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Causes of Foaming and Surfactant Source Identification in Sandy Creek Orleans and Monroe County, New York

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CAUSES OF FOAMING
 AND
 SURFACTANT SOURCE IDENTIFICATION
 IN
 SANDY CREEK
 ORLEANS AND MONROE COUNTY, NEW YORK

by

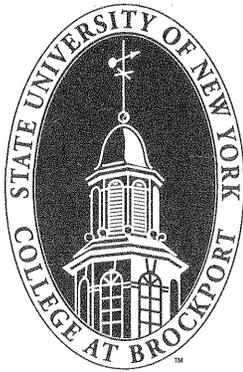
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for

Monroe County Department of Health
 Environmental Health Laboratory
 435 East Henrietta Road
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March 1994

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EXECUTIVE SUMMARY

For several years, accumulations of foam in Sandy Creek have been reported by citizens living in the watershed. Limited investigations by the Monroe County Health Department found that low levels of anionic surfactants (ca.60 $\mu\text{g/L}$) were present in the Monroe County sections of the stream. However, a source of these surfactants was not identified and this study was initiated to examine the entire Sandy Creek watershed, much of which lies west of Monroe County in Orleans County.

During this study, surfactant concentrations throughout the stream were found to be below 100 $\mu\text{g/L}$, the upper level for natural waters. A consistent increase in surfactant levels did occur as the west branch of Sandy Creek passed the discharge pipe of the Albion Wastewater Treatment Plant.

To better understand the contribution of the treatment plant, an additional investigation was conducted in December 1993 and January 1994. In December, an eight day study of Sandy Creek, at the Albion Wastewater Treatment Plant, verified that surfactant concentrations increased significantly as the stream passed the discharge pipe. The peak concentration was observed on Wednesday. In January an intensive 24 hour sampling within the treatment plant, and at the nearby stream sites, further confirmed effluent loading of anionic surfactants to the stream. However, concentrations were reduced to levels below 100 $\mu\text{g/L}$ at our normal sample site, approximately 100 meters below the discharge pipe. This is consistent with previous samples from

that location and a temporal pattern of discharge was not identified. During the 24 hour investigation in the treatment plant, we also found that the effluent concentration of anionic surfactants was approximately 10% of the levels occurring at the intake. The results of the eight day and 24 hour study are presented in **ADDENDUM 1** to this report.

Additional investigations of nutrient concentrations in the watershed also found that total phosphorus levels ranged from a low of 13 $\mu\text{g/L}$ in the upper reaches of the stream to a very high level of 457 $\mu\text{g/L}$ at a site in the village of Clarendon, NY. Typical levels of total phosphorus in other stream sections were between 30 and 150 $\mu\text{g/L}$. Nitrate-nitrite concentrations followed a similar pattern with a high of 3.19 mg/L measured in samples collected at Clarendon.

This study concludes that the Albion Wastewater Treatment Plant increases the anionic surfactant (MBAS) concentrations in Sandy Creek as it passes the plant discharge pipe. This increase ranges from less than 10% to more than 100% of background levels. However, for all samples collected in our investigation, the total concentration (background plus plant effluent) never reached 100 $\mu\text{g/L}$, the upper level for natural waters.

While only low stream levels were observed during our study, the high surfactant concentration in the plant influent of 2700 $\mu\text{g/L}$ presents a potential for much higher stream concentrations if plant "events" occur. Future complaints of high foam levels in

Sandy Creek should be compared with plant records to determine if an event has occurred.

Another consideration is that foaming may be the result of high concentrations of cationic or nonionic surfactants. These species were not analyzed for in this study since the most common surfactants are anionic (MBAS) and analyses for other forms is more complex and beyond the scope of this project. Simpler qualitative methods for the determination of cationic and nonionic surfactants were attempted but were not successful.

Finally, the source(s) of nutrient inputs upstream from Clarendon, and the overall high levels in other stream sections, should be investigated. These nutrient levels may have a more significant impact on the health of the Sandy Creek aquatic ecosystem than the low levels of anionic surfactant found in our investigation.

INTRODUCTION

Sandy Creek is a major stream draining a watershed of approximately 150 square miles of agricultural and lightly populated land in Orleans and western Monroe Counties of New York State. From its headwaters to the discharge at Lake Ontario, the stream is divided into an east and west branch which join to form the main branch several miles southwest of its mouth. The west branch passes through the village of Albion, NY and the east branch passes through the smaller villages of Clarendon and Holley, NY. There are no villages or major population centers on the main branch. Land use in the watershed is primarily agricultural with crops of cabbage, corn and apples being the most common. Wooded areas, wetlands and old fields make up the remainder (Figure 1).

Accumulations of unsightly foam have been observed in Sandy Creek at various times over the last few years by individuals living in the basin. Large piles of foam reduced the aesthetic value of the stream and there were concerns about the impact of surfactants on the aquatic life in the stream, adjacent wetlands and Lake Ontario waters near the stream mouth. In response to complaints of residents in Monroe County over the foaming problem, Monroe County Health Department demonstrated the presence of anionic surfactants in concentrations of approximately 60 $\mu\text{g/L}$. This level was below the upper level of 100 $\mu\text{g/L}$ found in environmental waters (APHA 1989). All sampling

took place in the Monroe County waters and a source, presumably in the Orleans County portion of the creek, was not identified.

In the fall of 1992 an investigation of the entire Sandy Creek watershed was initiated by the Center for Applied Aquatic Science and Aquaculture at SUNY Brockport to identify any point and non-point sources of surfactants discharged into Sandy Creek. Techniques related to stressed-stream methodology (Makarewicz 1993) were used to establish a pattern of surfactant concentrations at key points on major tributaries and thus to focus the investigation on stream sections that had the highest concentrations and most likely sources of surfactants.

For this study, surfactant analysis was limited to anionic forms which are commonly found in household detergents and cleaning agents and comprise more than 60% of all surfactant species (APHA 1989).

A qualitative evaluation of cationic and non-ionic forms, following the procedure outlined by Longman (1975) was attempted without success.

METHODS

One liter samples of water were collected at a total of 22 locations throughout the approximately 150 square mile watershed (Figure 1, Table 1). Collections took place during November and December, 1992 and January and May, 1993 (Table 2). Sample sites were systematically adjusted to focus on stream sections having the highest anionic surfactant concentrations. All samples were collected in phosphorus and surfactant free bottles, washed in 2%

RBS solution, rinsed in distilled water and prerinsed with sample water at the site.

Samples were taken at midstream, just below the surface, except on May 17, 1993 when the collection consisted of five evenly spaced samples across the stream above and below the Albion Wastewater Treatment Plant discharge.

Samples were transported to the Water Quality Laboratory at SUNY Brockport and analyzed for anionic surfactants as methylene blue active substances (MBAS) within 12 hours of collection (Method 5540C, APHA 1989). A Bausch and Lomb model 88 spectrophotometer was used to determine absorbance (5 cm cuvettes) of the extracted MBAS samples at 652 nm.

A coefficient of determination of at least 0.99 was used as the acceptance criteria for the standard curves. Replicates (n=5) at Site 4 indicate a high degree of precision (CV=11%) (Table 6). Nutrient analysis was verified by the U.S. Geological Survey Quality Assurance Program.

Analysis of variance determined the significance of the surfactant concentration change above and below the Albion Wastewater Treatment Plant for the May 17, 1993 sample. A criteria of $F_{\text{observed}} > F_{\text{critical}}$ at the 95% level ($P < 0.05$) was used.

Soluble reactive phosphorus (SRP) and total phosphorus (TP) were analyzed using a Technicon Autoanalyzer (Technicon method 15-71W, APHA 1985 Method 424). Nitrate-nitrite was determined using Technicon Method 100-70W/B. Alkalinity was determined using APHA (1989) Method 403 and pH was measured with a Beckman

Expandomatic SS-2 calibrated with pH 4.01 and 9.18 buffers. Conductivity was measured using a Thomas 275 meter corrected to 25.0 °C and calibrated with known conductivity standards.

RESULTS AND DISCUSSION

SURFACTANTS:

Anionic surfactant concentrations in the Main Branch of Sandy Creek (Sites 1,2,3,4 and 6), from Route 104 at Murray to Route 19 near Lake Ontario, ranged from 11 to 47 µg/L with average concentrations less than 32 µg/L at each site. For the East Branch (Sites 5,10,11,13,31A,13V and 13E) from Murray to south of Clarendon, concentrations ranged from 5 to 33 µg/L with averages less than 30 µg/L. Anionic surfactant concentrations were highest in the West Branch from Albion to Murray (Sites 7,8 and 9) ranging from 20 to 74 µg/L and averaging more than 30 µg/L at each site. The West Branch, upstream from Albion (sites 9A,9B and 9C) ranged from 11 to 46 µg/L with an average of 30 µg/L or less at each site (Figures 1,2,3,4,5; Table 3).

Samples collected on Friday November 27, 1992, had low anionic surfactant concentrations ranging from 11 to 25 µg/L and no significant peaks were observed. The December 21, 1992 sample was collected on a Monday morning at approximately 9:00 AM. Anionic surfactant concentrations were much higher (21 to 74

µg/L) than those found in November and a distinct peak (the highest level) was observed at Site 9, approximately 100 meters downstream from the Albion Wastewater Treatment Plant discharge. On Monday morning, January 11, 1993 levels were also higher than those observed in November 1992 with the maximum once again occurring at Site 9 below the treatment plant (Table 3). While stream flows and weather conditions varied among these sample dates, possibly affecting the base level of surfactants in the stream, the repeated peak below the treatment plant discharge was a strong indication of a point source of anionic surfactants at that location (Site 9). Also, the higher level of surfactants we found on Monday mornings was consistent with anecdotal evidence from citizens who described higher levels of foam on that day.

