UNIVERSITY OF MINNESOTA
ST. ANTHONY FALLS HYDRAULIC LABORATORY

Project Report No. 293

MODEL STUDY OF MIXING IN THE PROPOSED DECHLORINATION FACILITY OF THE SENECA WASTEWATER TREATMENT PLANT IN EAGAN, MINNESOTA

by

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LIST OF ABBREVIATIONS AND SYMBOLS

C_{br}	Clean water dye concentration on bottom of channel
C_{mr}	Clean water dye concentration at mid–depth of channel
C_{sr}	Clean water dye concentration at surface of channel
D_j	Diameter of the jet
DEV_b	Standard deviation of concentration fluctuations at the bottom
DEV_m	Standard deviation of concentration fluctuations at mid–depth
DEV_s	Standard deviation of concentration fluctuations at the surface
gpm	Gallons per minute
Hz	Hertz
mgd	Millions of gallons per day
Q	Flowrate
Q_d	Sulfur dioxide injection rate
Q_w	Channel wastewater flowrate
Re_{jm}	Jet Reynolds number of the model
Re_{jp}	Jet Reynolds number of the prototype
Re_m	Channel Reynolds number of the model
Re_p	Channel Reynolds number of the prototype
SO_2	Sulfur dioxide
V_j	Velocity of the jet

I. INTRODUCTION

The Seneca Wastewater Treatment Facility is located in Eagan, Minnesota. Recent plans to upgrade the facility include the addition of disinfection basins and a dechlorination channel. The dechlorination process uses an SO_2 solution that is injected through a multiport diffuser in the bottom of the dechlorination channel. The dechlorination channel and the SO_2 feed are shown in the plan layout in Fig. I–1.

The decision was made by the Metropolitan Waste Control Commission (MWCC) to investigate mixing under the specific conditions and geometry of the Seneca dechlorination channel before finalizing design and construction. The St. Anthony Falls Hydraulic Laboratory (SAFHL), University of Minnesota, in Minneapolis, was contracted to perform the study.

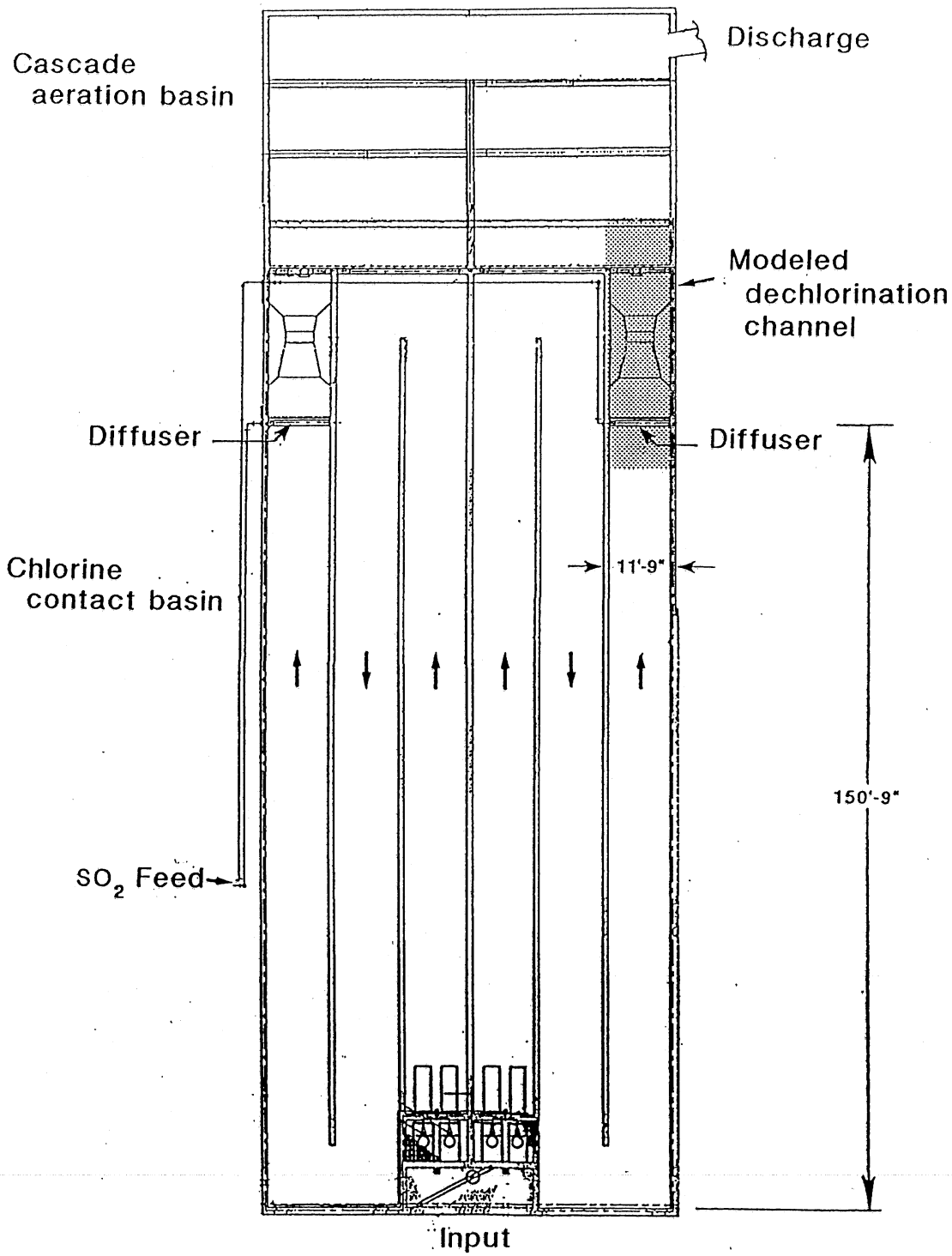


Fig. I–1. Proposed new chlorine contact basin layout.

II. EXPERIMENTAL FACILITY, OBJECTIVES AND PROCEDURES

The purpose of the study was to investigate the mixing that occurs in the proposed dechlorination channel, and provide data to support a decision involving the acceptability of the proposed design. An additional objective was to provide suggestions for improvement of the design, should problems with mixing in the original design become apparent.

To make the study, a laboratory experiment was proposed. It was decided to build a model of the dechlorination channel, the Parshall flow measuring flume, and a short section of the outlet cascade basin downstream.

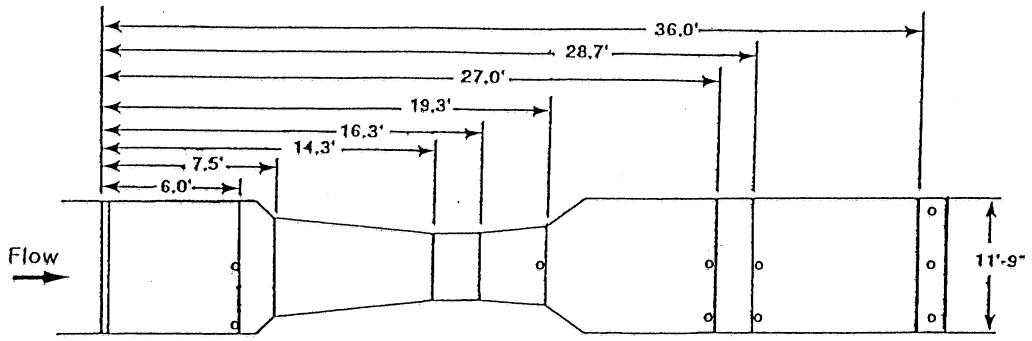
The flow from the chlorine contact basin to the dechlorination channel is through a long straight channel. At the end of the chlorine contact basin the flow rises and discharges over a sill into the dechlorination channel. The dechlorination channel is shown in Fig. II–1, in plan view and with elevations.

A 1:5.8 scale model of the dechlorination channel was built in a glass–walled laboratory flume. The 1:5.8 scale was chosen to fit the 11 ft, 9 inch wide dechlorination channel into a 2 ft wide existing flume. The first 36 ft of the channel was modeled, including the diffuser and the Parshall flume section. Changes in elevation within the Parshall flume were simulated. The prototype changes in elevations at each end of the section could not be attained fully in the model flume (see Fig. II–1). Figure II–2 shows an overview of the laboratory set–up. Flow enters from the foreground on the left and moves to the upper right portion of the picture.

