWI for the winter storm starting on 2/12/93

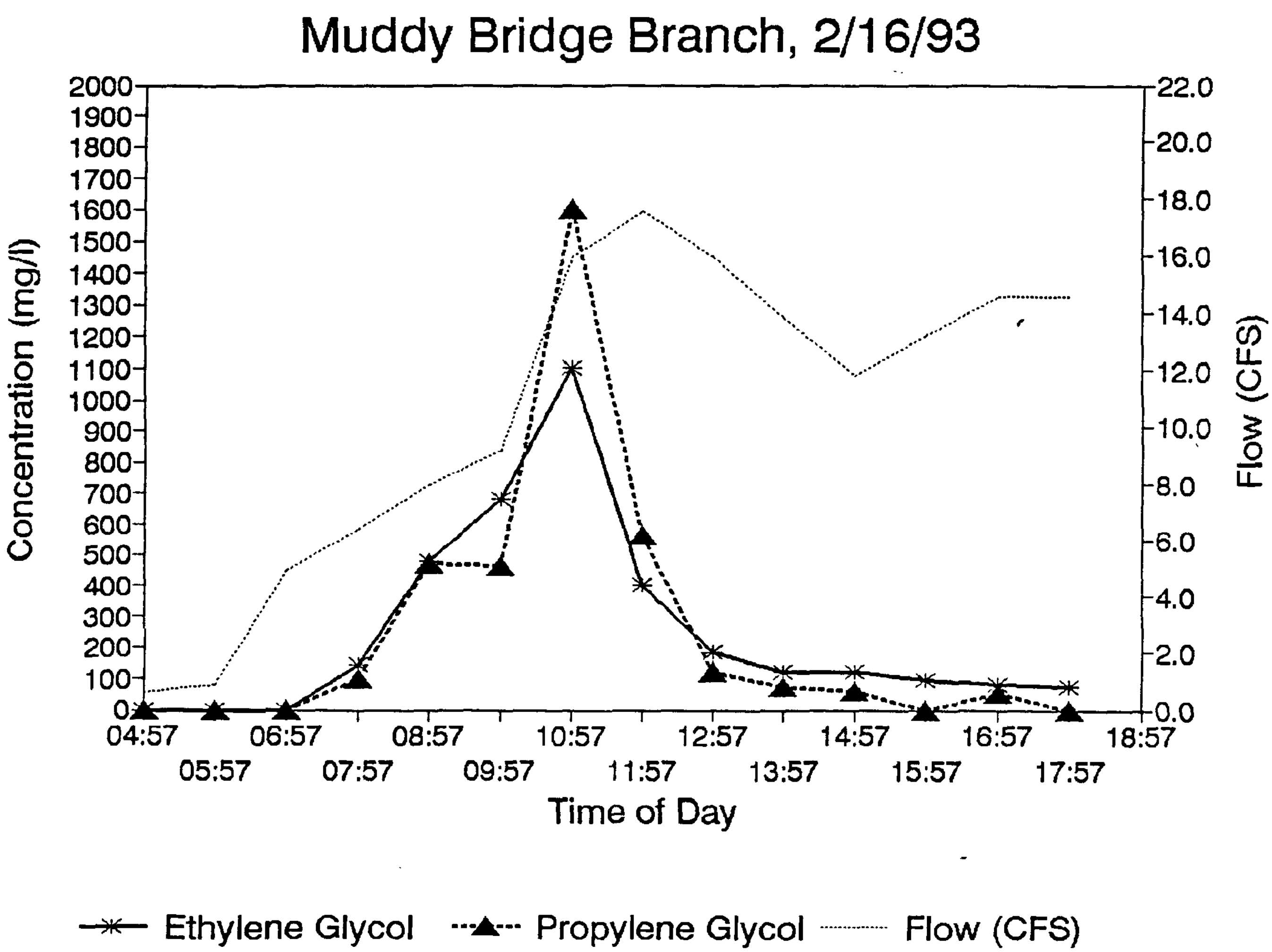

Figure 18. Ethylene and propylene glycol concentrations for the winter storm starting on 2/16/93

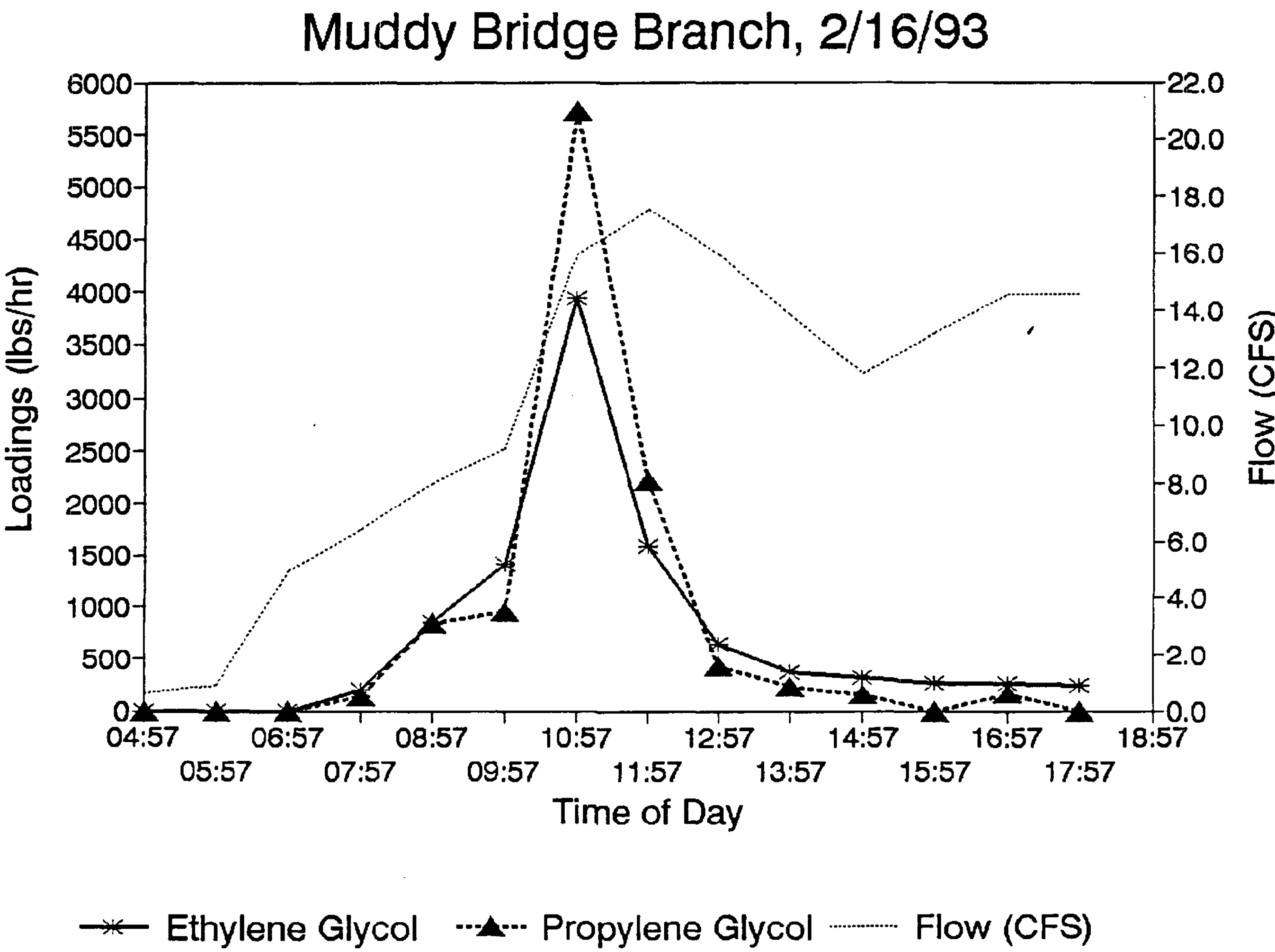

Figure 19. Ethylene and propylene glycol loadings for the winter storm starting on 2/16/93