A final sample was taken on May 17, 1993 at sites immediately upstream and downstream from the Albion discharge pipe; a diffuser system releasing treated water at four points across the stream. Five samples were collected at each site at even distances across the stream (midstream (1), one meter from each bank (2) and half way between midstream and bank (2)). The upstream site was approximately 100 meters above the discharge pipe and the anionic surfactant concentration averaged 22 µg/L for the five cross-stream samples. At Site 9, approximately 100 meters downstream from the discharge pipe, the average was 51 µg/L for the five cross-stream samples. Analysis of variance indicated a substantial and significant ($P < 0.05$) increase of surfactants at the plant discharge. Surfactant concentration of

the sample taken within one meter of the plant discharge (48 $\mu\text{g/L}$) was not significantly different from downstream Site 9 (100 m) but was significantly different from the site 100 meters upstream. An area of still-water, near the north bank at Site 9, had a surfactant concentration of 79 $\mu\text{g/L}$, significantly higher than the mean of 51 $\mu\text{g/L}$ found for the five cross-stream samples. This suggests that a higher discharge of surfactants had taken place earlier Monday morning and bank concentrations remained high due to poor mixing. (Figure 6, Tables 3 and 6).

Site 9A, approximately two miles upstream from the treatment plant and Site 8, approximately two miles downstream from the discharge were also sampled on May 17, 1993. Anionic surfactant concentration at Site 9A was 24 $\mu\text{g/L}$, similar to the upstream side of the discharge pipe (22 $\mu\text{g/L}$) and significantly lower than the downstream side (51 $\mu\text{g/L}$). At Site 8, a concentration of 46 $\mu\text{g/L}$ was found. This is similar to the downstream side of the discharge and significantly lower than the upstream side. These two additional samples confirm the significant increase in anionic surfactants occurring at the Albion Wastewater Treatment plant.

These data clearly demonstrate a point source of surfactants at the Albion Wastewater Treatment Plant discharge. However, our data also show that non-point sources are contributing low levels of anionic surfactants throughout the watershed. These apparent non-point sources may be natural or the

result of agricultural activities and probably contribute to the levels of foam observed in Sandy Creek.

On December 21, 1992, when surfactant levels were the highest for the dates sampled, the stream level was also very high and surrounding land was flooded due to the high levels of precipitation in November and December. At this time of year, leaves and decaying plant material, as well as the remains of agricultural products (cabbage is a major crop in the watershed) may contribute significant amounts of natural surfactants. However, while these non-point sources may have served to raise the overall level of surfactants in Sandy Creek, they cannot account for the significant increase at the Albion Wastewater Treatment Plant.

Throughout the investigation, foam was observed in the stream, accumulated in piles along the shore and in midstream snags. While correlations between observed quantities of foam and anionic surfactant concentrations were not obtained, observations indicated a negative relationship. At sites where large amounts of foam were observed stream concentrations of surfactants were low. For example, large amounts of foam were always observed below the small rapids in Bullard Park, Albion but concentrations were only 22 and 20 $\mu\text{g/L}$ in November and January respectively. At the Albion Treatment Plant discharge, where concentrations were the highest, little or no foam was observed on each sample date. Agitation, due to stream conditions, appears to be the proximate cause of foaming and this may remove the surfactants from

solution. Also, foam was observed in small clusters in the stream. Because foam may travel a considerable distance from a surfactant source before capture by bank or midstream obstructions, accumulations may be observed a substantial distance from the point of surfactant input.

WATER CHEMISTRY:

The limited investigation of nutrients in Sandy Creek revealed very high levels in the East Branch at Clarendon. Soluble Reactive Phosphorus (SRP) concentrations, were 442 and 213 $\mu\text{g/L}$ on December 8, 1992 and January 11, 1993 respectively. Total phosphorus (TP) concentrations on these dates were 457 and 247 $\mu\text{g/L}$. Nitrate-nitrite ranged from 2.74 to 3.19 mg/L at the same site. While levels dropped quickly downstream from Clarendon, SRP concentrations 0.5 mile above the stream mouth (Site 1) remained high at 44 $\mu\text{g/L}$ in December 1992 (Table 4; Figures 7,8).

Downstream from the Albion treatment plant discharge, SRP was 10.2 $\mu\text{g/L}$ on December 21, 1992 and 56.7 $\mu\text{g/L}$ on January 11, 1993, respectively, while TP was 92.4 $\mu\text{g/L}$ for the January sample. Nitrate-nitrite was 0.8 mg/L at this site for both dates. Above the plant, at Site 9A, SRP concentration was 11.6 $\mu\text{g/L}$, TP was 30.5 $\mu\text{g/L}$ and nitrate-nitrite 0.63 mg/L on January 11, 1993, all lower than those found below the discharge. This suggests that the treatment plant is a source of nutrients to Sandy Creek

and may be a major contributor to high levels found in the West and Main Branches. (Table 4).

While foaming, caused by surfactants, is a major concern, the high levels of nutrient loading should also be investigated. Concentrations observed during the course of this study are sufficient to cause stream eutrophication and reduced water quality. High levels of algal growth were observed in Sandy Creek on May 27, producing unsightly accumulations along the banks and in midstream. There may also be detrimental effects on aquatic life in areas of maximum growth.

SUMMARY

The Albion Wastewater Treatment Plant is a point source of anionic surfactant discharge into Sandy Creek. The higher concentrations observed on Monday compared with Friday may indicate a temporal relationship and further investigations, using time-series methodology, are required to identify peak discharges.

Non-point sources also appear to contribute surfactants throughout the watershed and these may be a combination of agricultural and natural processes. Sampling protocols, based on agricultural activities and seasonal changes, could be established to further identify non-point sources of anionic surfactants.

While surfactant concentrations found in this study produced accumulations of foam that reduced the aesthetic value of Sandy

Creek, levels were low and below the 100 µg/L expected for natural waters (APHA 1989).

Phosphorus is high in Sandy Creek and contributes to the high algal growth observed in May. Levels of SRP, TP and nitrate-nitrite, found at Clarendon, are very high and are likely to have a significant impact on the water quality in the east branch of Sandy Creek downstream from Clarendon. Identification of nutrient sources throughout the watershed, especially in East Branch tributaries upstream from Clarendon, is as important as the reduction of surfactants in improving the water quality of this major Lake Ontario basin stream.

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Table 1 - Description of water sample collection Sites in the Sandy Creek watershed for surfactant and nutrient analyses.

SITE	DESCRIPTION
Monroe County	
1	West of the bridge on Route 19 approximately 0.5 miles from the mouth of Sandy Creek.
2	South of the bridge on Brick Schoolhouse Road.
3	North of the Route 18 bridge at the intersection with Redman Road.
Orleans County	
4	West of the bridge on Route 272 (County Line Road) in Kendall Mills.
5	East of the bridge approximately 0.1 miles south of the intersection of Routes 104 and 237 in Murray (East Branch).
6	South of the Route 104 bridge approximately 0.2 miles west of Murray (Main Branch).
7	West of bridge on Hulberton Road just south of Route 104 west of Murray (West Branch).
8	West of bridge on Hindsburg Road approximately 2 miles east of Albion.
9	West of Butts Road bridge approximately 100 meters downstream from the Albion Wastewater Treatment Plant discharge.
BULLARD	Below the small waterfall (rapids) in Bullard Park, Albion.
9A	West of first bridge on Clarendon Road south of Route 31 in Albion.
9B	North of bridge on County House Road north of Route 31A and east of Route 98.
9C	North of bridge at bend on Limekiln Road south of Route 31A and east of Route 98.
10	East of second bridge on Route 272 south of Route 104.
11	South of old bridge abutments at end of Gulf Road, north of Holley.
13	East of first bridge on South Holley Road north of Route 31A.
31A	North of bridge on Route 31A approximately 0.1 miles east of Clarendon.
13V	Above the falls in Clarendon
13E	North of bridge on Browns Schoolhouse Road west of Route 237 and approximately 1.5 miles south of Clarendon.
UP1-5	Approximately 100 meters upstream from the Albion Wastewater Treatment Plant.
DIS	Approximately 0.5 meters downstream from the discharge pipe of the Albion WTP.

Table 2 - Collection dates and analyses performed for Sandy Creek samples.

COLLECTION DATES	ANALYSES
November 27, 1992	Anionic surfactant (MBAS)
December 1, 1992	Phosphorus, Nitrate, pH, Alkalinity, Conductivity
December 8, 1992	Phosphorus, Nitrate, pH, Alkalinity, Conductivity
December 21, 1992	Anionic surfactant (MBAS) Phosphorus, Nitrate, pH, Alkalinity, Conductivity
January 11, 1993	Anionic surfactant (MBAS)
May 17, 1993	Anionic surfactant (MBAS)

Table 3 - Surfactant concentrations in Sandy Creek (g/L). NS = Not Sampled, Site numbers refer to sites shown on Figure 1. All samples collected on Monday at approximately 9 AM except 11/27/93 which was obtained on a Friday at 9 AM. The site 9 and UP1-5 samples for 5/17/93 are averages of 5 evenly spaced shore to shore samples. All others are single grab samples.

SITE	11/27/92	12/21/92	1/11/93	5/17/93
1 Rt.19 bridge at lake	17	31	NS	NS
2 Bridge, Brick School-house Road	11	29	18	NS
3 Bridge, Rt.18 and Redman Road	24	25	NS	NS
3A Tributary, 100 meters west of site 3	20	38	NS	NS
4 Rt272 bridge at Kendall Mills	20	47	27	NS
5 E. Branch at Murray	17	28	31	NS
6 Main Branch, Rt 104 at Murray	20	45	NS	NS
7 W. Branch, Hulberton Road near Murray	20	58	23	NS
8 Hindsburg Road, east of Albion	23	61	28	46
9 100 meters downstream from Albion treatment plant, Butts Road bridge	23	74	46	51
B Bullard Park, Albion	22	NS	20	NS
9A First bridge south of Albion on Clarendon Rd.	24	46	19	24
9B County House Rd. south of Albion, east of Rt98	NS	NS	11	NS
9C Limekiln Rd. south of RT31A, east of Rt98	NS	NS	22	NS
10 Second bridge south of Rt104 on Rt272	25	30	NS	NS
11 End of Gulf Road, north-east of Holley	16	33	NS	NS
13 First bridge north of Rt31A on S. Holley Rd.	13	28	6	NS
31A Bridge on Rt 31A east of Clarendon	NS	NS	8	NS
13V Above falls in village of Clarendon	NS	32	5	NS
13E Browns Schoolhouse Rd west of Rt237, south of Clarendon	NS	21	6	NS
UP1-5 100 meters upstream from Albion treatment plant	NS	NS	NS	22
DIS 0.5 meters from Albion WTP discharge	NS	NS	NS	48

Table 5 - pH, Conductivity and Alkalinity for Sandy Creek. Sites are shown on Figure 1.