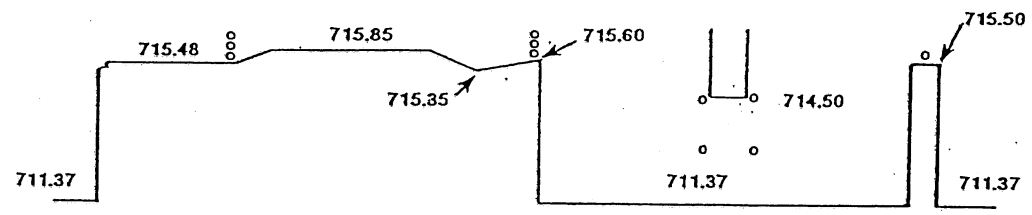
To save on modeling costs, a decision was made not to model the lateral expansion in the cascade section downstream from the dechlorination basin. Instead the model was built in a glass–walled laboratory flume, and a siphon was used to remove the excess lateral flow downstream. Flow depths on the cascade weir were modeled to the exact prototype values. Figure II–3 shows the area of the lateral expansion in the model and the siphon withdrawal.

The model was tested at prototype scaled flow rates ranging from 11 to 42.5 mgd, with a scaled SO_2 injection rate of 62 gpm. The flow rates and the siphon withdrawal could be adjusted independently.

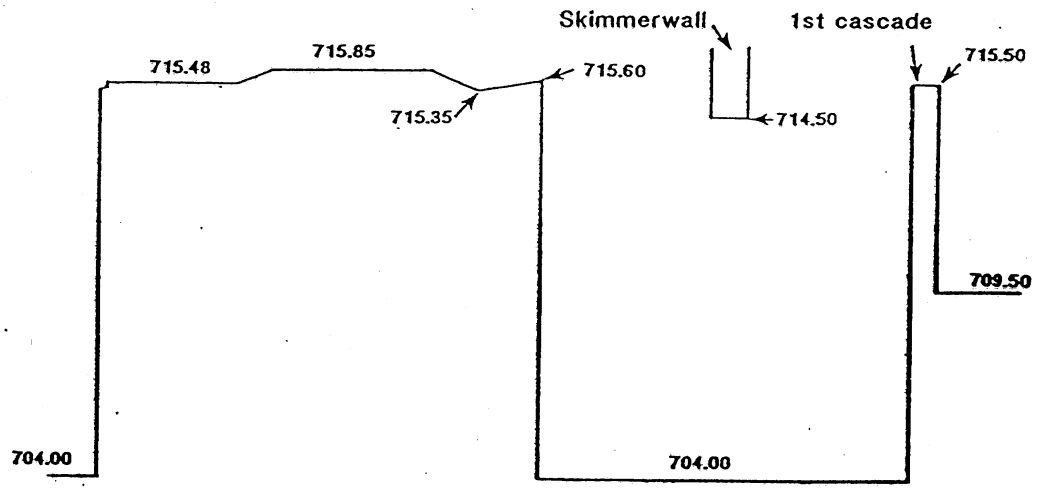
The prototype SO_2 diffuser is a circular pipe 2.5 inches in diameter set in the bottom of the channel; nineteen 5/16 inch diameter orifices, located on 6.75 inch centers, discharge the SO_2 solution into the wastewater flow. The diffuser was modeled also at a 1:5.8 geometrical scale.



(a) Plan view of prototype



(b) Elevations of model



(c) Elevations of prototype

Fig. II–1. Prototype geometry of dechlorination facility represented in model and sampling locations (circles).

Fig. II–2. Overview of laboratory channel with model.

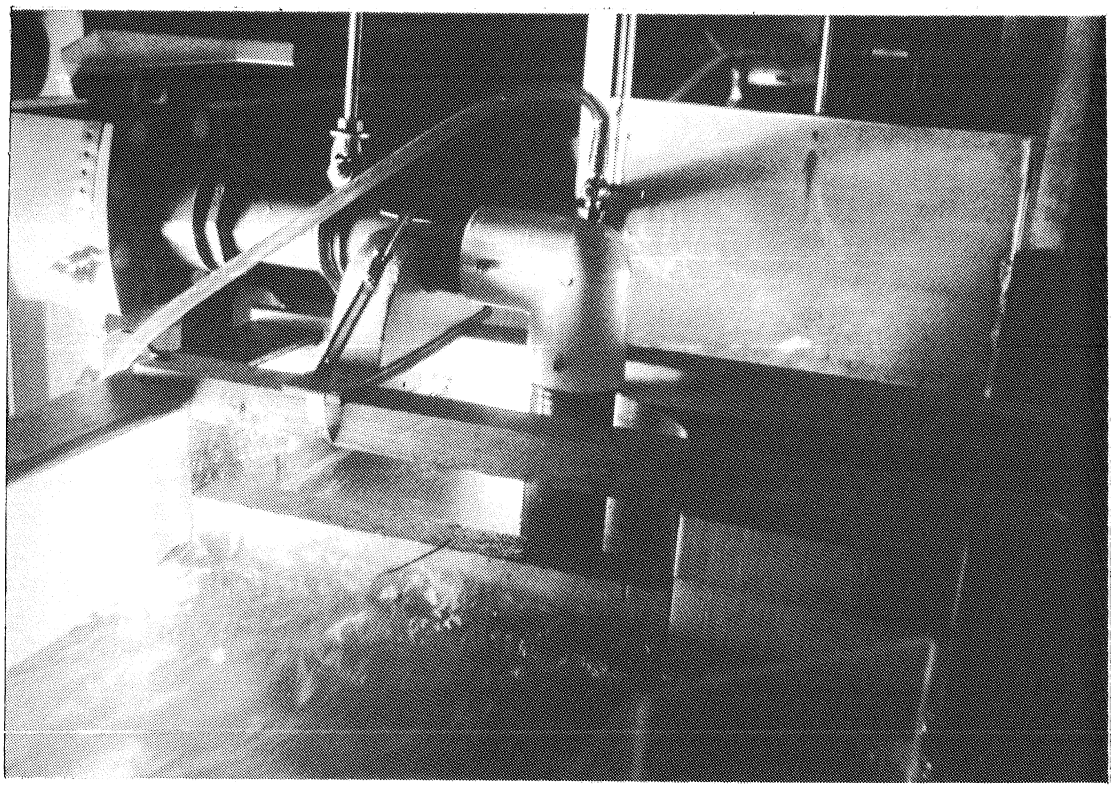


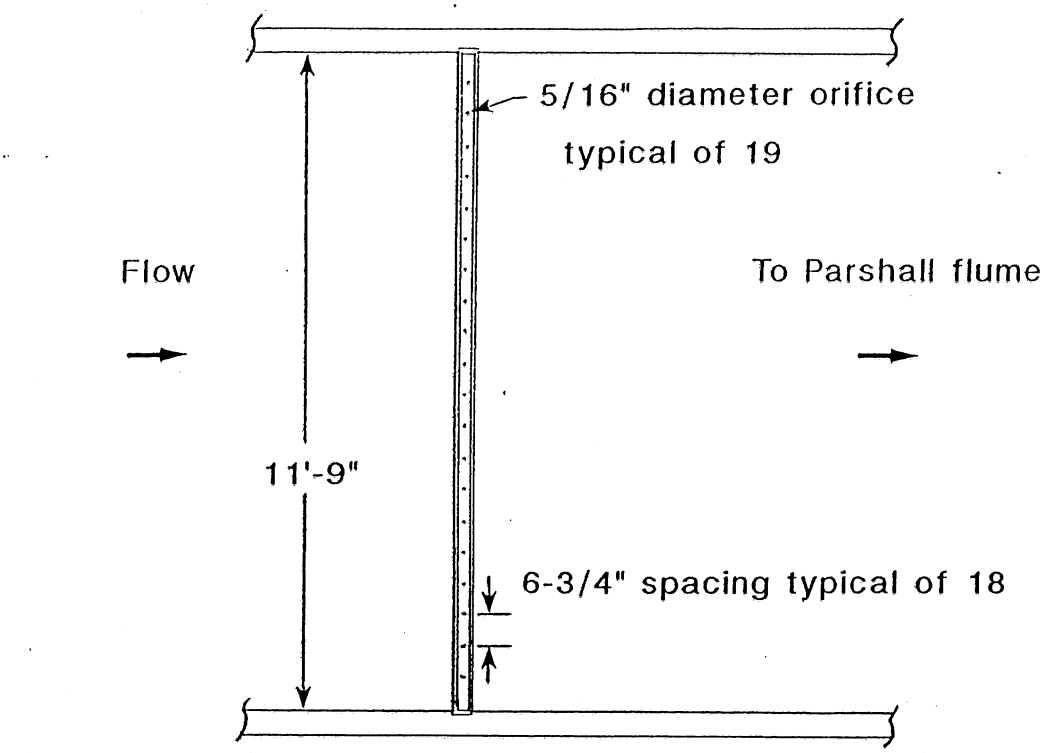
Fig. II–3. Close–up view of lateral Expansion and siphon withdrawal.