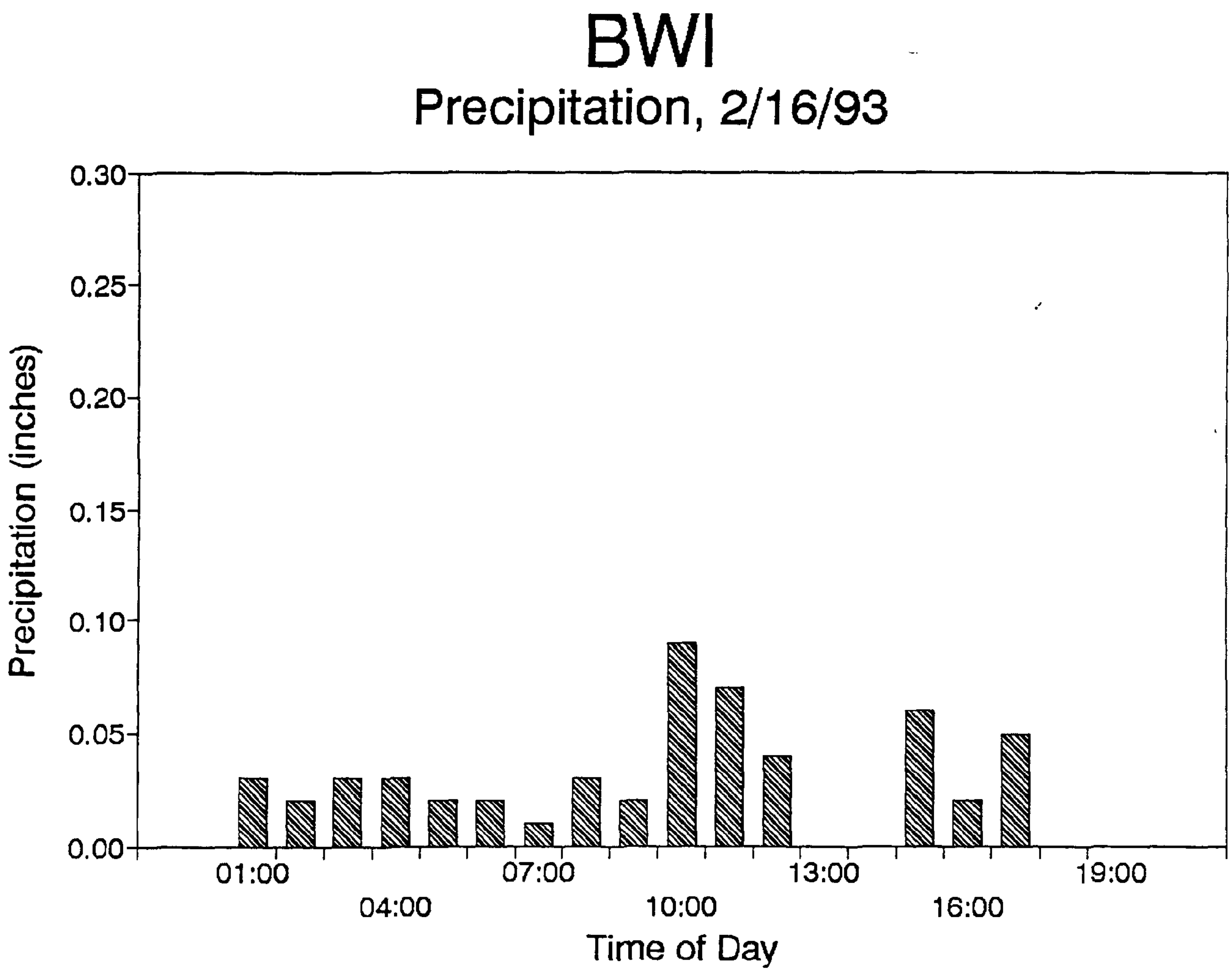

Figure 20. Precipitation at BWI for the winter storm starting on 2/16/93

Figures 21, 22, and 23 show measured glycols, calculated loadings, and precipitation for the event of 3/13/93. This was an unusually heavy snow of 11.9 inches followed by two days of near or below freezing weather. The sampler was inoperable for part of this runoff event.

Figures 24, 25, and 26 show measured glycols, calculated loadings, and precipitation for the events of 3/15-17/93. Figure 26 shows the 19 hour, 1.18 inch rainfall at the end of this event. As seen on figure 24, this rain resulted in very high flows which in effect diluted the glycols already coming off of the watershed with the melting snow. This snow was left over from the storm on 3/13.

Based on work done by DNR on the toxicity of glycols to aquatic life, concentrations of propylene glycol of 2000 mg/l of propylene glycol would kill all fathead minnows in a test solution within 3 hours (Hartwell et al. 1993). Concentrations of this magnitude were reached on 2/16/93 (Figure 18) and 3/15/93 (Figure 24) based on this sampling.

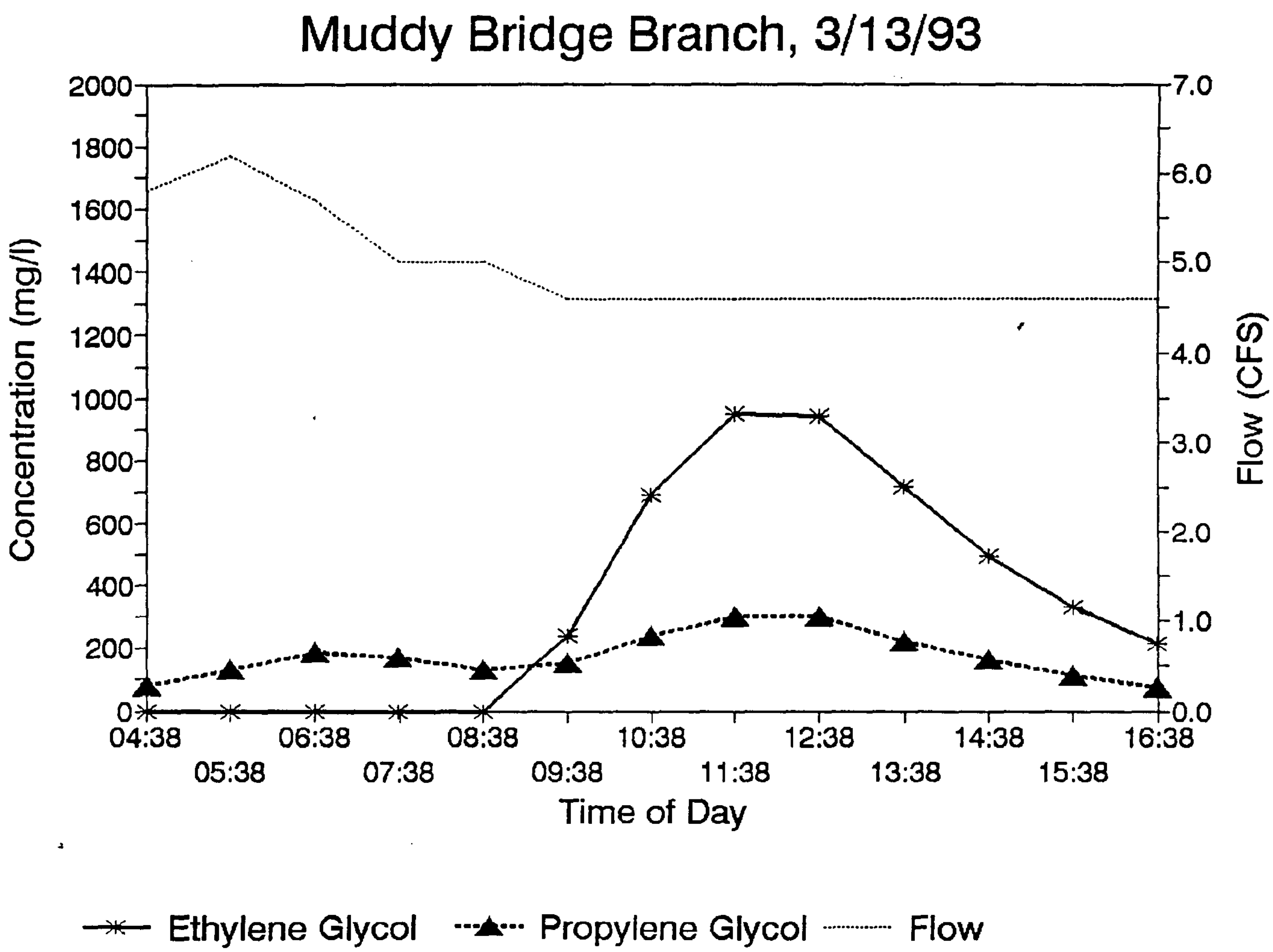

Figure 21. Ethylene and propylene glycol concentrations for the winter storm starting on 3/13/93

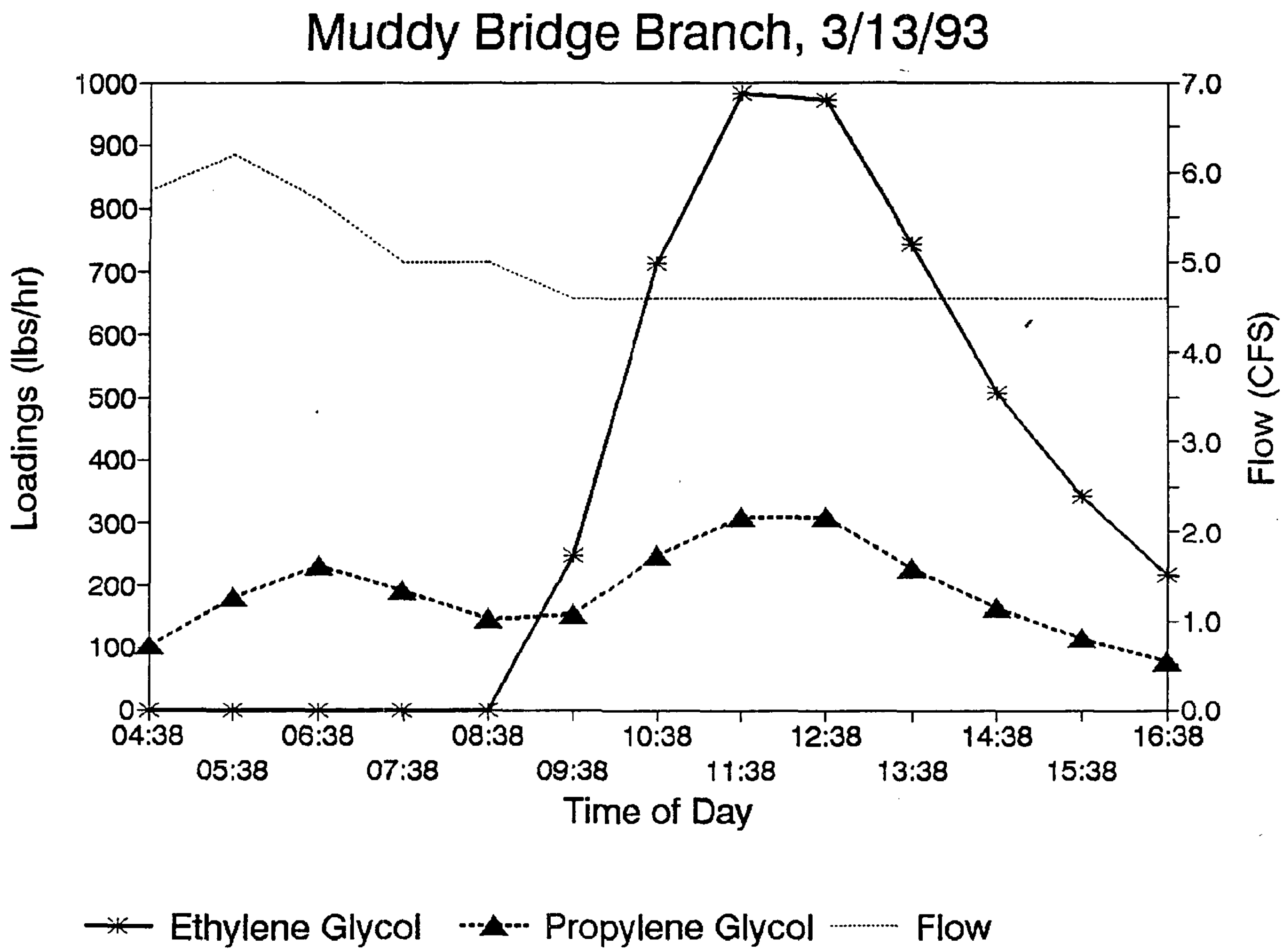

Figure 22. Ethylene and propylene glycol loadings for the winter storm starting on 3/13/93