SITE	pH			CONDUCTIVITY (μ mhos/cm)			ALKALINITY (mg CaCO ₃ /L)		
	12/1/92	12/8/92	12/21/92	12/1/92	12/8/92	12/21/92	12/1/92	12/8/92	12/21/92
1	8.36		7.91	590		413	215		136
2			7.85			436			135
3			7.88			435			142.6
3A			7.59			221			58.2
4			8.12			440			143
5	8.22		7.84	598		467	217		148
6	8.2		7.83	549		452	225		159
7	8.21		7.64	560		454	231		168.4
8			7.69			480			161.8
8A									
9			7.81			533			183.6
BULL									
9A	8.11		7.66	513		496	243		201
10			7.98			603			184.6
11			8.02			660			185
13	8.08	7.97	7.81	627	724	556	297	306	224
31A									
13V		7.4	7.35		748	686		326	281
13E		7.87	7.9		696	503		319	220
HILTON			7.71						
OAK ORCHARD			7.94						

Table 6 - Quality assurance and sample statistical data

Variability of five replicate samples from Site 4.

SAMPLE	CONCENTRATION (ug/L)
1	39
2	31
3	34
4	37
5	41
MEAN	36
STANDARD DEV	4
STANDARD ERROR	2
CV	11%

Coefficients of determination for standard concentrations regressed on absorbance (predictor variable).

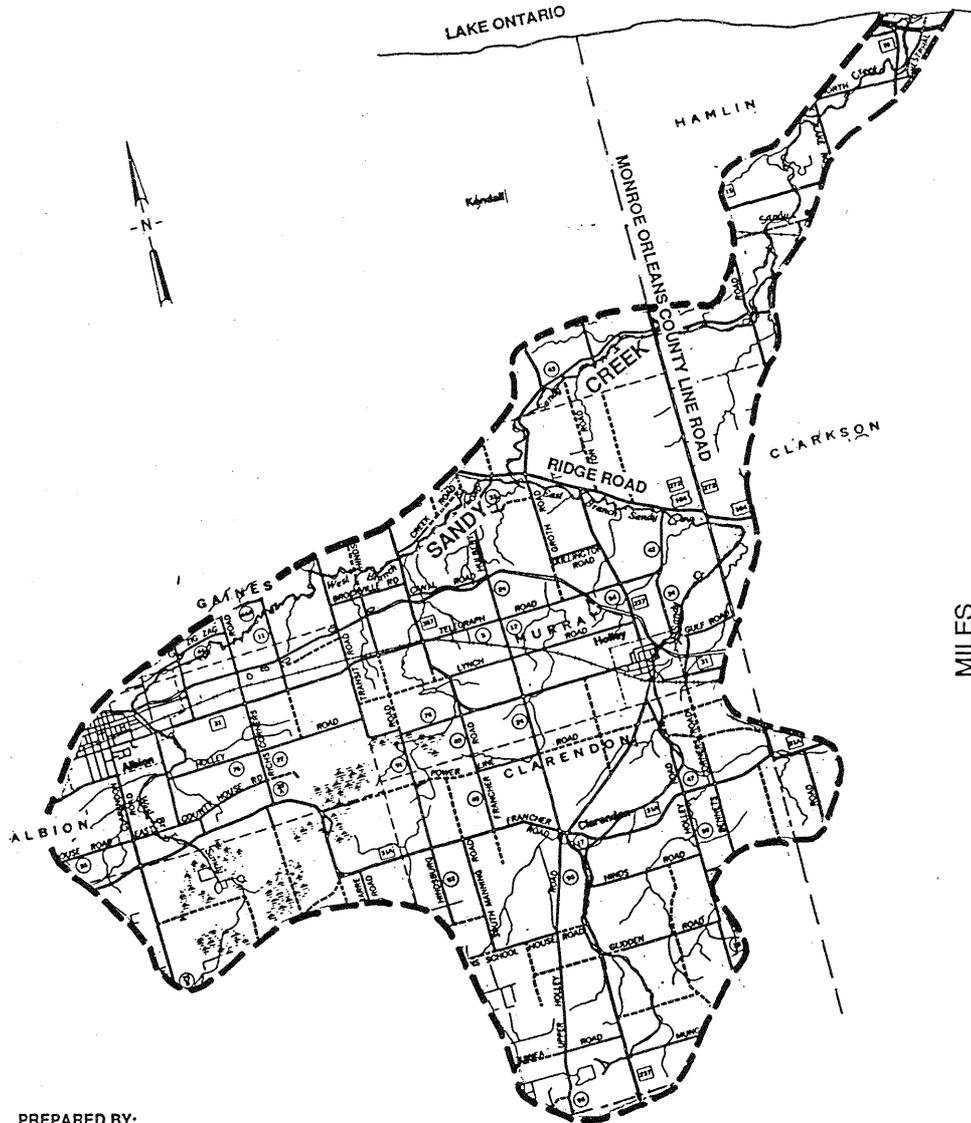
SAMPLE DATE	r ²
November 1992	0.99877
December 1992	0.98881
January 1993	0.99577
May 1993	0.99780

Analysis of variance of means of five upstream and five downstream samples at the Albion WTP on May 17, 1993

	N	MEAN	MEDIAN	STDEV	SEMEAN	MIN	MAX
UP	5	19.4	19.0	1.979	0.885	17.3	22.6
DOWN	5	51.1	45.8	15.9	7.11	41.1	79.2

F observed = 19.53 F critical (P<0.05) = 7.71

SANDY CREEK WATERSHED



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 MONROE COUNTY DEPT. OF PLANNING & DEVELOPMENT
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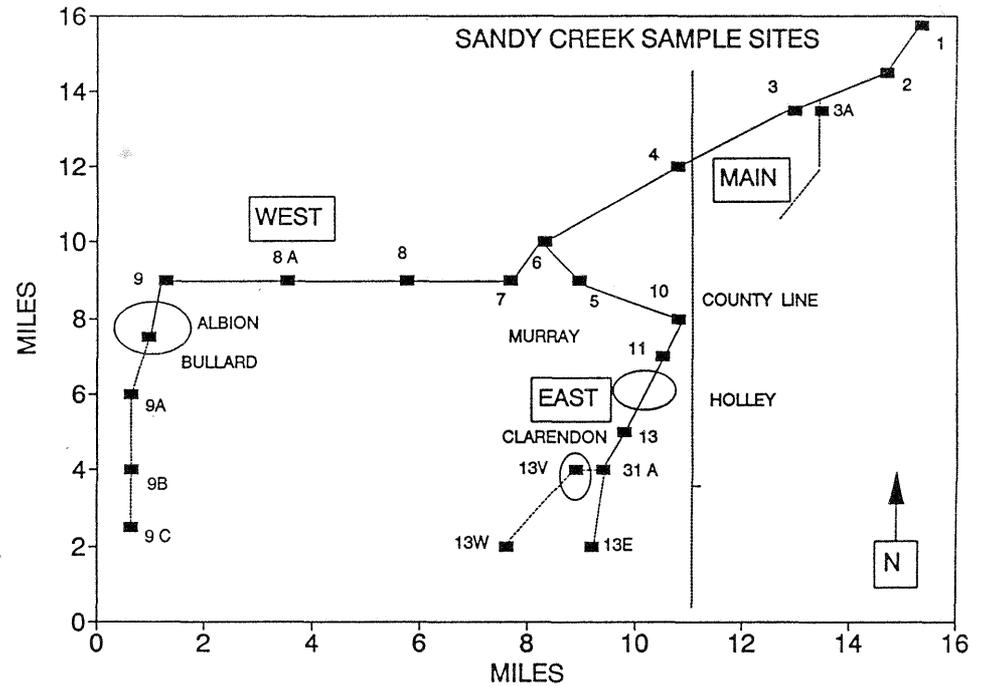


Figure 1 - Sandy Creek Watershed and Site locations for surfactant and nutrient sampling. Site locations are described in Table 1.

Figure 2 - Surfactant concentrations in Sandy Creek Main Branch. Site locations are described in Table 1. Site 4 is west of the bridge on Route 272 (County Line Road) in Kendall Mills, on the eastern boundary of Orleans County. Stream flow is left to right.