Three SO_2 injection angles were tested: (a) 54° to the channel flow, (b) perpendicular, or 90°, to the channel flow and, (c) directly into, or 180° to, the flow of the dechlorination channel (Fig. II–4). These angles were tested to investigate the possibility of improved mixing by better use of the jet trajectories, turbulence, and flow separations caused by the front edge of the channel.

A blue dye solution was used to simulate the SO_2 solution and measurements of dye concentrations in the channel were taken using a Kennek turbidity probe and a Fitness XT Turbo computer. The sampling was done at 10 Hz with a sample length of 120 sec and a low–pass filter with a cut–off frequency of 5 Hz was used to eliminate line noise. The turbidity of the river water used in the experiments was accounted for as a background (reference) value. Turbidity due to dye concentration was retained for further analysis.

A calibration of the turbidity probe was made using 10 different dye concentrations over and above the reference (river) value. Reference values were measured at the beginning and the end of each experiment and averaged. An example of concentration records is plotted in Fig. IV–1 (x is the distance from the injection manifold).

Sampling locations for the symmetrical upstream approach flow were shown in Fig. II–1. The surface sample is taken at 0.15 times the depth below the water surface. Similarly the bottom sample is taken at 0.15 times the depth above the channel bottom. The mid–flow samples for $x = 27$ ft and $x = 29$ ft were taken midway between the channel bottom and the bottom of the skimmerwall. At $x = 27$, $x = 29$, and $x = 36$ ft measurements were only taken for an injection angle of 90°. This was done on the assumption that any difference in the method of injection would have become negligible by the time the flow reaches these positions.



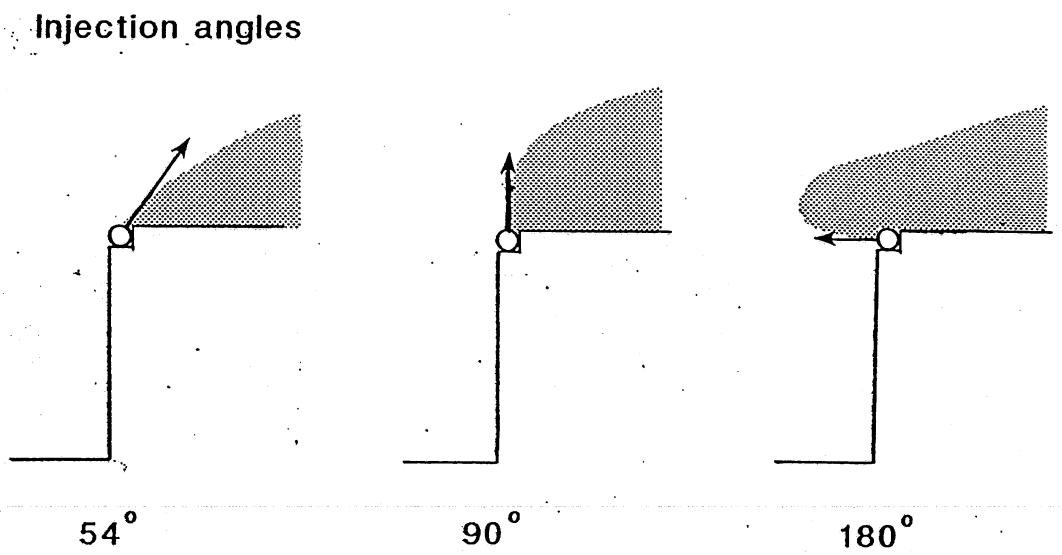


Fig. II–4. SO_2–injection manifold (diffuser).

III. SIMILITUDE

The model dechlorination channel and Parshall flume were geometrically similar to their respective prototypes.

Dynamic similarity of the model flow was achieved by Froude scaling. Froude similarity was chosen because flow through the channel, and in particular through the Parshall flume, is driven by gravity. In Froude scaling the following model to prototype ratios apply to this study.

Lengths, widths	1:5.87
Depths	1:5.87
Velocities	1:2.42
Times	1:2.42
Flow Rates	1:83.7

Mixing depends on turbulence and turbulence depends on Reynolds numbers and flow separation. In Froude models Reynolds numbers are scaled as the product of velocity times length, or in this case 1:14.2, if viscosities are the same in model and prototype. If they are not, viscosity ratios must also be considered based on the definition of Reynolds number

$$\mathrm{Re} = \frac{VD}{\nu} ,$$

where V = velocity
D = depth or diameter, and
ν = viscosity.

It is known from previous studies that turbulence and mixing scale well when model Reynolds numbers are in excess of 10,000. Lower numbers down to 500 still assure turbulence, but in the transitional range. In this study Reynolds numbers in the prototype with $\nu \approx 10^{-5}$ ft^2/s ($\sim$ 70°F) were as follows:

TABLE III–1. Channel Reynolds Numbers

Q (mgd)	Q (cfs)	VD (ft^2/s)	Re_p	Re_m
11	17.0	1.45	145,000	10,200
17	26.3	2.24	224,000	15,800
34	52.6	4.48	448,000	31,500
42.5	65.8	5.60	560,000	39,400

The model Reynolds number (Re_m) for flow rates is above the desirable value of 10,000. The flow situation is further improved by the flow separation at the leading edge of the dechlorination channel. Thus, if the model performs satisfactorily at the model Re numbers, the prototype can be expected to do the same.

Another turbulence scale is introduced by the jets from the diffuser orifices. The jet Reynolds numbers were as follows:

TABLE III–2. Jet Reynolds Numbers

Q (gpm)	V_j^* (ft/s)	D_j (in)	Re_{jp}	Re_{jm}
62	13.0	.31	33,800	2,400

*with zero contraction.

The model jet Reynolds numbers are not ideal but acceptable. They do assure a turbulent jet. Jet velocity to crossflow velocity ratios are more significant and are modeled correctly (see Section V).

IV. RESULTS OF CONCENTRATION MEASUREMENTS

A. CONDITIONS TESTED

Channel flows of 11, 17, 34, and 42.5 mgd were tested. A diffuser flowrate of 62 gpm was tested for this range of wastewater flows.

B. SAMPLE DATA

Records of concentration versus time for one experiment are shown in Fig. IV–1. The sampling locations are shown in Fig. II–1. Sampling time in the model is 120 sec which translates into 290 seconds prototype time. Dye concentrations measured below the surface (top), at mid–depth (middle) and near the bottom of the channel (bottom) are presented in Fig. IV–1 for distances of 6 ft, 19 ft, 27 ft, 29 ft, and 36 ft from the injection manifold. For the 6 ft, 19 ft, 27 ft, and 29 ft stations data were taken at both the side and the center of the channel. At the 27 ft and 29 ft sections the data positions correspond to the bottom of the skimmer wall and the middle of the flow depth beneath this wall. At the 36 ft station measurements were only taken at the mid–depth position for the right side, left side, and center of the channel. Additionally, at the 6 ft (side and center) and 19 ft (center) stations the diffuser was rotated and concentrations were measured with dye injection into the flow (180°), perpendicular to the flow (90°), and with the channel flow (54°). It is important to note that at x = 27 ft and x = 29 ft air bubbles were present in the flow (entrained from the skimmerwall). To illustrate their effect on the measurements concentration records that only account for any bubbles (no dye), and are therefore not an indication of any mixing are also given.

Examination of Fig. IV–1 indicates the following features of the dye distribution and mixing:

> x = 6 ft (entrance to Parshall flume): Along the side wall there is a stagnation zone and dye is fairly evenly distributed from top–to–bottom, but fluctuations are large. In the center the dye is concentrated along the bottom and only intermittently reaches the surface.
>
> x = 19 ft (end of Parshall flume): The fluctuations have been somewhat reduced, and the concentration is now more uniform throughout the cross–section. Also, differences due to the angle of injection, apparent at x = 6 ft, have been greatly reduced.