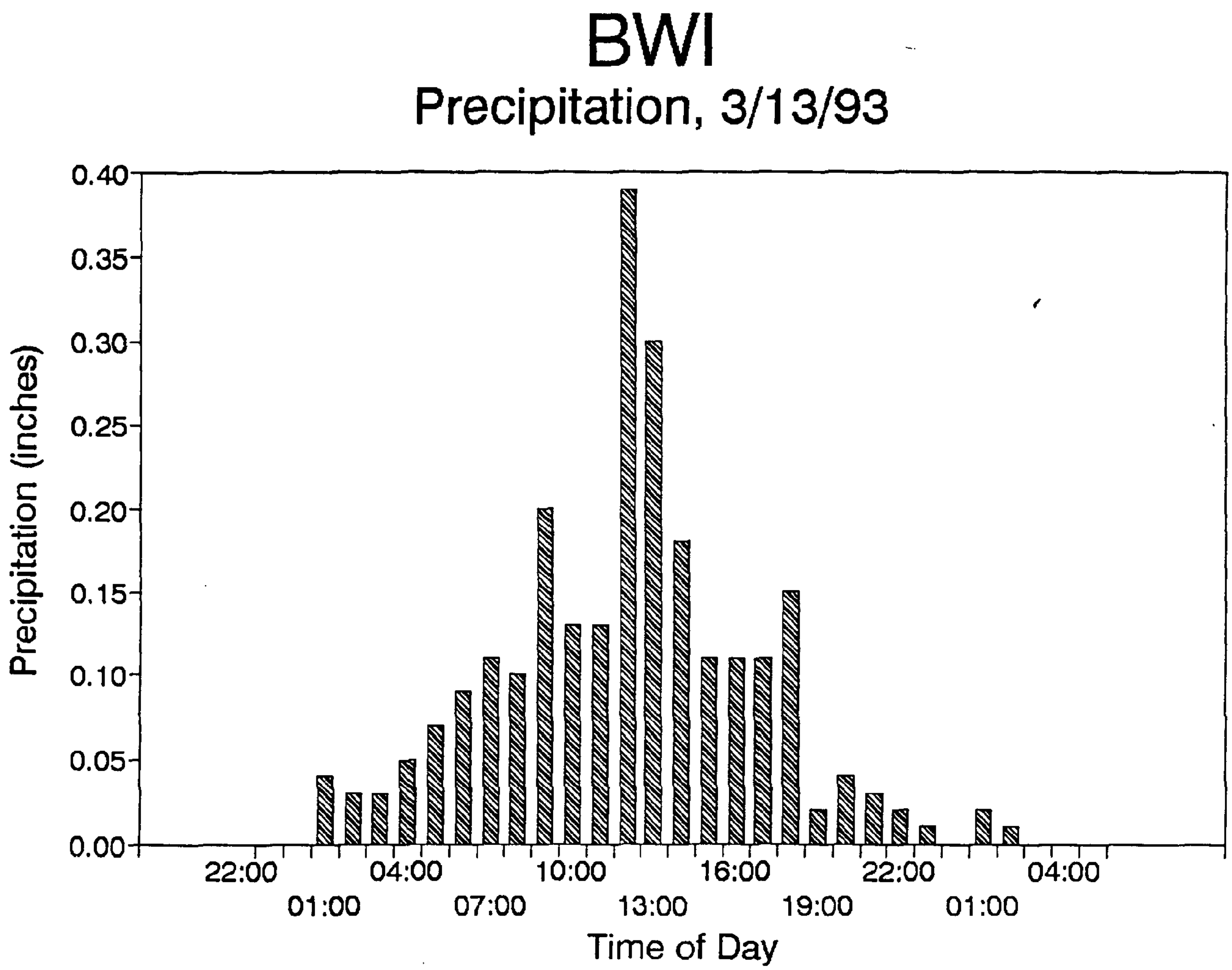

Figure 23. Precipitation at BWI for the winter storm starting on 3/13/93

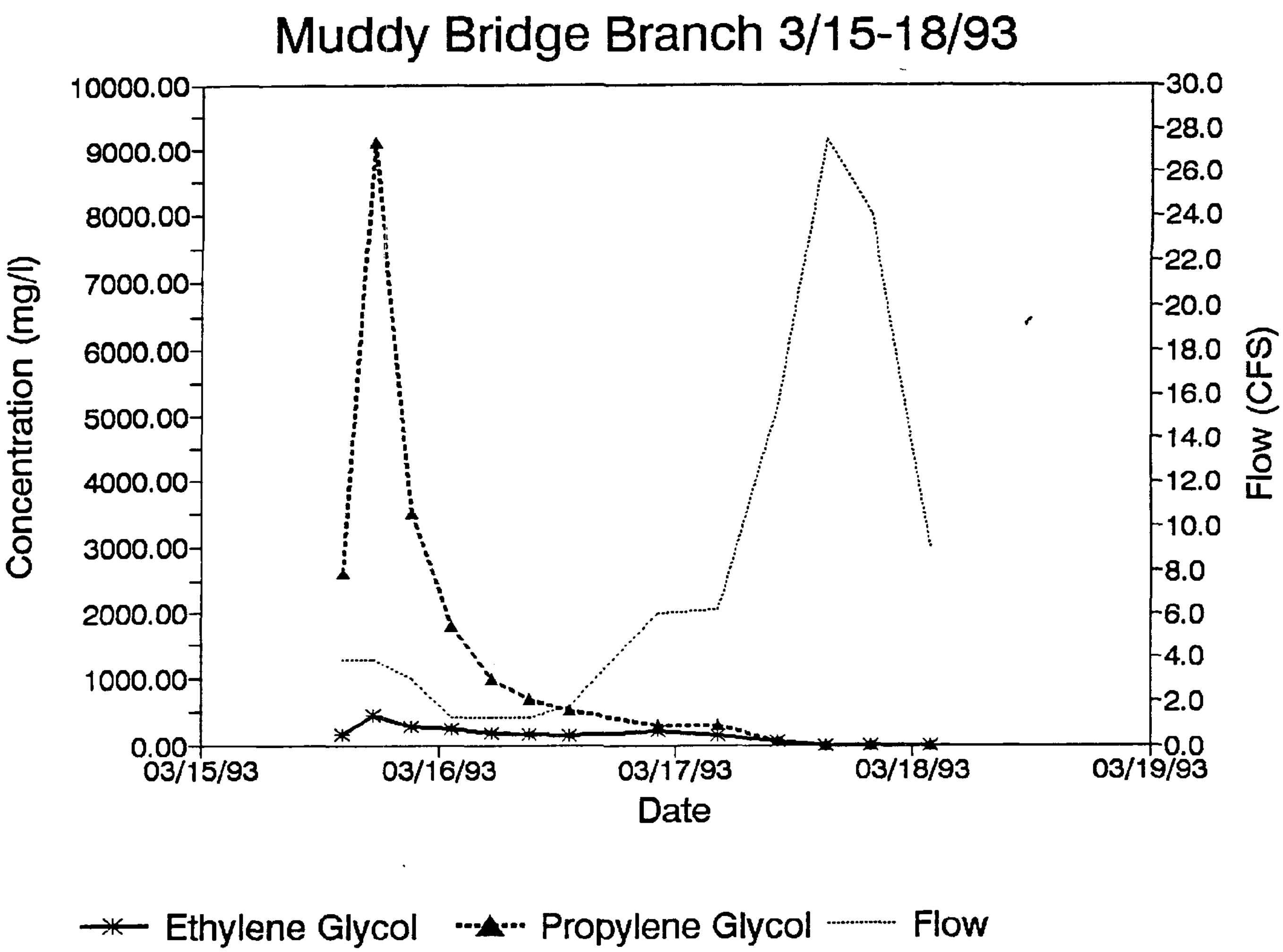

Figure 24. Ethylene and propylene glycol concentrations for the winter storm starting on 3/15/93