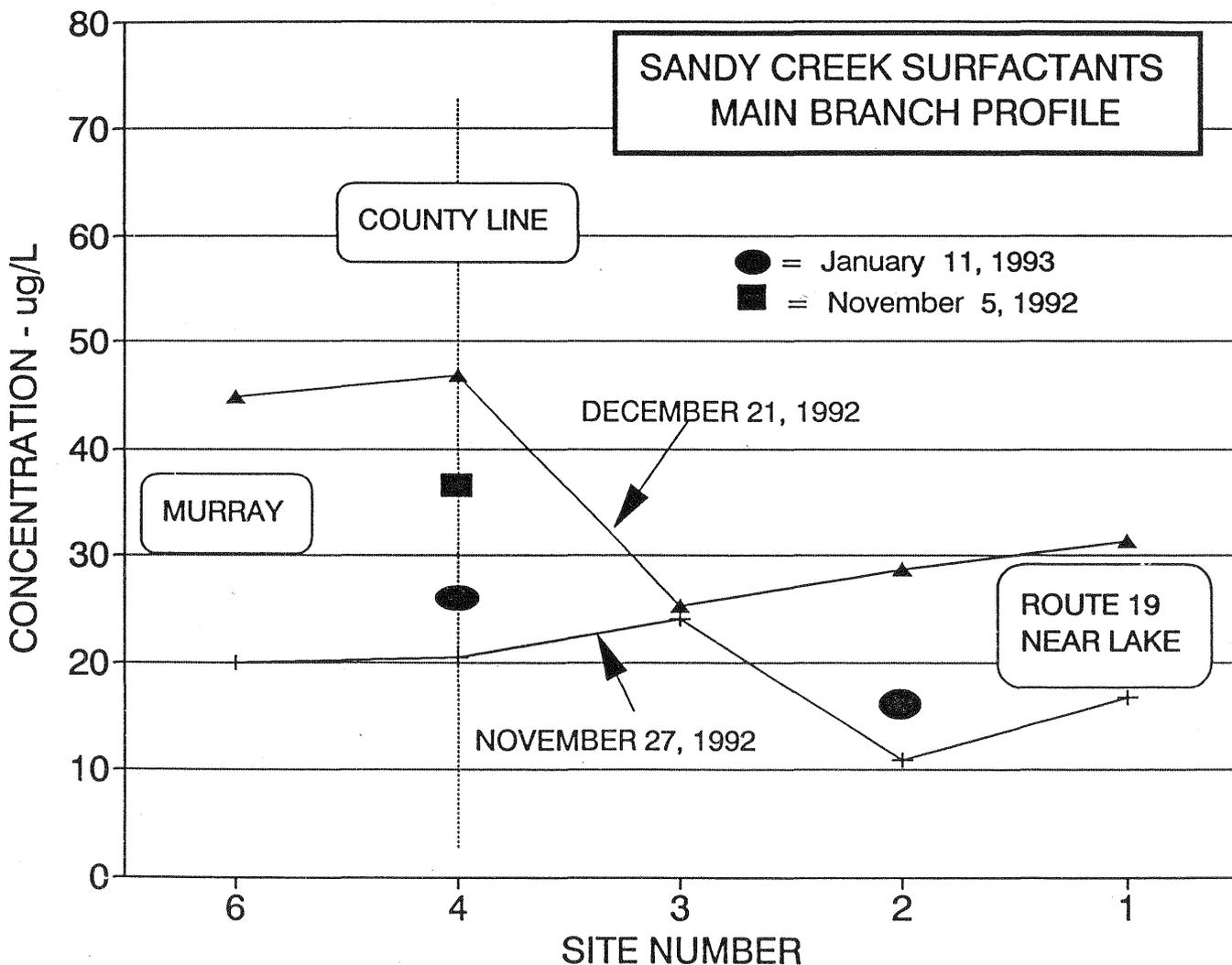


Figure 3 - Surfactant concentrations in Sandy Creek East (Site 5 - 13E) and West (Sites 7 - 9A) Branches. Sites 5, 7 and 6 are near the juncture of the East Branch (5) with the West Branch (7) and the Main Branch (6) in Murray.

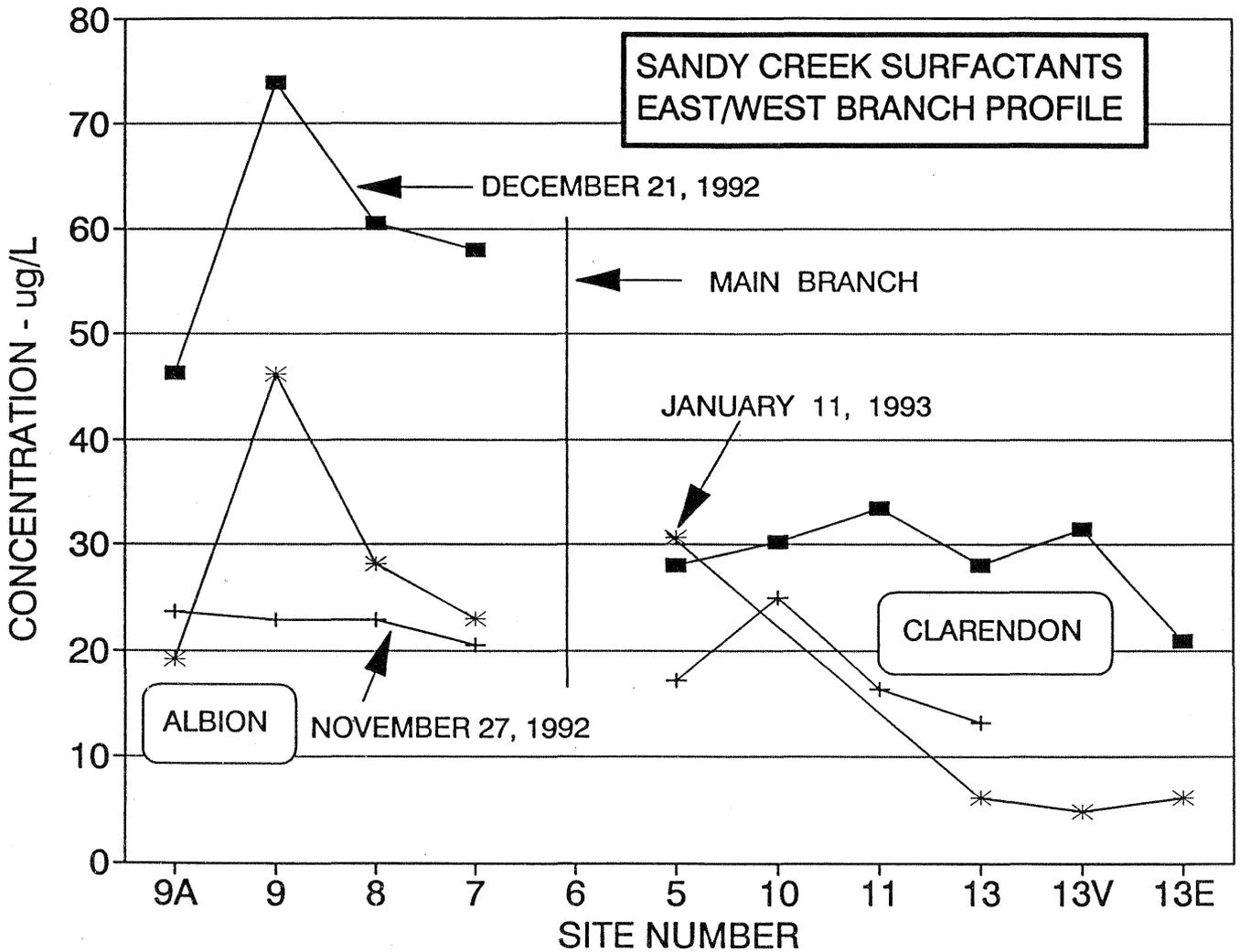


Figure 4 - Average surfactant concentrations in the Main Branch of Sandy Creek. Values are average of 11/27/92 and 12/21/92 samples. Site 4 also includes 11/5/92 and 1/11/93 samples. Site location descriptions are in Table 1. Stream flow is from left to right.

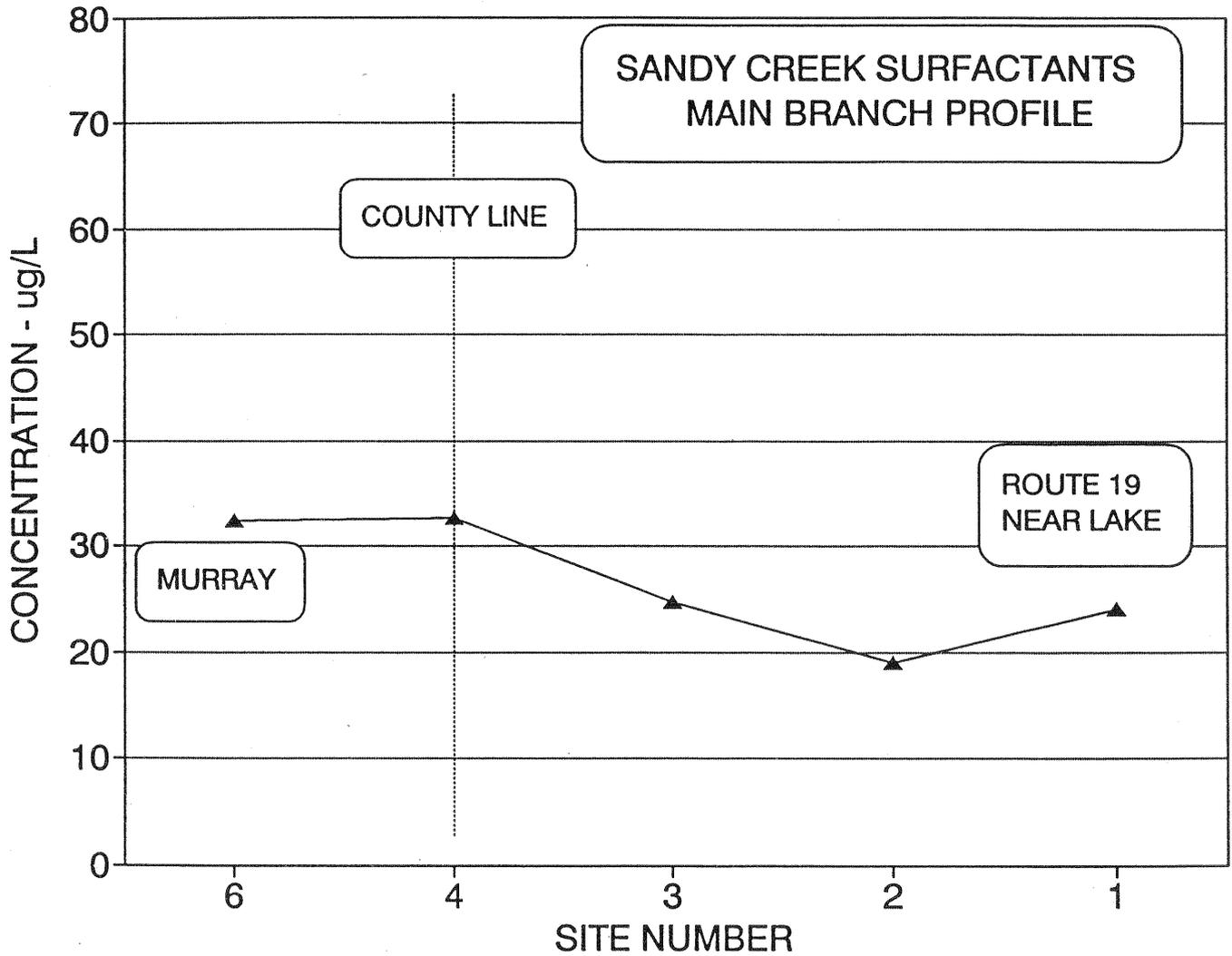


Figure 5 - Average surfactant concentrations in the East (Sites 5 - 13E) and West (Sites 7 - 9A) Branches of Sandy Creek. Sites 5, 7 and 6 are near the juncture of the East Branch (5) with the West Branch (7) and the Main Branch (6) in Murray. Site location descriptions are in Table 1. Values are average of 11/27/92, 12/21/92 and 1/11/93 samples.