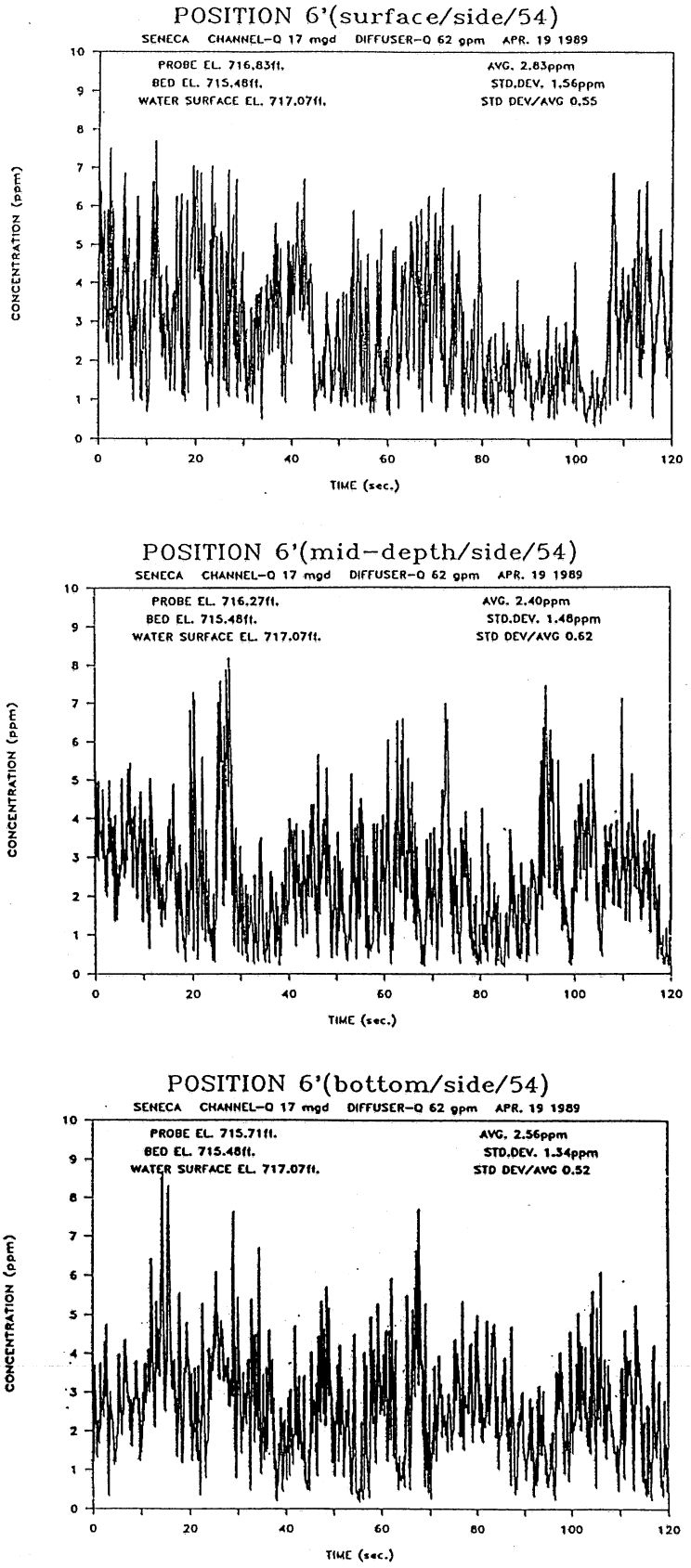
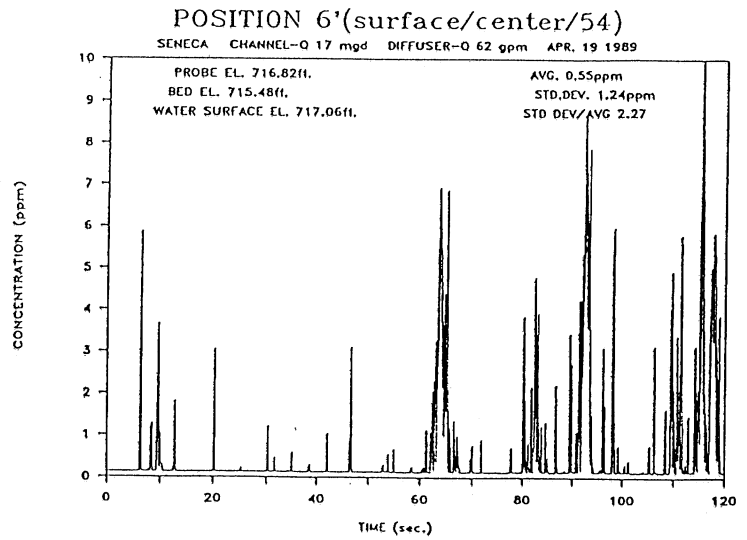


Fig. IV–1. Concentration versus time data. $Q_w = 17$ mgd.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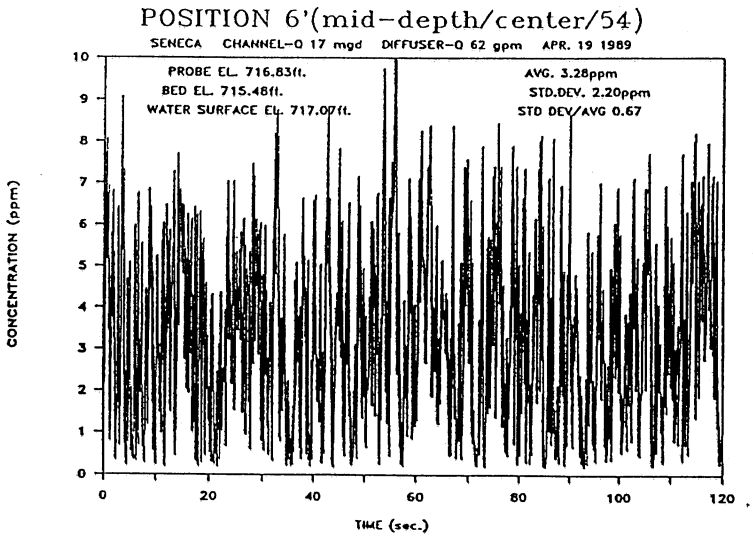
STD DEV/AVG 2.27
CONCENTRATION (ppm)
TIME (sec.)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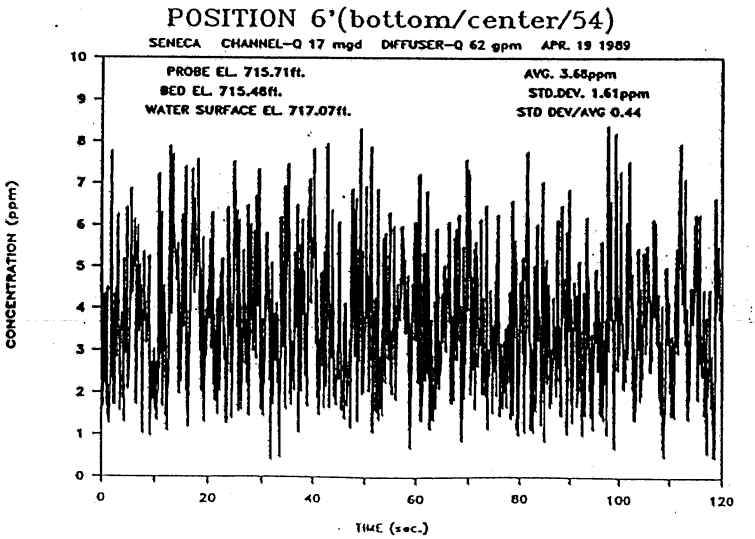
CONCENTRATION (ppm)
TIME (sec.)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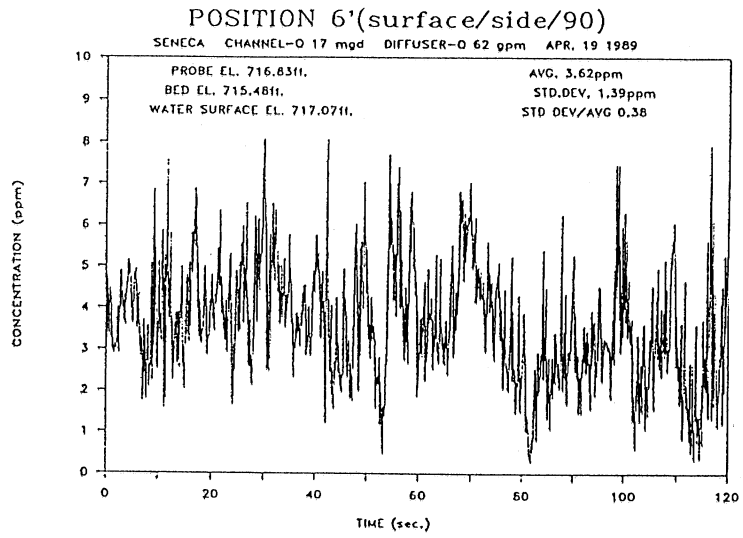
TIME (sec.)