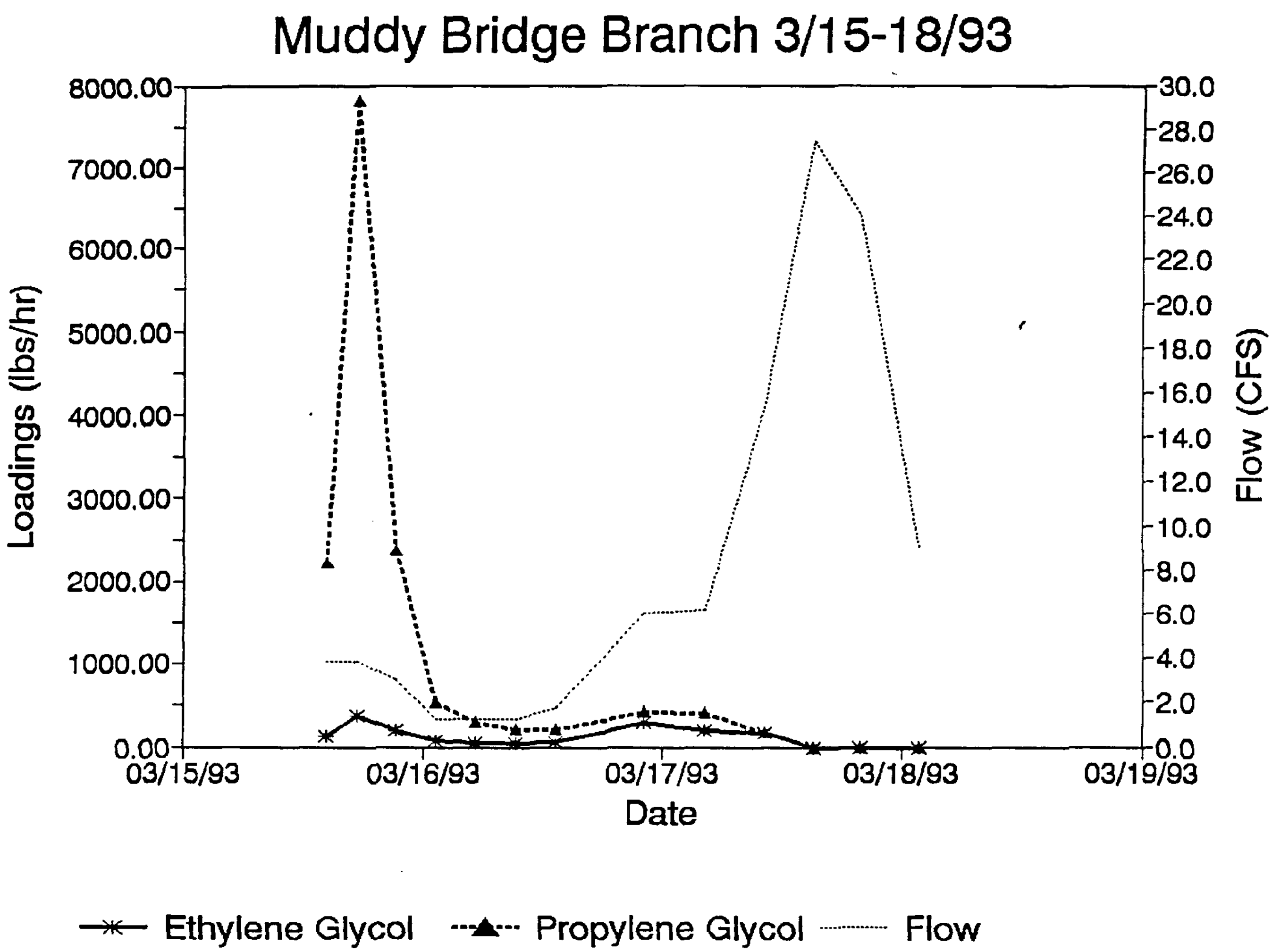

Figure 25. Ethylene and propylene glycol loadings for the winter storm starting on 3/15/93

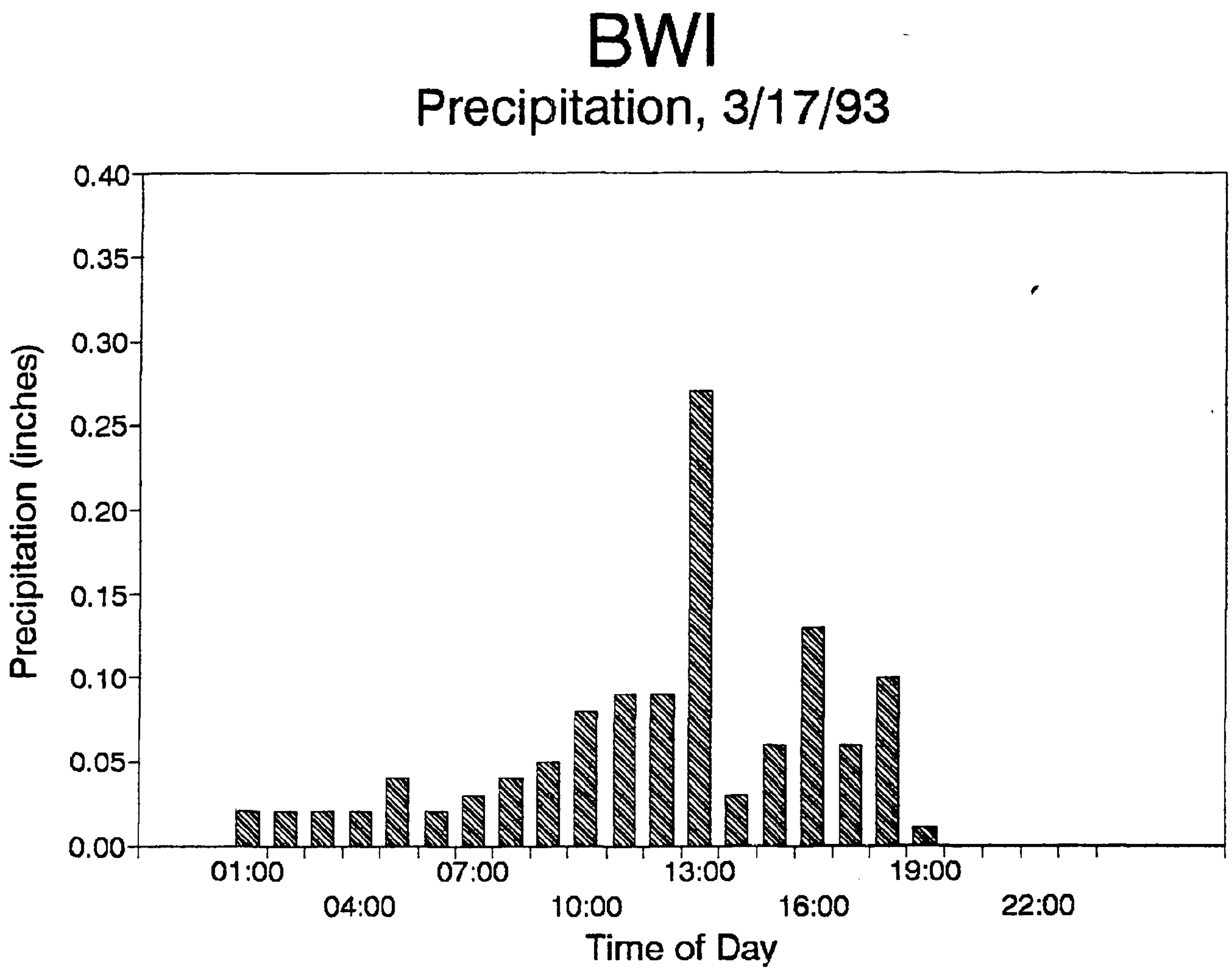

Figure 26. Precipitation at BWI for the winter storm starting on 3/15/93

RECOMMENDATIONS

German Branch

1. **Track agricultural and sludge management activities** - This project has begun using Geographic Information Systems (GIS) to track land use in specific sub-watersheds. Sludge management has been identified as a potential source pollution in the watershed. The results of this monitoring show that it is not the only source. Work in this project involved mapping by Salisbury State University. Potential sources of nutrients should continue to be mapped using the assistance of agricultural experts in the watershed.

2. **Identify treatment options for container nursery in Wild Cat Branch.** - This sub-watershed produced the highest level of nitrate + nitrite in the watershed, based on our measured and adjusted concentrations. If this facility is exempted from wastewater treatment requirements, voluntary containment and treatment of runoff could be pursued. Otherwise a treatability assessment should be made at this facility by professional engineers and appropriate permits should be obtained for construction of containment or treatment facilities.

3. **Further investigate possible denitrification from farm ponds** - There was only a hint of possible nitrogen removal at a pond discharge in this watershed. It may be possible to manage existing ponds and ditches to attain some degree of N-removal. If funding is available, ponds such as two in series at Station 19 could be monitored for nutrients necessary to determine treatment efficiency.

Sawmill Creek

1. **Collect and treat de-icers from Baltimore/Washington International Airport (BWI)** - These sampling results showed concentrations of glycols running off the airport that could produce toxic impacts on aquatic life. Existing efforts to assess the quantities and treat or recycle these compounds should continue.

2. **Inventory nitrogen compounds used at BWI** - One winter storm sample showed a total nitrogen spike of almost 12 mg/l. This was possibly the result of urea use to control airport runway icing at BWI. High nitrogen has been found in other airport samples collected for MDOT. An inventory would be a good first step to identify the actual source of these compounds and to develop a management or treatment plan.

3. **Survey watershed for potential sources of priority pollutants above storm drain on east side of Wagner's Pond** - Most of the pollutants found in this sampling for toxics were near or below detection levels and protection criteria, however at Station K the PAH concentrations found appear to warrant a visual watershed survey to inventory possible commercial or industrial sources. If the sources are atmospheric or diffuse, control may not be feasible in this project.

4. **Assess extent of groundwater pollutants and develop a remediation plan at the printing company on B&A Boulevard** - The discovery of xylenes and toluene in surface waters of Sawmill Creek on 3/11/93, may indicate that contaminated groundwater from a RCRA/CERCLA site extends over a greater area than previously thought. The Maryland Department of the Environment is continuing to require groundwater assessments for the development of a plan for remediation. Due to the existence of drinking water wells in the watershed, an assessment should be made of the geological formations separating the wells from the contaminated groundwater.