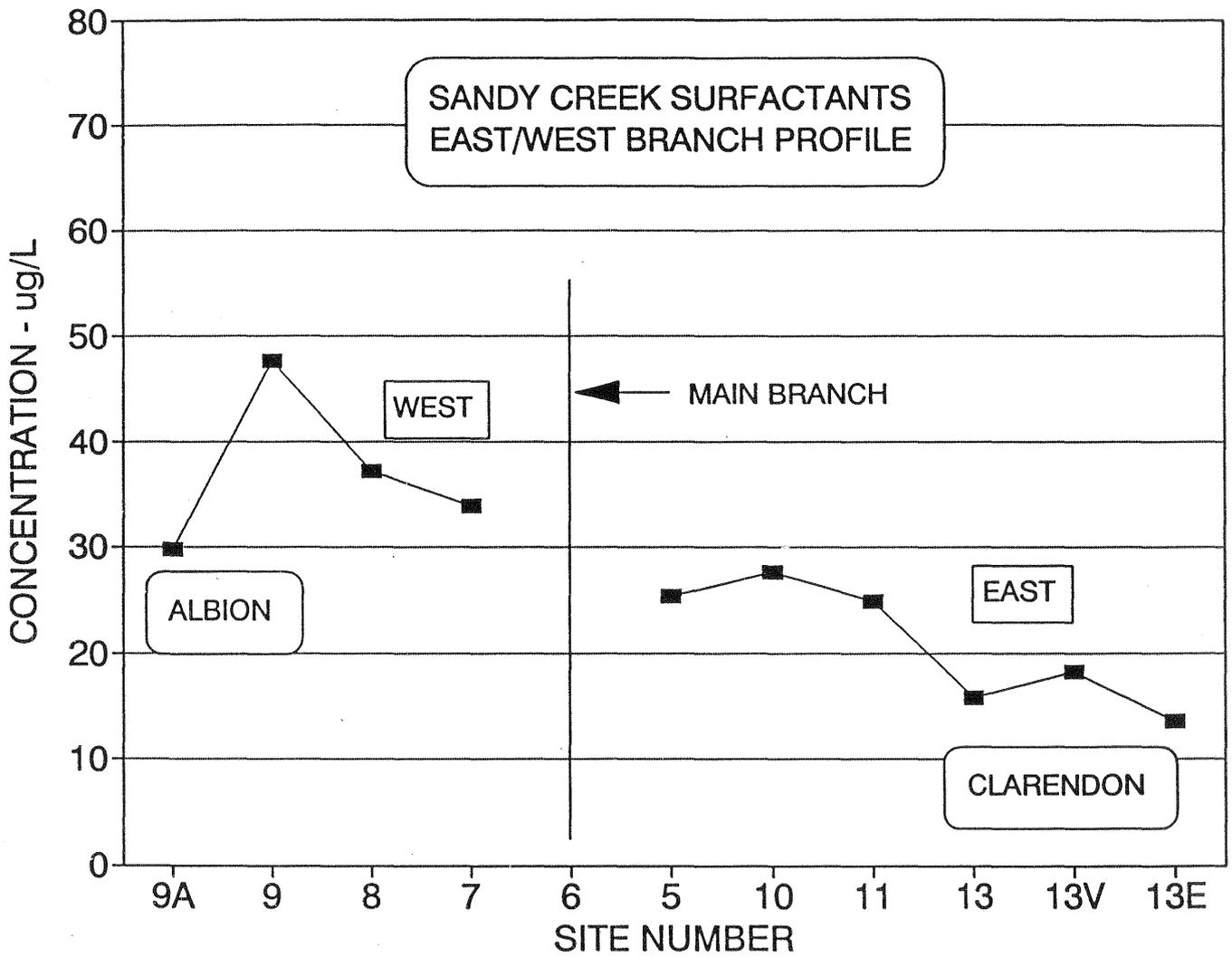


Figure 6 - Samples collected upstream and downstream from the Albion wastewater treatment plant. Sites UP1,UP2,UP3,UP4 AND UP5 located 200 meters upstream from the plant discharge pipe (DIS). Sites 9-1,9-2,9-3,9-4 and 9-5 located 100 meters downstream from discharge pipe. UP3 and 9-3 are midstream. Site 9A is approximately 1 mile upstream from the plant and Site 8 is approximately 2 miles downstream. Site locations are described in Table 1.

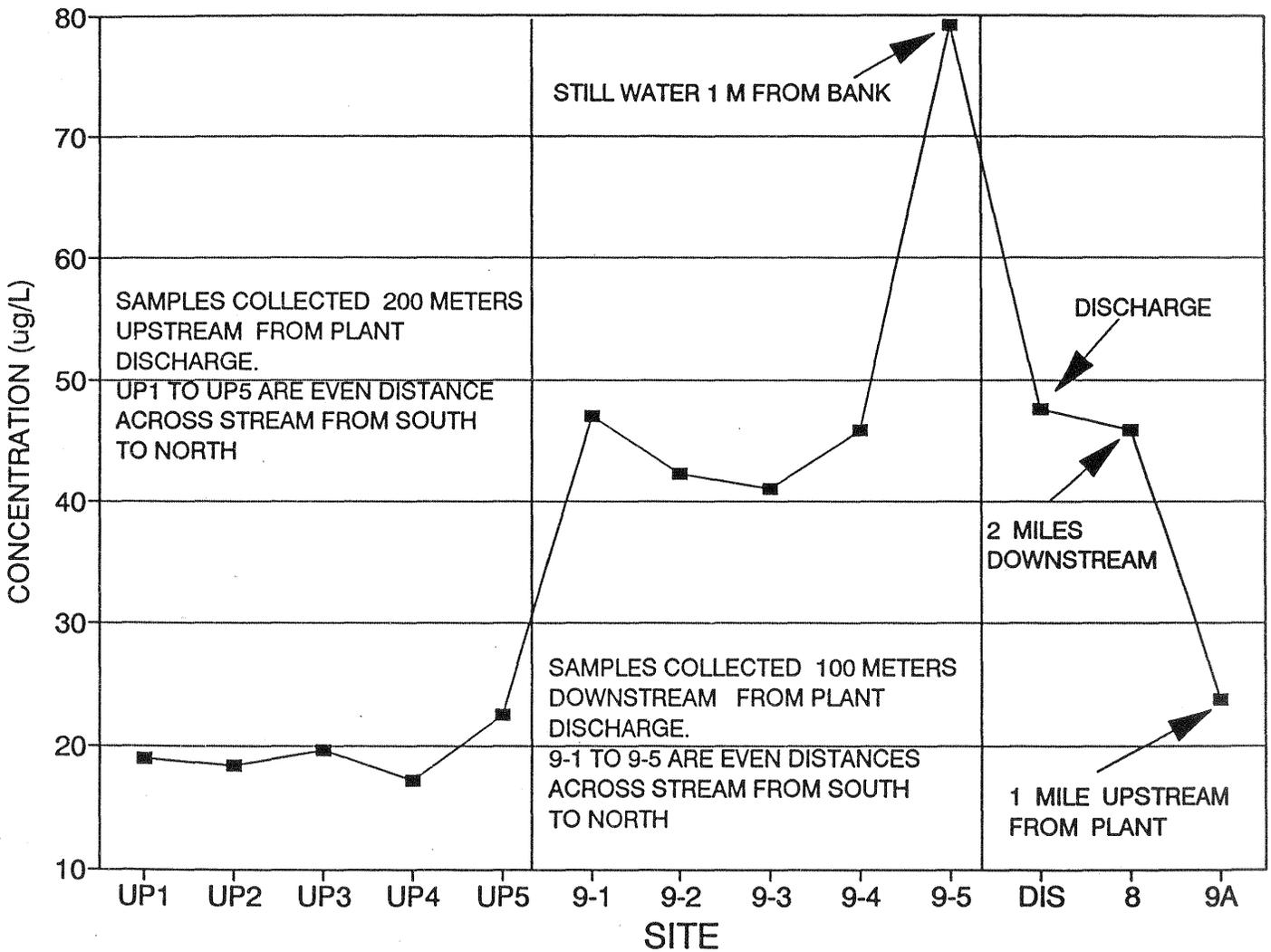


Figure 7 - Soluble reactive phosphorus (SRP) concentrations in the Main Branch of Sandy Creek. Site locations are described in Table 1. Flow is from left to right. Sample dates are noted in legends box.