Fig. IV–1. Cont.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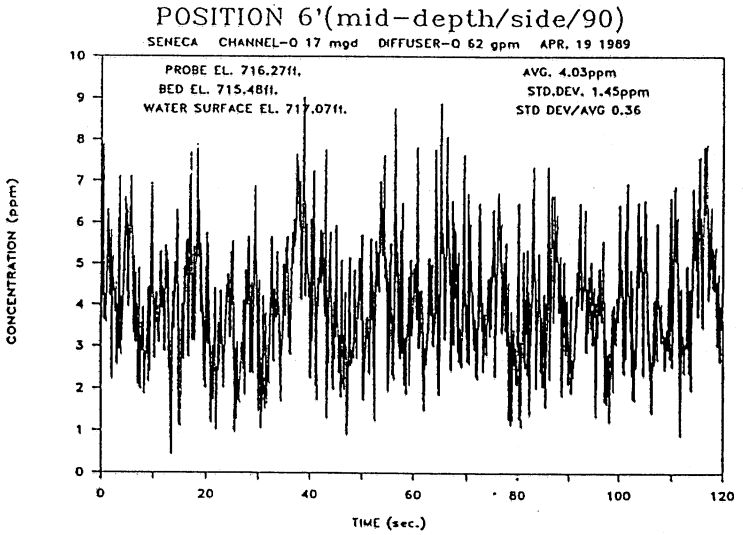
TIME (sec.)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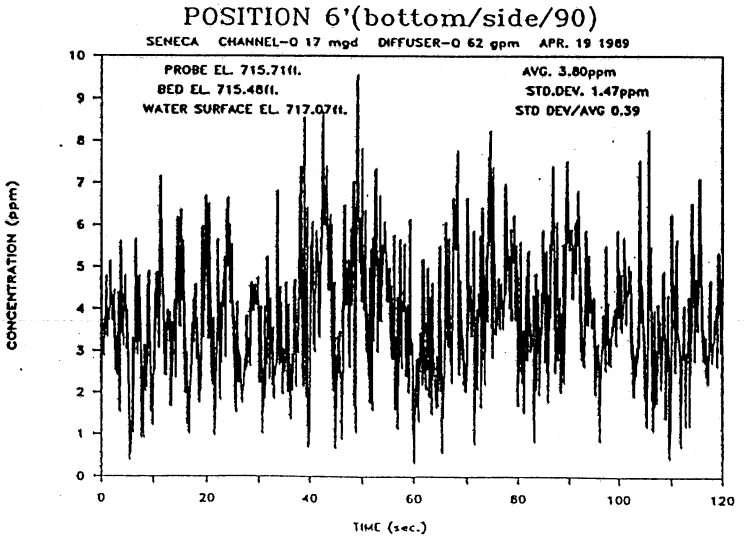
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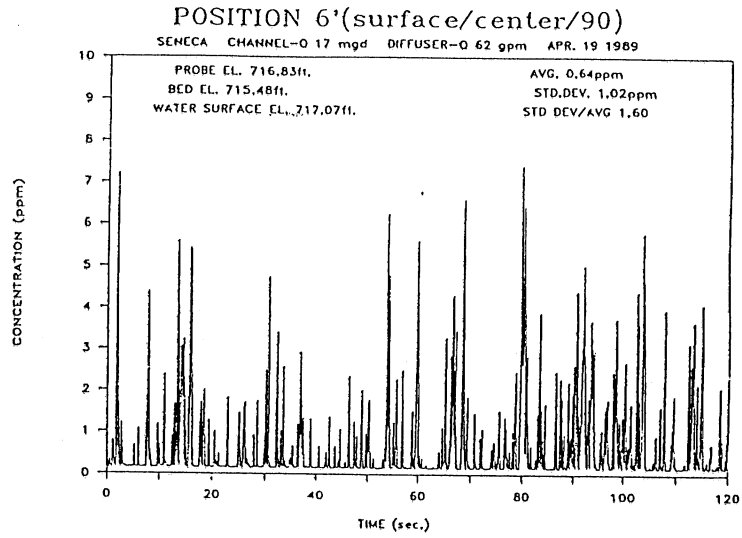
Fig. IV–1. Cont.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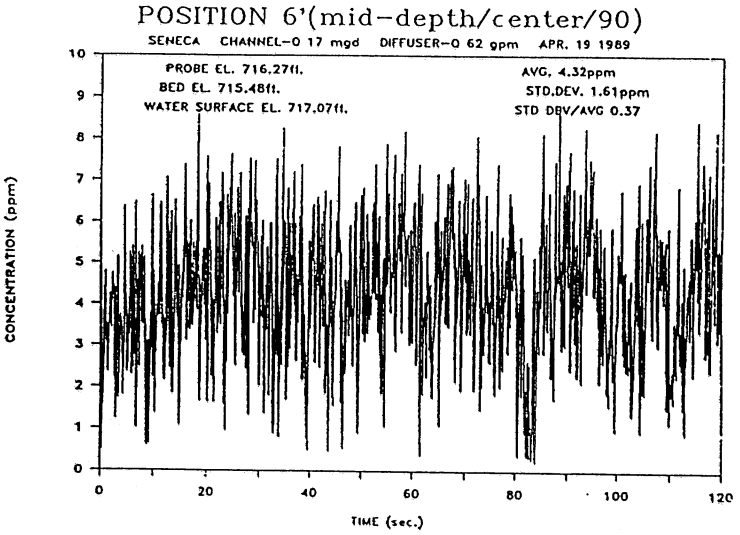
CONCENTRATION (ppm)
TIME (sec.)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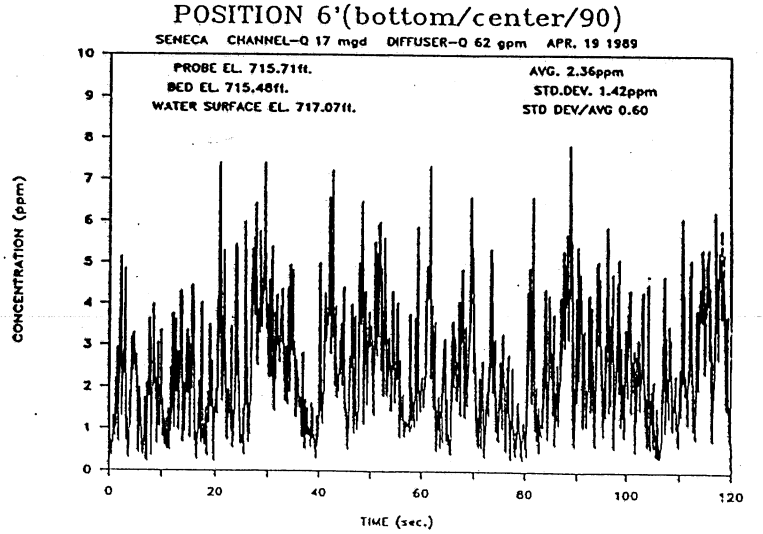
CONCENTRATION (ppm)
TIME (sec.)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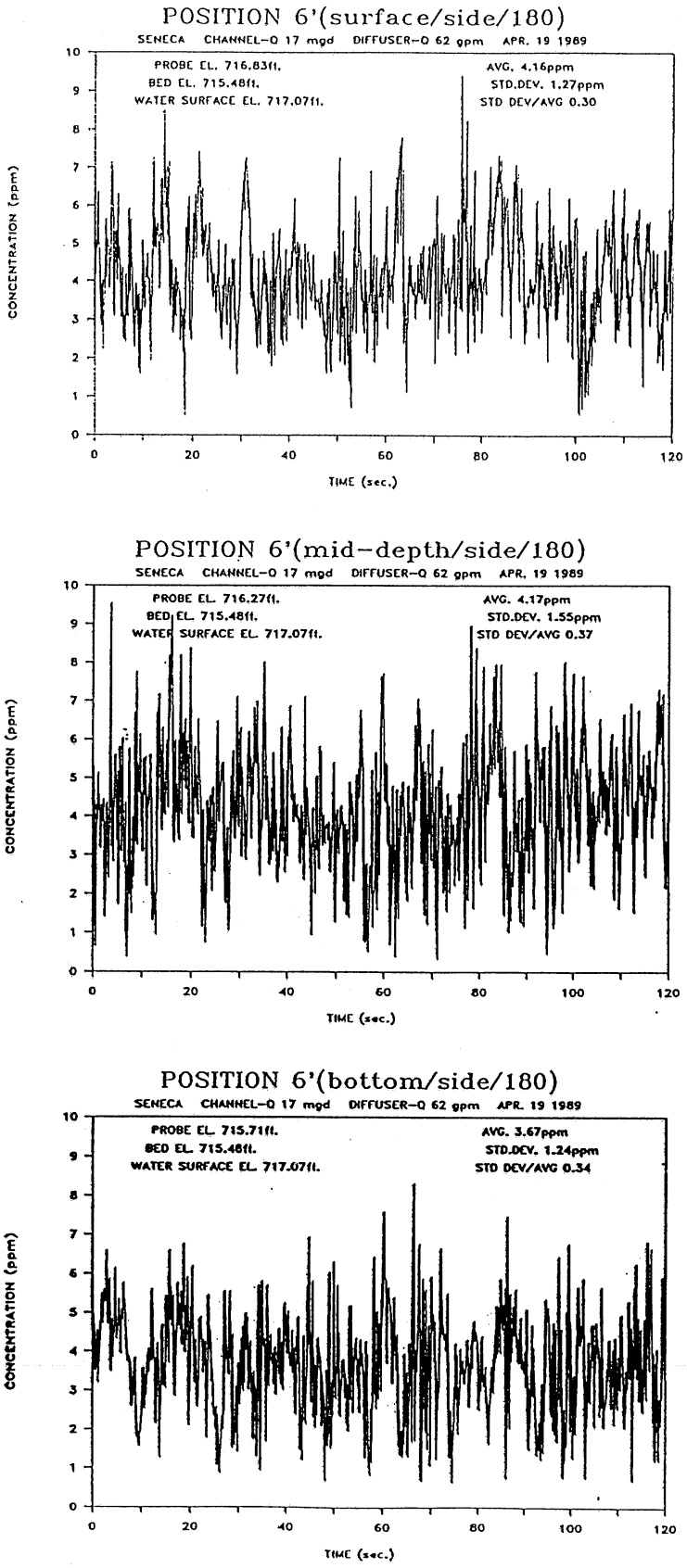
CONCENTRATION (ppm)
TIME (sec.)