5. **Re-survey fecal coliform concentrations during summer periods in Sawmill Creek headwaters** - The concentrations of fecal coliforms during the time period studied in this project did not confirm earlier observations. Seasonal variations in temperature, runoff, stream flow, and number of animals will have to be reviewed in more detail to develop a suitable sampling strategy. Summer and late spring sampling may be necessary to provide more useful data.

REFERENCES

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Haddaway, Mike, Stuart Lehman, Fred Paul, John Christmas, Niles Primrose, John McCoy, Doug Marshall, and Dave Jordahl. July 1992. German Branch baseline monitoring report - October 1989-September 1990. Maryland Department of Natural Resources, Maryland Department of the Environment, and U.S. Fish and Wildlife Service. Annapolis, Maryland.

Hartwell, S. Ian, David M. Jordahl, and Eric B. May. May 1993. Toxicity of aircraft de-icer and anti-icer solutions to aquatic organisms. CBRM-TX-93-1. Maryland Department of Natural Resources, Tidewater Administration, Chesapeake Bay Research and Monitoring Division, Fisheries Division, Annapolis, Maryland.

Marshall, Doug, Stuart Lehman, Mike Haddaway, John Christmas, Niles Primrose, John McCoy, Fred Paul, and Dave Jordahl. April 1992. Sawmill Creek baseline monitoring report - October 1989-September 1990. Maryland Department of Natural Resources, Maryland Department of the Environment. Annapolis, Maryland.

U.S. EPA. March 1983. Methods for chemical analysis of water and wastes. EPA-600/4-79-20. Environmental Monitoring and Support Laboratory, Cincinnati, OH.

Appendix A. Example of adjustment calculation for Station 28 on 8/11/93

60% of w/s at Sta 28. times [x - unknown concentration] +

40% of w/s at Sta. 29 times [at station 29]

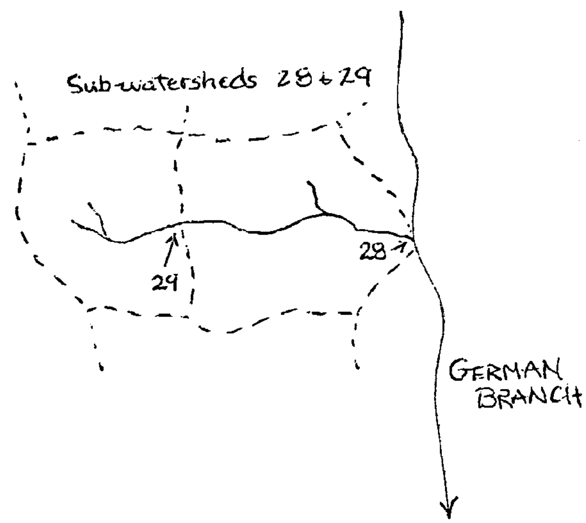
= 100% of w/s [at lower watershed stations Station 28]

or:

0.60 [X] + 0.40 [0.11 mg/l] = 1.0 [4.08mg/l]

Solving for X: X = 6.73 mg/l - the adjusted concentration at Station 28

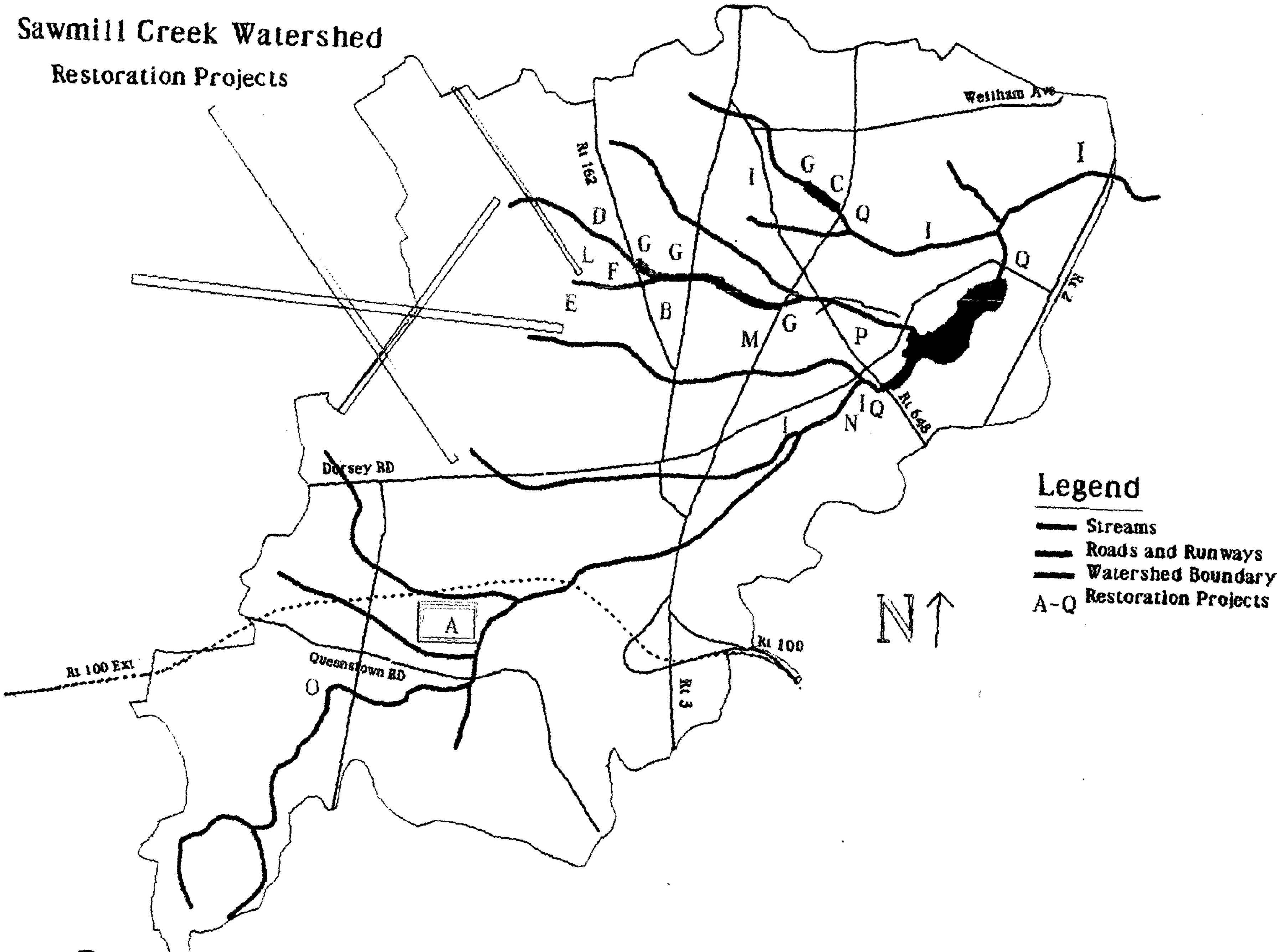
[ ] = Concentration

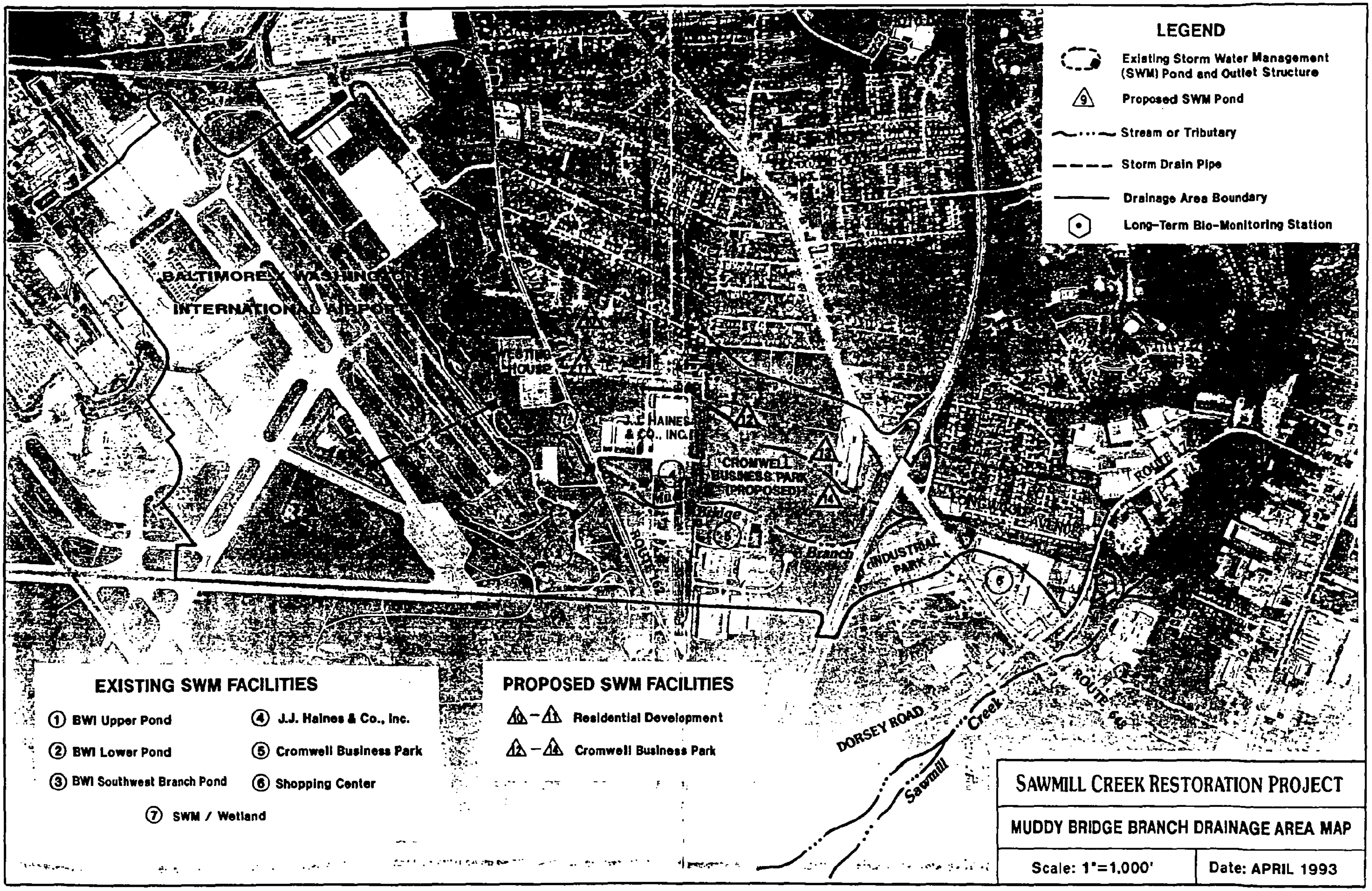


Appendix B. Maps of Muddy Bridge Branch and Sawmill Creek showing areas of where restoration projects are underway.