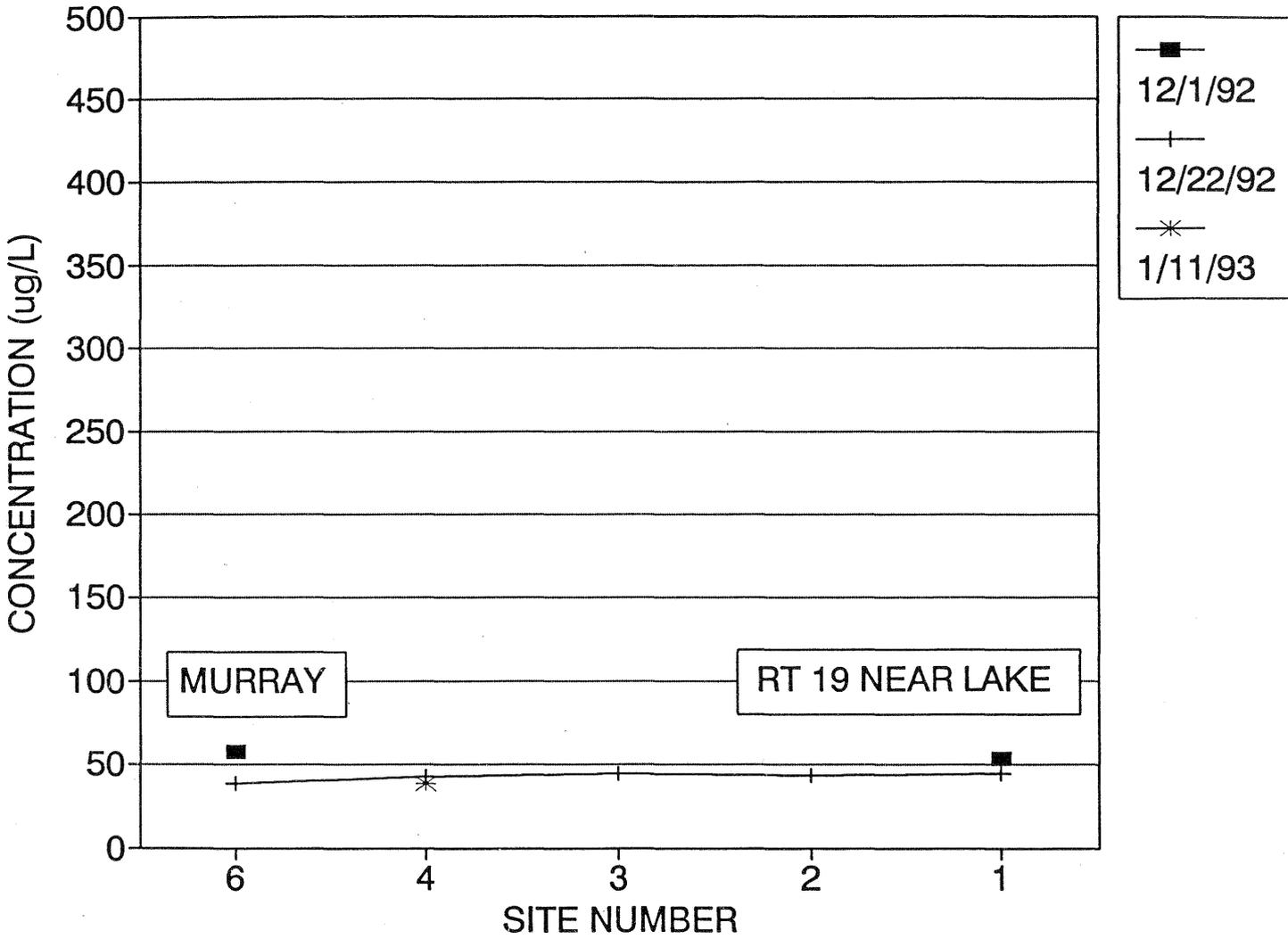
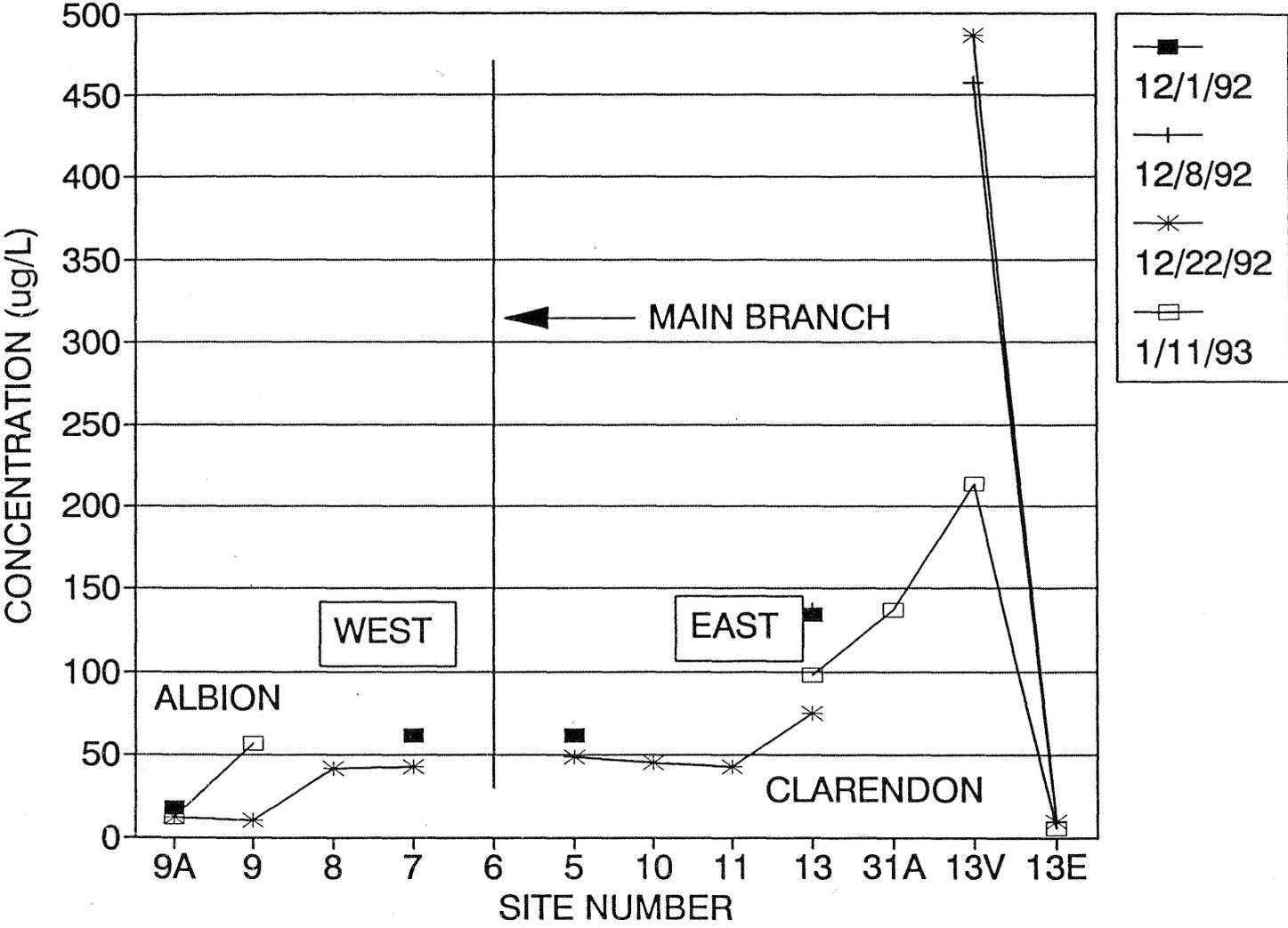


Figure 8 - Soluble reactive phosphorus (SRP) concentrations in the East (Sites 5 - 13E) and West (Sites 7 - 9A) Branches of Sandy Creek. Sites 5, 7 and 6 are near the juncture of the East Branch (5) with the West Branch (7) and the Main Branch (6) in Murray. Site location descriptions are in Table 1. Sample dates are shown in the legends box.



ADDENDUM

to:

**CAUSES OF FOAMING
AND
SURFACTANT SOURCE IDENTIFICATION
IN
SANDY CREEK
ORLEANS AND MONROE COUNTY, NEW YORK**

by

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INTRODUCTION

A watershed wide study of the anionic surfactant (Methylene blue active substances - MBAS) concentrations in Sandy Creek concluded that levels increased in the stream as it passed the discharge pipe of the Albion Wastewater Treatment Facility (Makarewicz and Cady 1993). Based on the data obtained in that study, a more intensive investigation was conducted at the Albion plant to verify the increase and attempt to determine a cause. Results of this investigation are presented here.

METHODS

The investigation was divided into two aspects: (1) a daily sampling to identify if there were specific days of high surfactant release; and (2) an intensive 24 hour study of the Albion Wastewater Treatment Plant.

Part 1:

One liter samples were collected daily for eight days, from December 3 to 10, 1993, at sites approximately 100 meters above and 100 meters below the Albion plant discharge. Samples were collected at 8:30 AM on each day. At the upstream site, a single midstream sample was collected and three samples were collected at the downstream site, two approximately one meter from each bank and one in midstream (Table A1). All samples were collected approximately 3 cm below the surface in surfactant free bottles pre-rinsed with stream water immediately prior to collection.

Part 2:

Data from the eight day investigation were used to determine the day of peak surfactant concentrations in Sandy Creek downstream from the plant. These data were reviewed with Mr. David Millis, Chief Operator, Albion Wastewater Treatment Facility, and an intensive 24 hour investigation at the plant was planned. Hourly samples were taken at the outflow of the final clarifier, within the plant from 8:45 AM on January 5 to 7:45 AM on January 6, 1994 using an ISCO model 2900 wastewater sampler. At the end of the 24 hour period stream samples were taken at sites described in Table A1 and at the plant intake. Samples were collected in 1 L (stream and plant intake) and 500 mL (ISCO sampler) surfactant free bottles.

All samples were analyzed for anionic surfactants (MBAS) within eight hours of collection at the SUNY Brockport Water Quality Laboratory (Method 5540C, APHA 1989). A Bausch and Lomb model 88 spectrophotometer was used to determine absorbance (5 cm cuvettes) of the extracted MBAS samples at 652 nm. All methodology was identical to that used in the initial study.

Surfactant concentration data for both the eight day and 24 hour investigations were graphically and statistically analyzed to determine if an increase occurred downstream from the plant discharge pipe. Also, plant data (e.g., discharge volume, temperature, pH and settleable solids) were compared with these data and with the combined data set which included values obtained in the previous investigation. Acceptance criteria for linear regressions were $r^2 > 0.5$, $p < 0.05$ and for ANOVA's, $p < 0.05$.

RESULTS

EIGHT DAY INVESTIGATION:

For the December 3 - 10, 1993 period, the surfactant concentrations in Sandy Creek below the plant discharge pipe were significantly greater than those found above it (ANOVA, $P < 0.01$). At the upstream site, anionic surfactant (MBAS) concentrations ranged from 36 $\mu\text{g/L}$ to 44 $\mu\text{g/L}$ ($\bar{x} = 40 \mu\text{g/L}$) for the eight samples. At the downstream site, the range was 38 $\mu\text{g/L}$ to 57 $\mu\text{g/L}$ for the midstream sample and 39 $\mu\text{g/L}$ to 58 $\mu\text{g/L}$ when values for the three cross-stream samples were averaged. The downstream means were 47 $\mu\text{g/L}$ for both the midstream and averaged values (Table A2). For the eight day period, the peak concentration (58 $\mu\text{g/L}$) was observed at 8:30 AM on Wednesday December 8, 1993. While the original investigation suggested that peak concentrations were present on Monday mornings, our more thorough daily sampling suggested differently. Figure 1 shows an increase in concentration from Sunday through Wednesday with a decline for the remainder of the week. The very low concentration observed on Sunday December 5, 1993 (39 $\mu\text{g/L}$) was at least partially due to high storm related stream discharge on that date. This may have also depressed levels the next day.