Fig. IV–1. Cont.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TIME (sec.)

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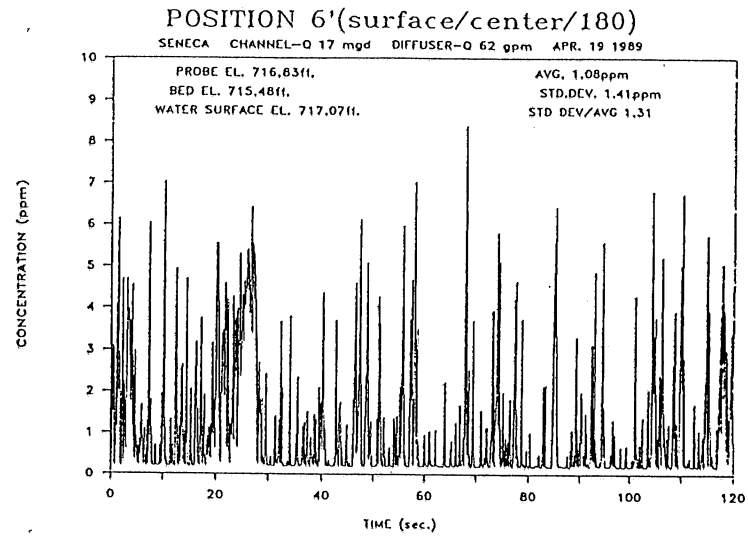
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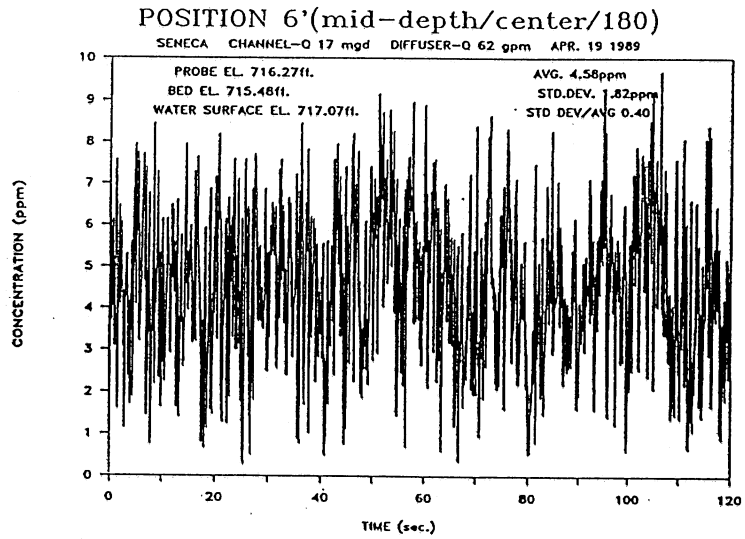
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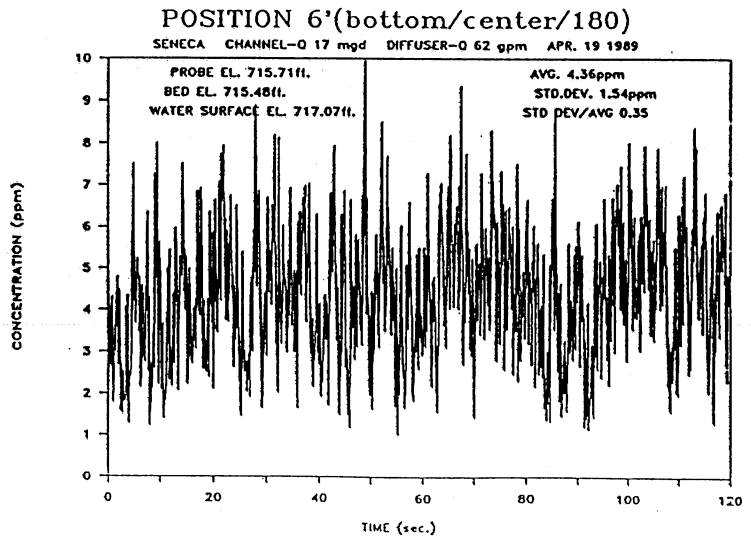
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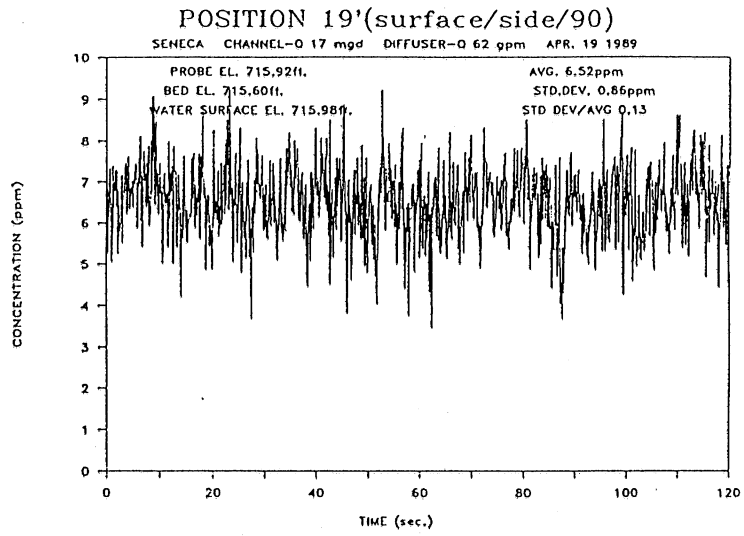
CONCENTRATION (ppm)
TIME (sec.)