Sawmill Creek Watershed

Restoration Projects





LEGEND
Existing Storm Water Management (SWM) Pond and Outlet Structure
Proposed SWM Pond
Stream or Tributary
Storm Drain Pipe
Drainage Area Boundary
Long-Term Bio-Monitoring Station
BALTIMORE-WASHINGTON INTERNATIONAL AIRPORT
J.J. HAINES & CO., INC.
CROMWELL BUSINESS PARK (PROPOSED)
INDUSTRIAL PARK
Branch
DORSEY ROAD
Sawmill Creek
ROUTE 648
ROUTE 176
EXISTING SWM FACILITIES
① BWI Upper Pond
② BWI Lower Pond
③ BWI Southwest Branch Pond
④ J.J. Haines & Co., Inc.
⑤ Cromwell Business Park
⑥ Shopping Center
⑦ SWM / Wetland
PROPOSED SWM FACILITIES
Residential Development
Cromwell Business Park
SAWMILL CREEK RESTORATION PROJECT
MUDDY BRIDGE BRANCH DRAINAGE AREA MAP
Scale: 1"=1,000'
Date: APRIL 1993

L. Airport runoff: Deicer management plan.

M. RCRA Site: Water contamination management plan.

N. Oil Storage Facility: Clean up plan in place.

O. Pig Pens in Floodplain: Seasonally high bacterial counts, streambed fouling, discolored water.

P. Stream channelization: 1600 feet of aquatic habitat and riparian buffer destroyed, then dredged and mowed periodically.

Q. Fish Blockages: Mainstem at Eighth Avenue, Tributary 9 at Olen Dr., USGS Gage at Rt. 648.

SAWMILL CREEK WATERSHED

RESTORATION PROJECTS: 6/28/93

A. **Sand and Gravel Mine Reclamation:** Create 29 acre park linkage and wildlife corridor with reforestation, wetlands restoration and stream buffers.

* B. **Muddy Bridge Branch Stream Restoration:** 3100 feet sediment and erosion control, habitat re-creation, & removal of 3 fish passage blockages (G).

C. **Tributary, 9 Stream Restoration:** 900 feet sediment and erosion control, habitat recreation, & removal of 1 fish passage blockage (G)

* D. **Stormwater Management Retrofits:** Reduce frequency and duration of out-of-bank flows and protect the restored stream from erosive storm flow events.

* E. **Stormwater Management Diversions:** Direct excess runoff away from Muddy Bridge Branch, increase ground water infiltration and enhance base flow.

* F. **Wetlands Restoration and Stormwater Detention Basin:** 2 acres

G. **Fish Passage Blockage Removal:** Total of 5 projects confirmed thus far.

I. **Citizen's Activities:** Targeting team monitors, Sawmill Creek Watershed Association, SOS, Glen Burnie Improvement Association.

Water Quality Monitoring (weekly)
Tree plantings
Stream cleanups
Storm Drain Painting
Workshops; mudbusters, household toxic reduction

* Muddy Bridge Branch projects funded by SHA & MAA, approximately $1 millon to reduce frequent storm flows at BWI by 50% to 70%, and sediment loading by 80%.

Appendix C. Report by Larry Lubbers, MDNR on the laboratory and field studies on aircraft de-icers at BWI airport.

Maryland Department of Natural Resources

Tidewater Administration
Tawes State Office Building
580 Taylor Avenue
Annapolis, Maryland 21401

William Donald Schaefer
Governor

Torrey C. Brown, M.D.
Secretary

Presentation to the
SAE Aircraft Ground Deicing Conference
June 15-17, 1993
Salt Lake City, Utah

Laboratory and Field Studies of the Toxicity of Aircraft Deicing Fluids[1]

Slide # 1
Map of BWI Airport and Adjacent Streams

I would like to present some new information on the impact of deicing fluids on fresh water streams near Baltimore Washington International Airport (BWI). This was a multi-agency effort with both laboratory and field studies. It involved the Maryland Aviation Administration, MD Department of the Environment, MD Department of Natural Resources, and the University of Maryland. We looked at the fish, benthic invertebrate, and microbial communities. We found acute and chronic impacts that were worse than the available scientific literature would predict. This literature includes EPA data bases and publications from the aviation industry, particularly the deicing fluid manufacturers.

The airport is located on a small hill that forms the drainage divide for 3 separate streams that feed into the Patapsco river. One of those streams, Sawmill Creek has been the focus of a multi-agency restoration project for the last several years. Our initial monitoring surveys indicated that the tributary that receives the most airport runoff had the least number of fish and invertebrates. Additional sampling indicated that some of the surviving fish in this tributary had tissue damage that could attributed to exposure to deicing fluids. These observations caused us to initiate a more intensive study of the effects of airport runoff.

Slide # 2
Summary of Results

The first set of results shown here were laboratory studies in which fish and invertebrates were exposed to a range of deicer

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[1] by Larry Lubbers, Watershed Impact Evaluation Program, MD Department of Natural Resources

Telephone: (410) 974-5780
DNR TTY for Deaf: 301-974-3683

concentrations that were prepared from Type I and Type II fluids that we received from MAA. In the interest of time I am only reporting on the fish data, but we had similar mortality rates with the invertebrates. The Type I deicer killed all the fish at a concentration of 8.75 ml/L. That is roughly a 0.87% solution. The Type II deicer was more toxic and killed all the fish at 0.063 ml/L. We also noted tissue damage increased in severity as the time of exposure was increased. Tissue damage was noted in the gills, skin and kidneys.

The second set of tests involved collecting stream water and airport runoff and exposing our test organisms to the water and deicer mixtures. We noted higher mortality rates in the fish and invertebrates and there were chronic impacts on reproductive capacity of the zooplankton, as well as the tissue damage that I mentioned in the first set of tests. The metabolism of the microbial community was also impacted and we think this has an effect on the relationship of BOD (biological oxygen demand) to the COD (chemical oxygen demand).

During 1993 we made a number of measurements of deicer concentrations in the airport's runoff. The peak concentration for the Type I deicers was 89.1 ml/L, and for the Type II anti-icer the concentration was 154.5 ml/L. That is about a 15% solution.

Slide # 3

Mortality (LC50) & Tissue Damage

This graph compares the relative toxicity of various glycol based solutions. An LC50 (Lethal Concentration 50%) is a standard method used by EPA and toxicologists all over the world. It tells you the concentration of a compound that will kill 50% of the test animals in a particular experiment. The bars on this graph indicate a range lethal concentrations because the tests can be run for varying periods of times, typically 2, 4, or 7 days. In many cases mortality rates are inversely related to the time of exposure. (See the attached table A-1: Time To Median and Total Mortality. This figure was not included in the SAE presentation.)

The first two columns show the LC50 values for ethylene and propylene glycols as reported by EPA and the deicing manufacturers. As you can see lethal concentrations are fairly high and the propylene glycol is much less toxic than the ethylene glycol. The third column shows the toxicity of the Type I fluid that we used in our laboratory tests. It was an ethylene glycol based compound and it is more toxic that the straight ethylene glycol. I have also included the range of concentrations that caused tissue damage in fish that were not killed outright. In this case the damage was located in the kidneys and appears to be unique to exposure to the ethylene glycol and not to additives in the Type I formulation.

The fourth column shows the LC50 concentrations for the Type II fluid that we tested in the laboratory. This was a propylene glycol based fluid and it is three orders of magnitude more toxic than the literature values indicate for the primary ingredient.

The last column shows the 50% lethal concentration for mixtures of Type I and II fluids that were collected from airport runoff. As you can see toxic concentration falls between our two laboratory test results. The relative proportion of Type I to Type II fluid in the stormwater runoff varied between 20 and 80 percent. The ratio varied with different storms and also changed over time during a individual runoff event. (The attached report from the University of MD to the MD Dept. of the Environment contains more details on the stormwater studies. This report was not presented at the SAE conference.)

The last point I want to make is that LC50 values are <u>not</u> used a direct standards for resource management. They are simply a way to compare the relative toxicity of different chemical compounds.

Slide # 4
BWI Runoff, Sawmill Creek Tributary

This graph shows the stream discharge and deicing fluid concentrations at an automated sampling station that is about one half mile downstream of the airport's boundary. The snow storm dropped about 12 inches of snow in a 30 hour period. Type I fluid concentrations peaked at about 1 ml/L during the storm but deicing fluids persisted in the stream for almost 4 days.