Linear regression analysis did not show any correlation ($r^2 > 0.50$, $P < 0.05$) between surfactant concentrations in the stream (100m below the discharge pipe) and discharge volume, effluent temperature, effluent pH or influent solids. These parameters are measured daily by the plant and were provided by Mr. David Millis, Chief Operator, Albion Wastewater Treatment Facility. Figure 1 shows what appears to be an inverse correlation between plant discharge and the downstream surfactant concentration, but this was not statistically valid ($r^2 = 0.19$, $P = 0.281$). However, it does suggest that when flows are low in the sewage treatment plant (STP) that concentrations below the discharge point in the stream increase. We have no explanation for this. A seepage area that runs through the STP property and empties into the stream only a few meters downstream from the STP discharge pipe may be the cause. This seepage area drains an

agricultural field across the street from the plant and did have high concentrations of surfactants (Fig. 3). However, flow was almost nonexistent during our sampling visits and did not seem to have a major affect on surfactants in the stream.

Combining these data with those obtained for previous samples from the same sites (Table A4) also showed that surfactant concentrations below the discharge were significantly greater than those found above (ANOVA, $P < 0.01$). As before, linear regression analysis did not result in any correlation ($r^2 > 0.50$, $P < 0.05$) between the levels of surfactants below the discharge and plant data. However, there was a modest relationship between effluent temperature and midstream concentrations below the discharge ($r^2 = 0.43$, $P = 0.029$).

24 HOUR SAMPLE:

Based on the data obtained during the eight day investigation, a 24 hour sample run was scheduled with the Albion Wastewater Treatment Plant for Wednesday and Thursday January 5 and 6, 1994. Sampling was planned to commence at approximately 8:00 AM on the 5th and end at approximately the same time on the 6th.

For the hourly samples taken in the plant, at the final clarifier outflow, surfactant concentrations ranged from 228 $\mu\text{g/L}$ to 306 $\mu\text{g/L}$ with the highest value occurring at 7:45 AM on the 6th (Table A3, Fig. 2). The influent sample taken at 8:00 AM on the 6th produced an anionic surfactant concentration of 2700 $\mu\text{g/L}$, a level nearly nine times higher than the effluent level at that time. Raw domestic wastewater is reported to have surfactant concentrations ranging from 1 to 20 mg/L with approximately 60% anionic types (APHA 1989). However, since the flow delay in the plant is approximately 24 hours (D. Millis), the concentrations we found at the

effluent are not related to those found at the influent and the change in concentration in the plant cannot be determined from these data. Nevertheless, a significant decrease in surfactant concentrations within the STP are evident.

On Thursday 6 January 1994, five stream samples were taken within one hour of the final effluent sample from the plant (7:45 AM). These samples indicate that surfactant concentrations increased from 38 $\mu\text{g/L}$ above the plant discharge pipe to 100 $\mu\text{g/L}$, 0.5 m downstream from the plant discharge pipe. One hour earlier the concentration at the outflow of the final clarifier in the plant was 306 $\mu\text{g/L}$. Downstream from the discharge pipe, levels decreased rapidly to a value of 60 $\mu\text{g/L}$ at our normal sample site, approximately 100 m downstream from the discharge. This value is similar to those found on previous dates at that site (Fig. 3).

In addition to these data, a high foam event was observed in the village of Albion on December 5, 1993 approximately 1.5 Km upstream from the treatment plant discharge. Foam was observed covering the stream in some areas and was an estimated 20 cm to 30 cm deep where it collected in piles. This foam event coincided with a major storm runoff event on that day and is reported to occur several times during the year (D. Millis). Large amounts of foam were also observed on that date in Bullard Park, approximately 2.0 Km above the plant and a site where piles of foam were observed regularly in the initial investigation. Since the watershed upstream from the observed foam in Albion is primarily agricultural or old field, the source of this foam is presumed to be natural or the result of agricultural practices. In addition, a seepage area running through the STP property from an adjoining agricultural field has elevated levels of surfactants (Fig. 3). Since flow was almost nonexistent during our visits, its impact on stream surfactant concentrations appears to be minimal.

SUMMARY

The data presented in this addendum clearly confirm that the concentration of anionic surfactants in the west branch of Sandy Creek increases as the stream passes the discharge pipe of the Albion Wastewater Treatment Facility. However, as discussed in the previous investigation these levels are low and below the 100 µg/L considered as the upper level in natural waters (APHA 1989).

The treatment plant reduces surfactant concentrations significantly and the levels at the outflow of the final clarifier, while higher than those normally found in natural waters, are quickly diluted by the stream immediately below the discharge pipe. This dilution effect was evident on 6 January 1994 (Figure 3) when Sandy Creek was at a low flow level due to severe cold winter weather over the previous two weeks when runoff was non-existent.

The observations of large amounts of foam in Sandy Creek above the Albion Wastewater Treatment Plant are obviously not caused by the plant effluent.

CONCLUSION

While the Albion Wastewater Treatment Plant does increase the level of anionic surfactant (MBAS) concentrations in the west branch of Sandy Creek by as much as 142 % (11 January 1993), total values were below 100 µg/L for all of our samples, a value considered to be within the range of environmental background concentrations (APHA 1989). Also, the observations of high foam levels above the plant, and in a drainage ditch entering the stream at Kendall Mills (previous study), suggest sources other than the Albion Wastewater Treatment Plant . However,

the high surfactant concentrations in the plant influent also suggest that failure of plant processes to reduce this level could lead to event type discharges into the stream, potentially producing high levels of foam downstream. Discussion with Dave Millis, Chief Operator of the Albion STP, indicate that because of an old and outdated sanitary system excessive infiltration and inflow, caused by heavy rains or snow melt, can exceed the plant design capacity of 2.3 million gallons per day. In this case, decomposition of surfactants may not take place in the plant and high levels could be passed directly to Sandy Creek. Future observations of foam in the west and main branches of Sandy Creek should be compared with plant discharge data to determine if plant overload events are involved.

ACKNOWLEDGMENTS

This study would not have been possible without the excellent cooperation of Mr. David Millis, Chief Operator, Albion Wastewater Treatment Plant. His willingness to share data and allow access to plant facilities for sampling are much appreciated.

LITERATURE CITED

APHA. 1989. Standard Methods for the Examination of Water and Wastewater. American Public Health Association. Washington, DC.

Table A1 - Sample dates and locations for eight day and 24 hour investigation of surfactant (MBAS) increase in Sandy Creek below the Albion Wastewater Facility. All December 1993 samples were collected at 8:30 AM at Sites 1 through 4. Site P1 samples were collected hourly for 24 hours with an automated sampler. Sites P2 thru P7 were sampled between 8:00 AM and 8:30 AM on January 6, 1994.

DATE	LOCATION
December 3, 1993	Site 1 South side of stream, 100 meters below plant
December 4, 1993	discharge, west of Butts Road bridge.
December 5, 1993	Site 2 Mid-stream 100 meters below plant discharge, west
December 6, 1993	of Butts Road bridge.
December 7, 1993	Site 3 North side of stream 100 meters below plant
December 8, 1993	discharge, west of Butts Road bridge.
December 9, 1993	Site 4 Mid-stream 100 meters above plant discharge.
December 10, 1993	
January 5 1994	P1 - Inside plant at outflow from final clarifier, ISCO sampler.
January 6 1994	P1 - Inside plant at outflow from final clarifier, ISCO sampler.
	P2 - Plant intake.
	P3 - At plant discharge in mid-stream of Sandy Creek.
	P4 - 100 meters upstream from the plant discharge.
	P5 - 15 meters upstream from the plant discharge.
	P6 - 10 meters below plant discharge on north bank near area where seepage was observed in December.
	P7 - 100 meters downstream from the plant discharge, west of the Butts Road bridge.

Table A2 - Seven day sample of Sandy Creek upstream and downstream from the Albion Wastewater Treatment Facility. The Upstream site is 100 meters above the plant discharge; the downstream site is 100 meters below the discharge and west of the Butts Road bridge. Surfactant (MBAS) concentrations are $\mu\text{g/L}$ and all samples were collected at 8:30 AM. Concentrations for the downstream site are the mean of three cross stream samples: north bank, mid-stream and south bank. Plant discharge is daily average in million gallons per day (mgd). Discharge data were provided by Mr. David Millis, Chief Operator, Albion Wastewater Treatment Facility.

SAMPLE DATE	UPSTREAM MBAS ($\mu\text{g/L}$)	DOWNSTREAM MBAS ($\mu\text{g/L}$)	PLANT DISCHARGE (mgd)
December 3, 1993	44	45	1.816
December 4, 1993	37	47	2.456
December 5, 1993	36	39	2.235
December 6, 1993	38	48	2.263
December 7, 1993	42	50	2.053
December 8, 1993	43	58	1.747
December 9, 1993	41	45	1.950
December 10, 1993	41	45	2.012

Table A3 - Twenty-four hour sample at the Albion Wastewater Treatment Facility. PLANT samples were taken at the final clarifier outflow using an automated sampler. A single UPSTREAM and DOWNSTREAM sample were collected at the end of the 24 hour period on January 6. The UPSTREAM sample was taken 100 meters above the plant discharge and the DOWNSTREAM sample was collected 100 meters below the discharge, west of the Butts Road bridge. Plant discharge is the mean for each day in million gallons per day (mgd). Discharge data were provided by Mr. David Millis, Chief Operator of the Albion Wastewater Treatment Facility.