Fig. IV–1. Cont.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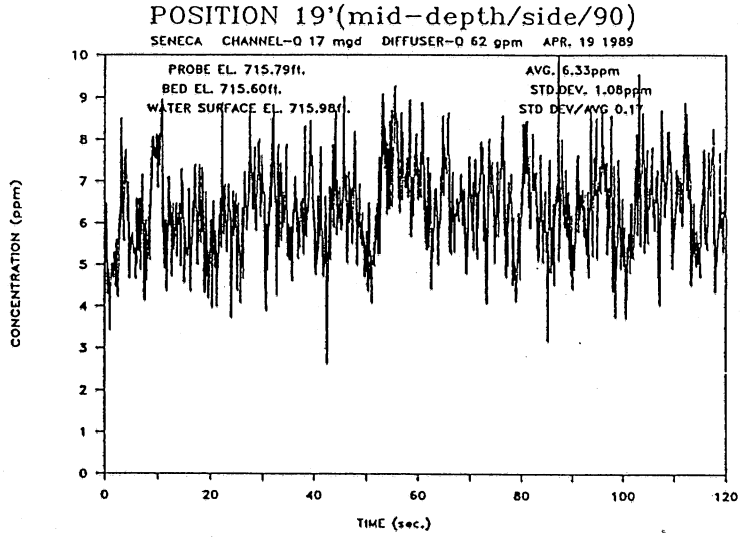
TIME (sec.)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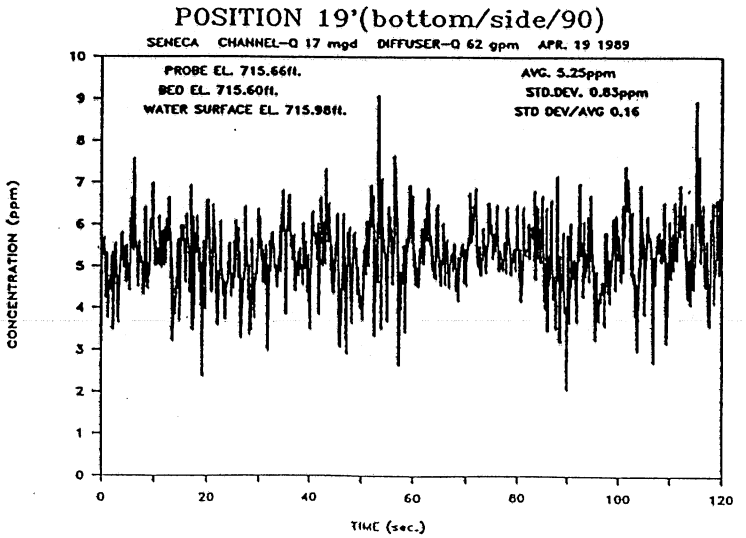
TIME (sec.)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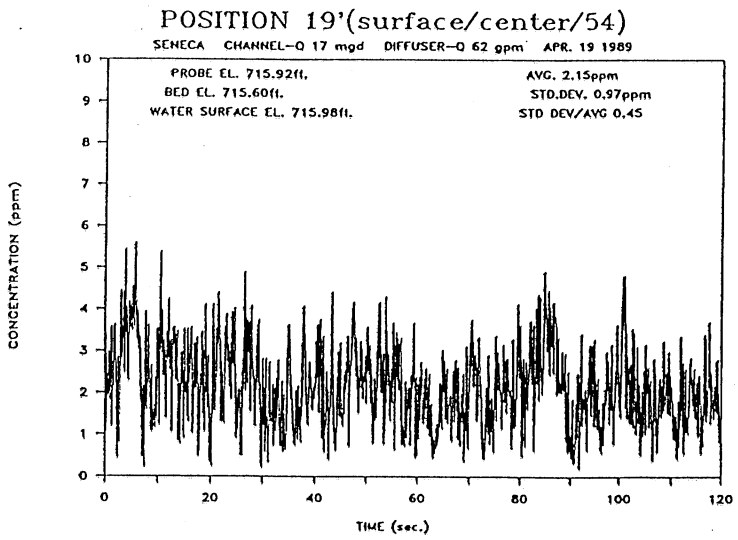
STD DEV/AVG 0.16
CONCENTRATION (ppm)
TIME (sec.)

Fig. IV–1. Cont.


POSITION 19'(surface/center/54)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.92ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 2.15ppm
STD.DEV. 0.97ppm
STD DEV/AVG 0.45
CONCENTRATION (ppm)
TIME (sec.)

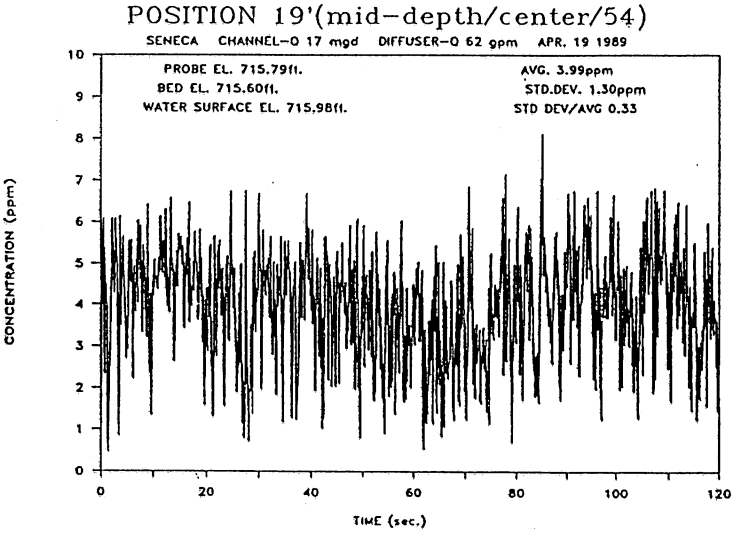
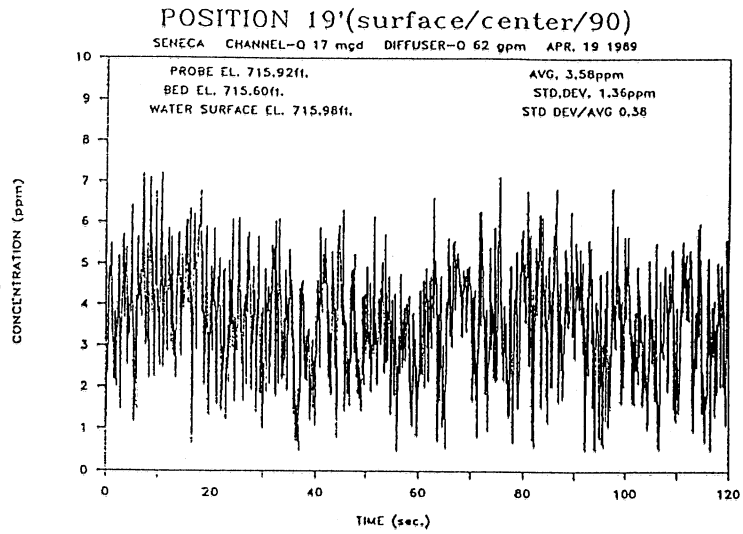

POSITION 19'(mid-depth/center/54)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.79ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 3.99ppm
STD.DEV. 1.30ppm
STD DEV/AVG 0.33
CONCENTRATION (ppm)
TIME (sec.)

Fig. IV–1. Cont.


POSITION 19'(surface/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.92ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 3.58ppm
STD.DEV. 1.36ppm
STD DEV/AVG 0.38
CONCENTRATION (ppm)
TIME (sec.)