We could not reset our sampler immediately after the storm but when it was restarted Type II concentrations were above 2 ml/L. The Type II concentrations peaked at 8.3 ml/L and stayed above 2 ml/L for over 6 hours. From our laboratory studies we know that exposure to a 2 ml/L solution would kill all our test fish in less than three hours.

Slide # 5
BWI Runoff, Stony Run Tributary

This graph shows deicer concentrations in airport runoff during a small snow storm (2.25 inches of snow). These samples were taken at the point of discharge into a stream on the western side of the airport. The total glycol concentration exceeded 200 ml/L, or about 20% of the runoff volume. This runoff represents about 60% of the combined stream flow at this point in the channel.

At the beginning of the storm the ratio of Type I to Type II was almost 50:50. The concentrations went down as flow increased but then rose again towards the end of the storm. At that time the Type II fluid made up over 80% of the deicer fluids or about 15% of the total runoff volume.

In summary:

*Both types of deicing fluids are more toxic than the primary ingredients.

*Type II propylene based fluid is considerably more toxic than the available literature would have predicted.

*We documented tissue damage from exposure to ethylene glycol at concentrations that did not kill the fish out right.

*We found very high field concentrations and measured lethal concentrations in the streams for long periods of time after snow fall ended.

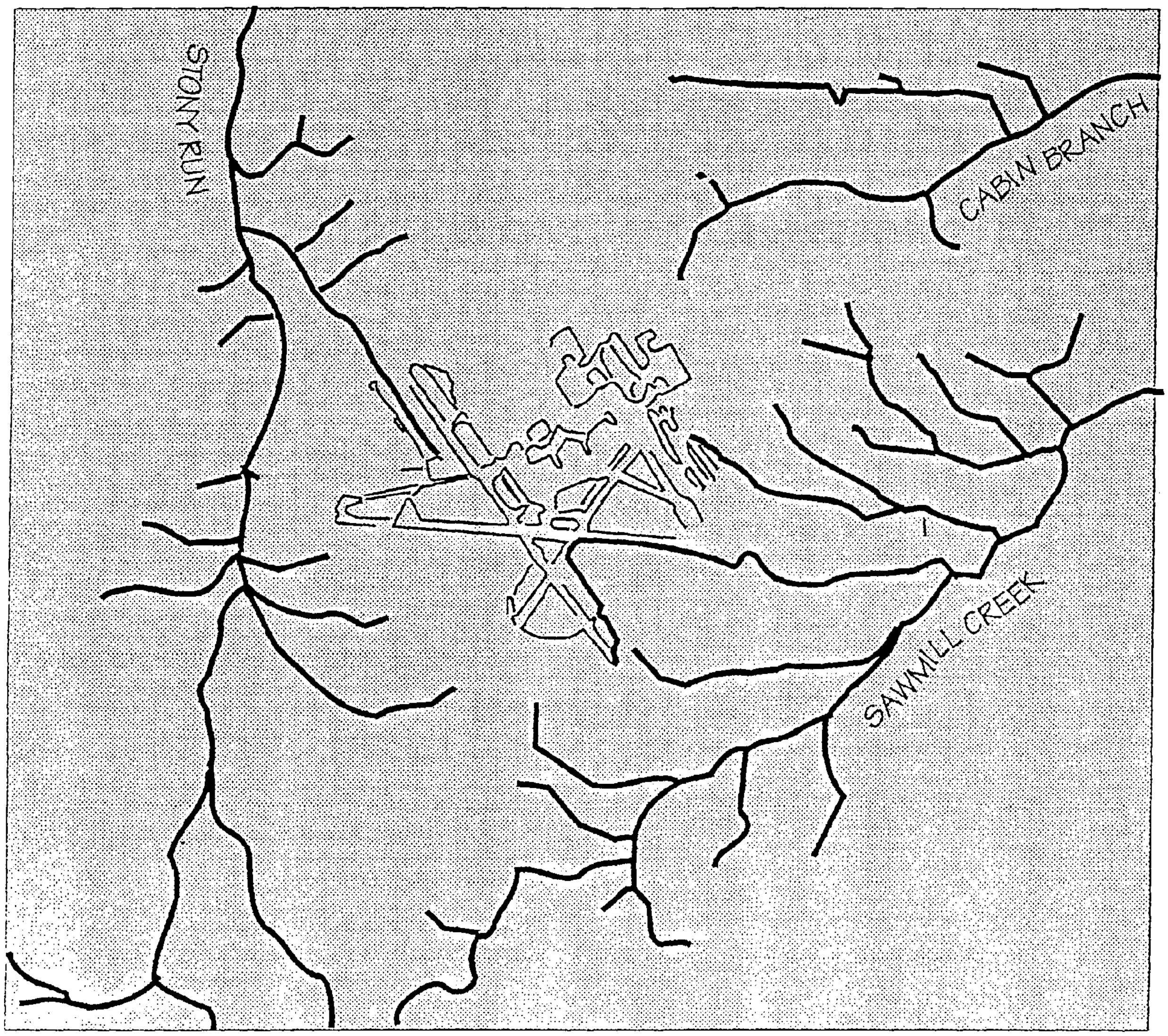
References

Hartwell,S.I., D.M. Jordahl, E.B. May. May, 1993. Toxicity of Aircraft De-Icer and Anti-Icer Solutions to Aquatic Organisms. Maryland Department of Natural Resources. Annapolis, Maryland 21401.

Maryland Department of the Environment. April 28, 1993. Investigation of the Impact of Whole Water Effluent Toxicity of Storm Water to Aquatic Life. First Quarterly Report from the Wye Research and Education Center, UMS. MDE, 2500 Broening Highway. Baltimore Maryland 21224.

Slide
#1

BWI AIRPORT AND ADJACENT STREAMS



#2

SUMMARY OF RESULTS

TOXIC RESPONSES IN SOLUTIONS (FISH)

100% MORTALITY	DE-ICER:	8.750 ml/L	(9600 mg/L)
	ANTI-ICER:	0.063 ml/L	(70 mg/L)
TISSUE DAMAGE	PROGRESSIVE		

TOXIC RESPONSES IN STREAM WATER

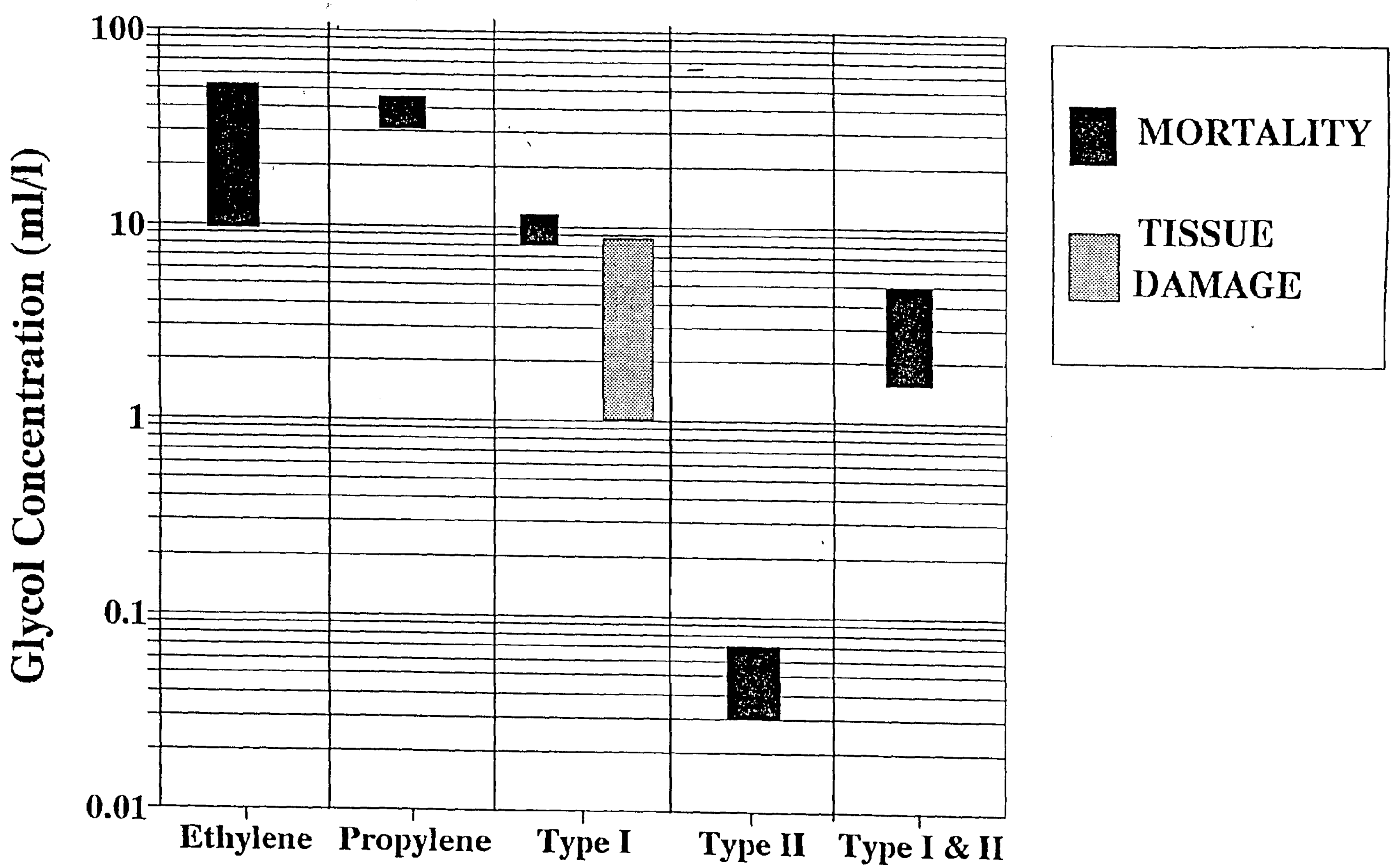
ACUTE	(FISH & ZOOPLANKTON)
CHRONIC	(REPRODUCTION & HISTOLOGY)
STIMULATION/INHIBITION	(MICROTOX)