SAMPLE DATE	SAMPLE TIME	PLANT MBAS ($\mu\text{g/L}$)	UPSTREAM MBAS ($\mu\text{g/L}$)	DOWNSTREAM MBAS ($\mu\text{g/L}$)	DISCHARGE (mgd)
1/5/94	08:45	257			1.550
	12:45	268			
	16:45	248			
	20:45	228			
	00:45	252			
	07:45	305			
1/6/94	08:30		38	60	1.447

Table A4 - Surfactant concentrations ($\mu\text{g/L}$) in Sandy Creek at the Albion Wastewater Treatment Facility and plant discharge volumes (mgd) for all sample dates. The UPSTREAM site is 100 meters above the discharge for the 5/17/93, 11/9/93, December 1993 and January 1994 samples. For the 11/27/92, 12/21/92 and 1/11/93 samples, the UPSTREAM site is approximately 4.8 Km (3 miles) above the plant discharge. The DOWNSTREAM site is 100 meters below the discharge for all samples. For December 1993 and January 1994, the DOWNSTREAM values are the average of three cross-stream samples. Plant discharge data were provided by Mr. David Millis, Chief Operator, Albion Wastewater Treatment Facility

SAMPLE DATE	UPSTREAM MBAS ($\mu\text{g/L}$)	DOWNSTREAM MBAS ($\mu\text{g/L}$)	PLANT DISCHARGE (mgd)
11/27/92	24	23	2.202
12/21/92	46	74	2.946
1/11/93	19	46	2.074
5/17/93	22	51	1.242
11/9/93	33	42	1.702
12/3/93	44	45	1.816
12/4/93	37	47	2.456
12/5/93	36	39	2.235
12/6/93	38	48	2.263
12/7/93	42	50	2.053
12/8/93	43	58	1.747
12/9/93	41	45	1.950
12/10/93	41	45	2.012
1/6/94	38	60	1.447

Figure 1 - Anionic surfactant (MBAS) concentrations ($\mu\text{g/L}$) and average plant discharge volumes (million gallons/day = mgd), in the west branch of Sandy Creek at the Albion Wastewater Treatment Plant during an eight day period in December 1993. The UPSTREAM and DOWNSTREAM values were obtained approximately 100 meters above and below the plant discharge pipe. Plant discharge volumes were provided by Mr. David Millis, Chief Operator, Albion Wastewater Treatment Plant.

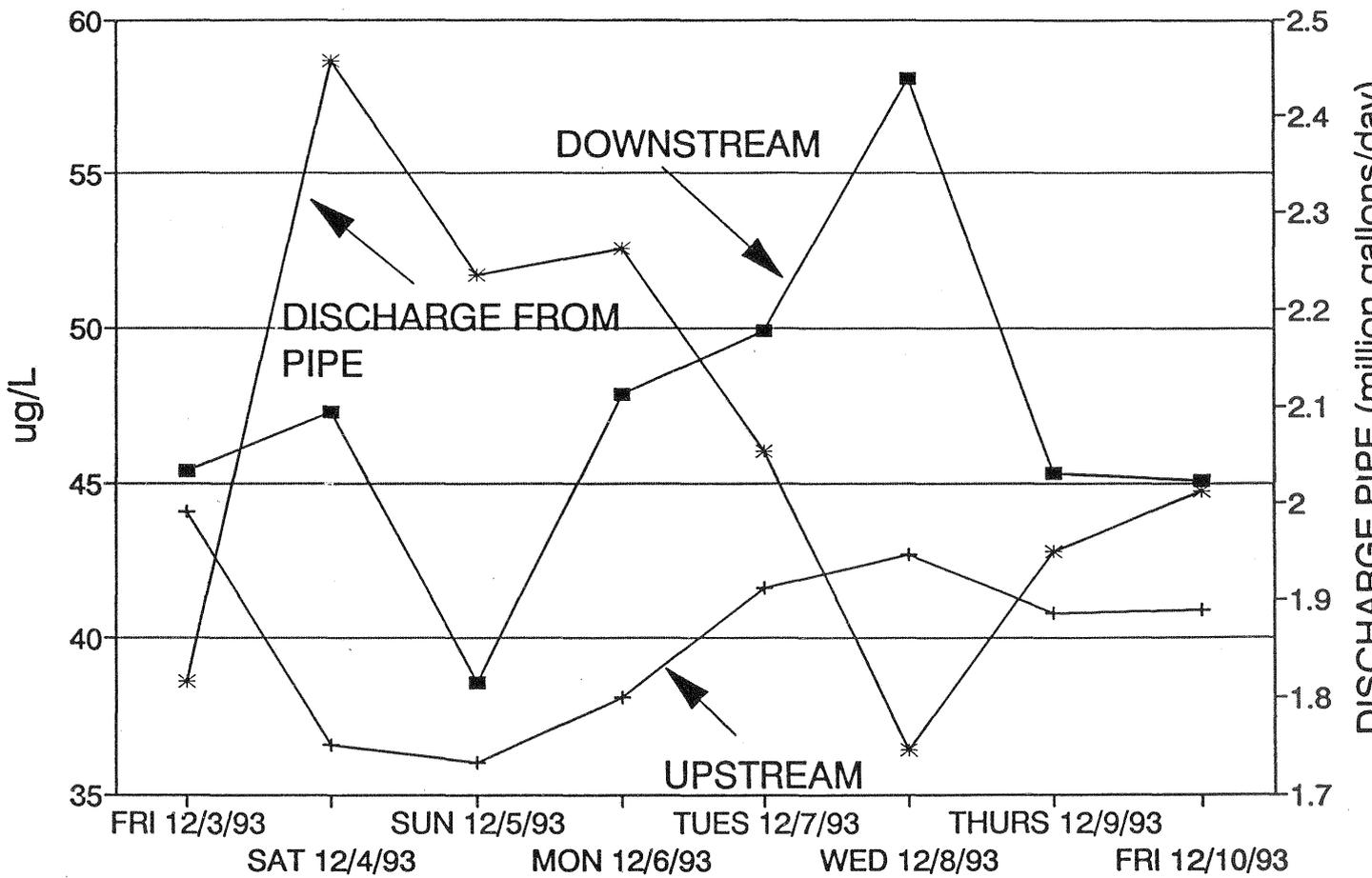


Figure 2 - Anionic surfactant (MBAS) concentrations ($\mu\text{g/L}$) at the outflow of the Albion Wastewater Treatment Plant final clarifier over a 24 hour sample period from 8:45 AM January 5 to 7:45 AM January 6, 1994. The INFLUENT surfactant concentration (right hand Y-axis) was obtained from a sample taken at 8:00 AM on January 6, 1994.

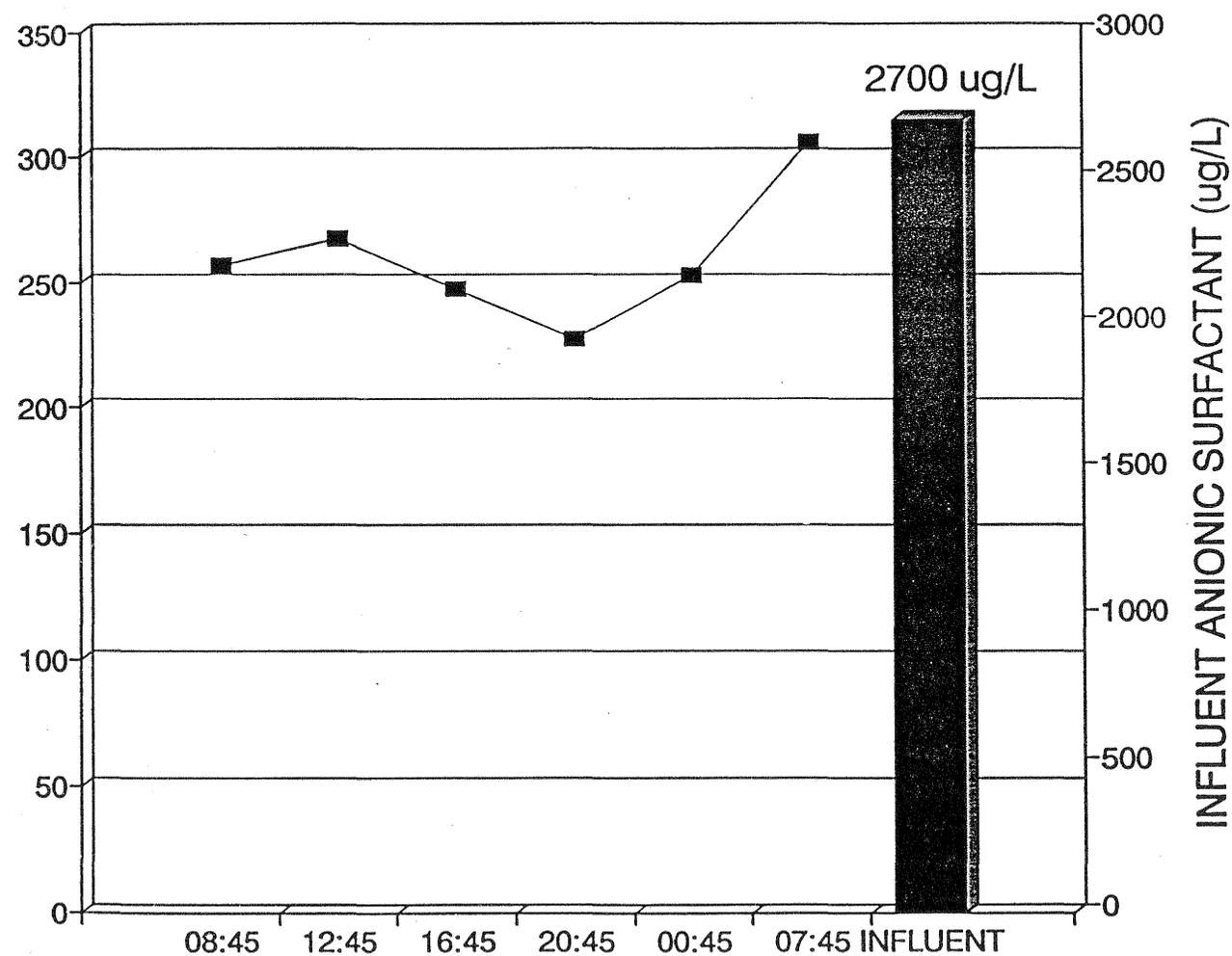


Figure 3 - Anionic surfactant (MBAS) concentrations ($\mu\text{g/L}$) in the west Branch of Sandy Creek at the Albion Wastewater Treatment Plant at 8:30 AM, 6 January 1994. UPSTREAM = 100 meters above the plant discharge pipe; UPSTREAM15 = 15 meters above the plant discharge pipe; DISCHARGE = 0.5 meters in front of the discharge pipe; SEEPAGE = a site 10 meters downstream from the discharge pipe near the north bank where groundwater seepage was observed coming from plant property in December, 1993; DOWNSTREAM = 100 meters below the plant discharge pipe, west of the Butts Road bridge.