RUNOFF CONCENTRATIONS

DE-ICER	89.1 ml/L
ANTI-ICER	154.5 ml/L

Mortality (LC50) & Tissue Damage

Finfish



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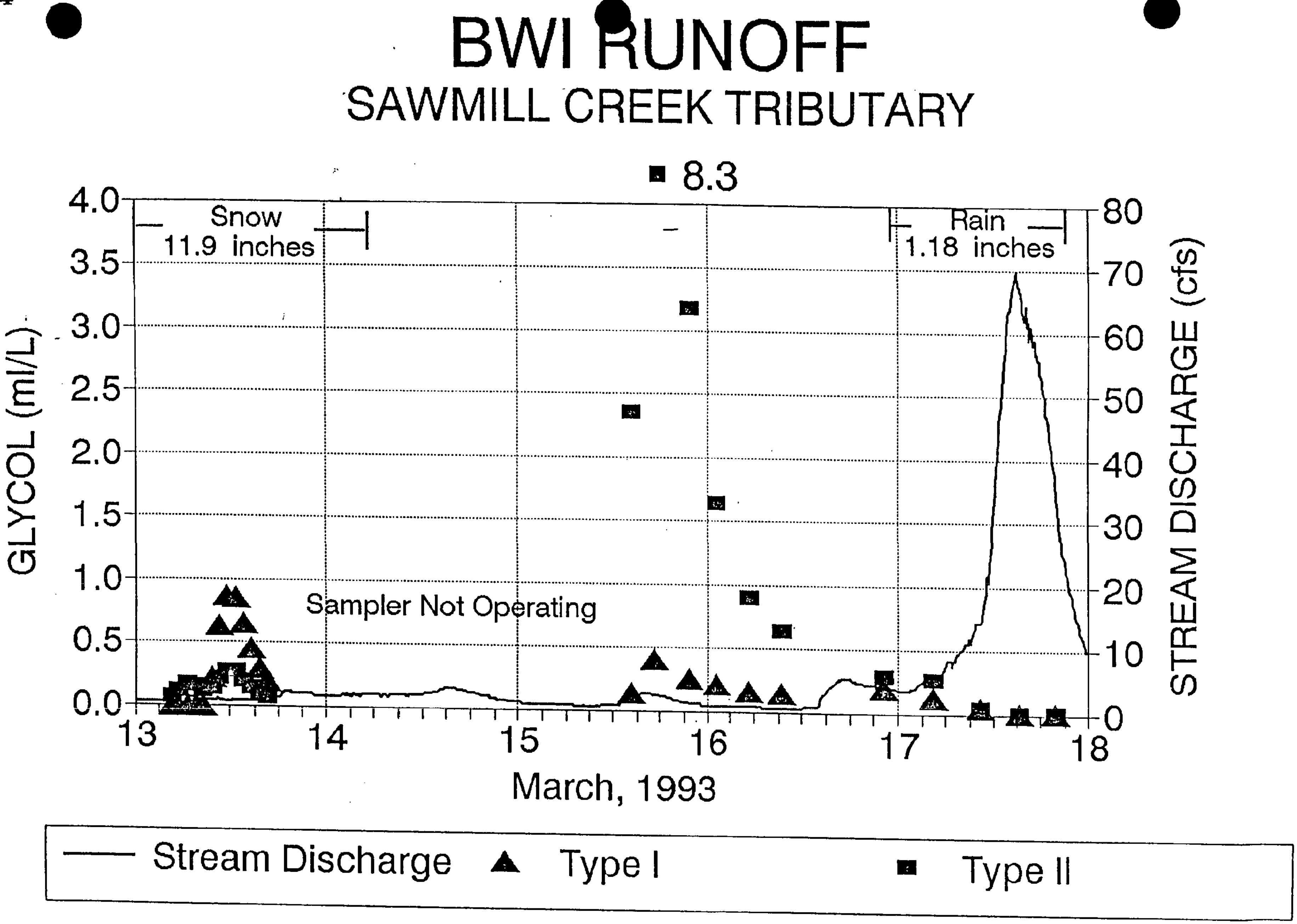

BWI RUNOFF
SAWMILL CREEK TRIBUTARY
8.3
Snow
11.9 inches
Rain
1.18 inches
Sampler Not Operating
GLYCOL (ml/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
STREAM DISCHARGE (cfs)
80
70
60
50
40
30
20
10
0
13
14
15
16
17
18
March, 1993
Stream Discharge
Type I
Type II

Slide #5

BWI RUNOFF
STONY RUN TRIBUTARY

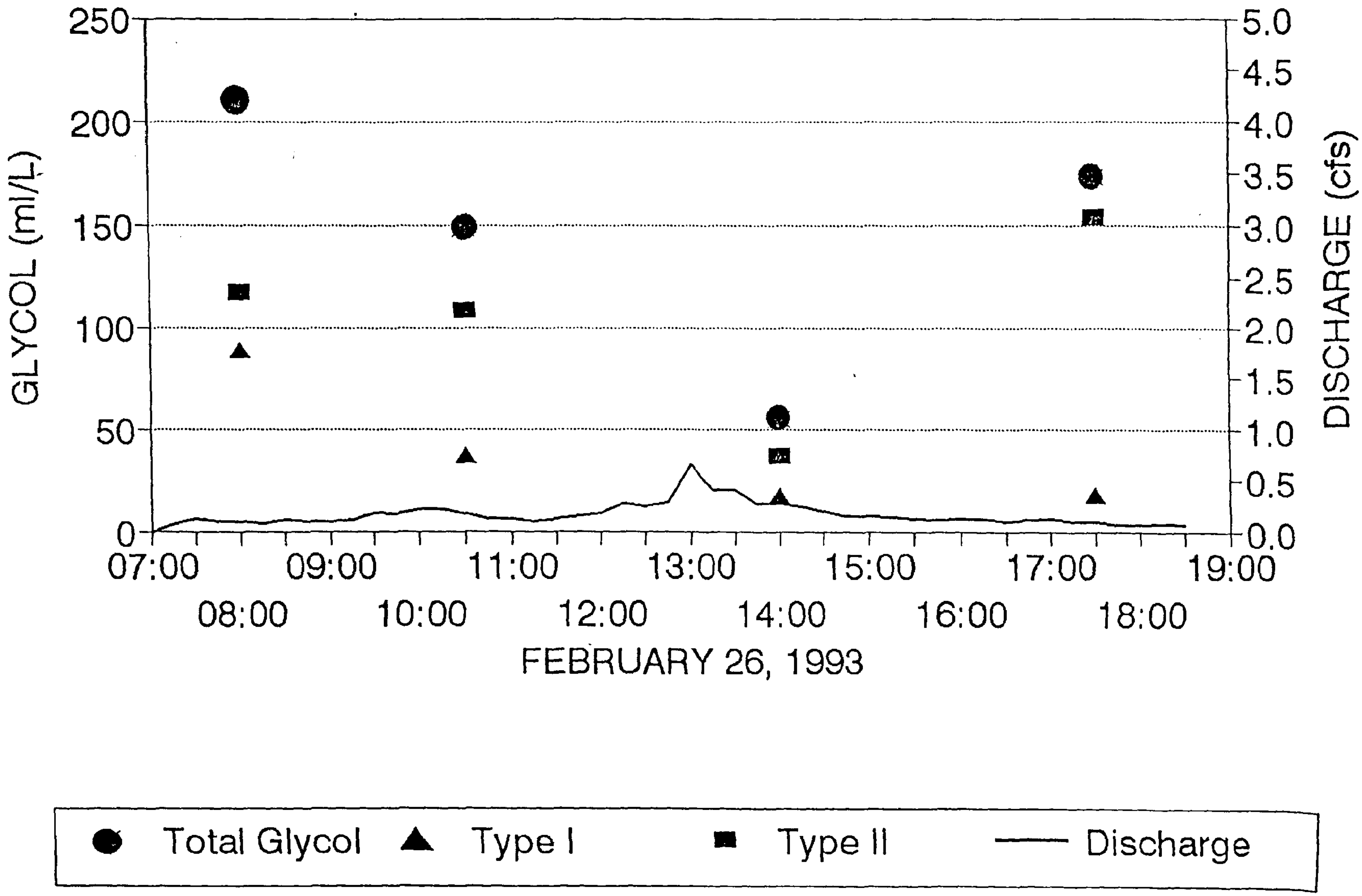

Table A-1

TIME TO MEDIAN AND TOTAL MORTALITY

GLYCOL (ml/L)	TYPE I DE-ICER MEDIAN	TYPE I DE-ICER TOTAL	TYPE II ANTI-ICER MEDIAN	TYPE II ANTI-ICER TOTAL
70	N/A	45 min	N/A	15 min
35	1.5hr	2.5hr	N/A	30 min
17.5	2.5hr	2.5hr	N/A	1 hr
8.75	-	-	N/A	2 hr
4.375	-	-	30 min	2 hr

GLYCOL (ml/L)	TYPE II (only) ANTI-ICER MEDIAN	TYPE II (only) ANTI-ICER TOTAL
2.0	1hr	3hr
1.0	2hr	3.25hr
0.5	3.25hr	6hr
0.25	12hr	30hr
0.125	36hr	72hr
0.063	48hr	96hr
0.031	84hr	-
0.016	-	-