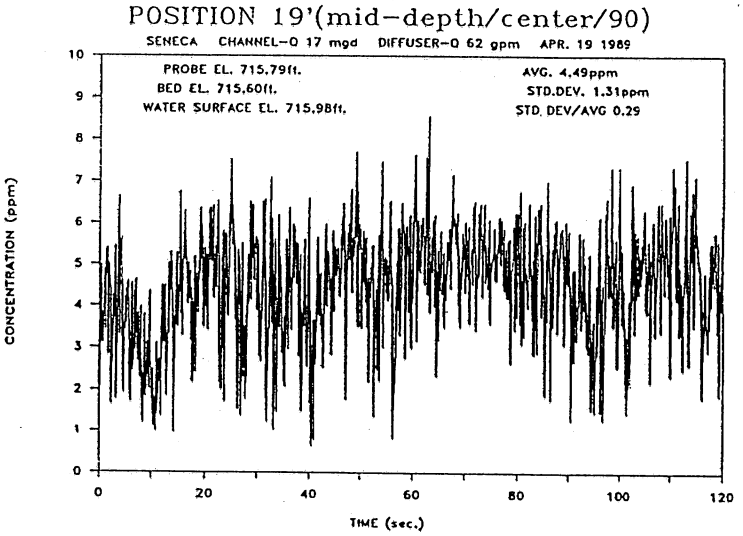
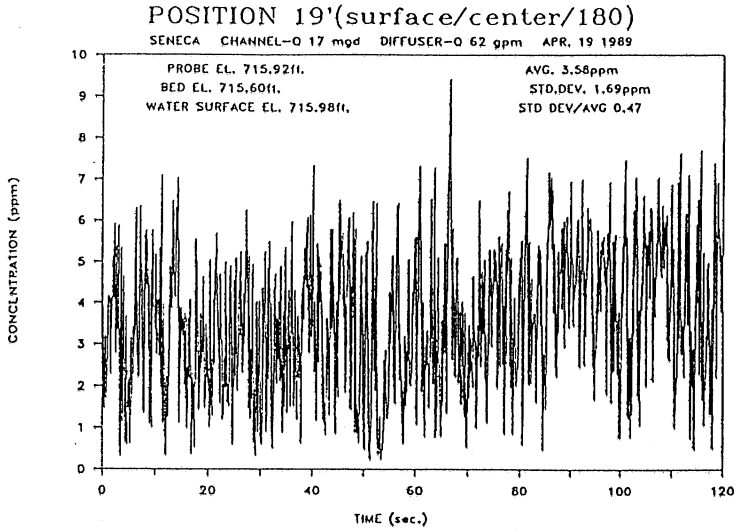

POSITION 19'(mid-depth/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.79ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 4.49ppm
STD.DEV. 1.31ppm
STD. DEV/AVG 0.29
CONCENTRATION (ppm)
TIME (sec.)

Fig. IV–1. Cont.


POSITION 19'(surface/center/180)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.92ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 3.58ppm
STD.DEV. 1.69ppm
STD DEV/AVG 0.47
CONCENTRATION (ppm)
TIME (sec.)

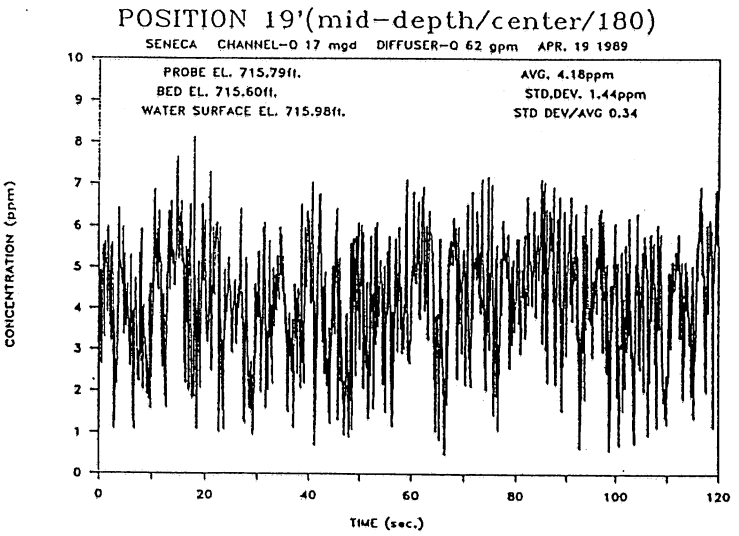
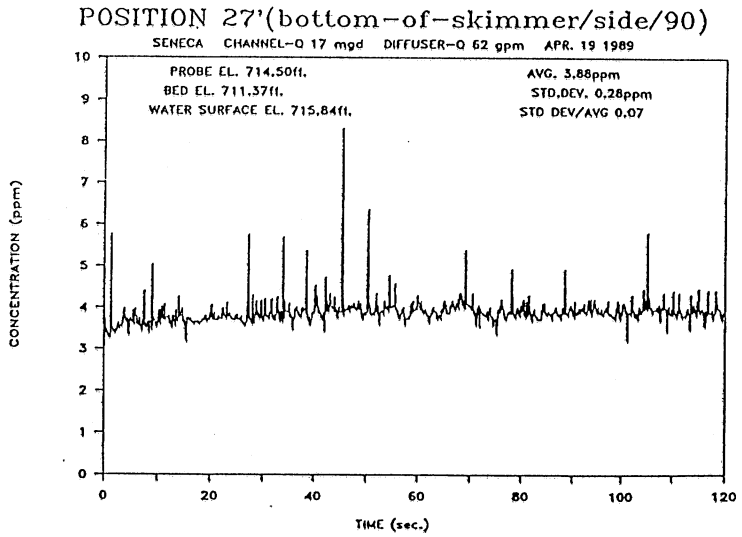

POSITION 19'(mid-depth/center/180)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.79ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 4.18ppm
STD.DEV. 1.44ppm
STD DEV/AVG 0.34
CONCENTRATION (ppm)
TIME (sec.)

Fig. IV–1. Cont.


POSITION 27'(bottom-of-skimmer/side/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 714.50ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.84ft.
AVG. 3.88ppm
STD.DEV. 0.28ppm
STD DEV/AVG 0.07
CONCENTRATION (ppm)
TIME (sec.)

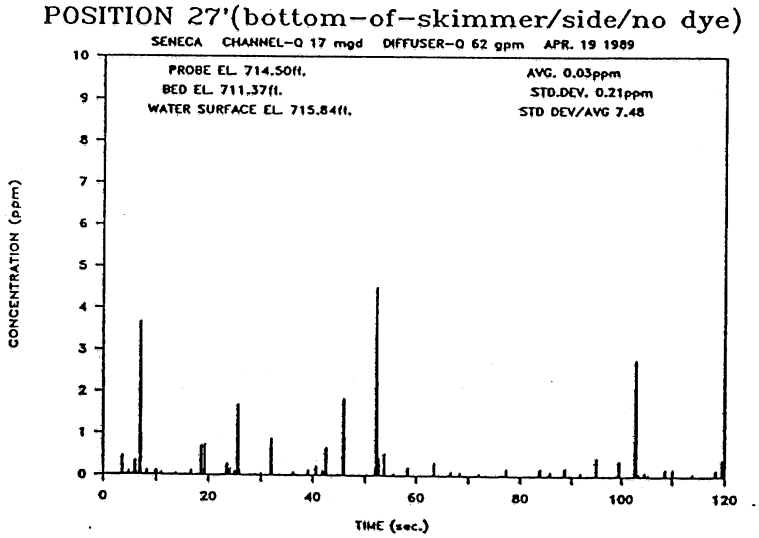
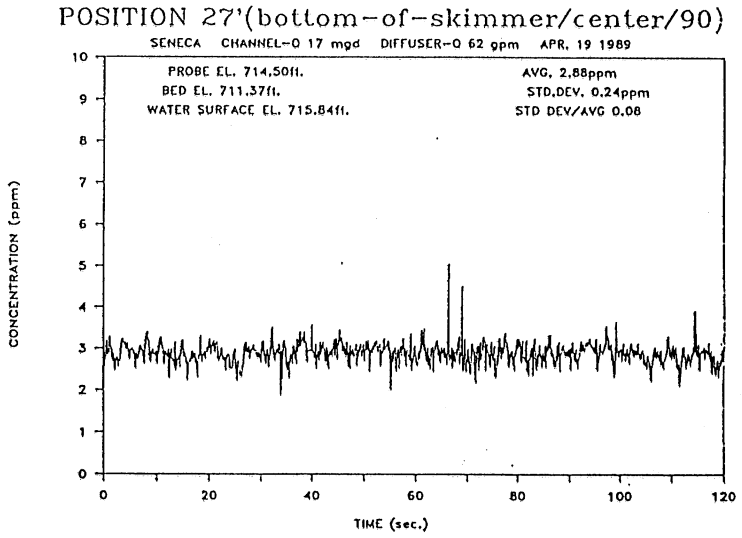

POSITION 27'(bottom-of-skimmer/side/no dye)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 714.50ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.84ft.
AVG. 0.03ppm
STD.DEV. 0.21ppm
STD DEV/AVG 7.48
CONCENTRATION (ppm)
TIME (sec.)

Fig. IV–1. Cont.


POSITION 27'(bottom-of-skimmer/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 714.50ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.84ft.
AVG. 2.88ppm
STD.DEV. 0.24ppm
STD DEV/AVG 0.08
CONCENTRATION (ppm)
TIME (sec.)

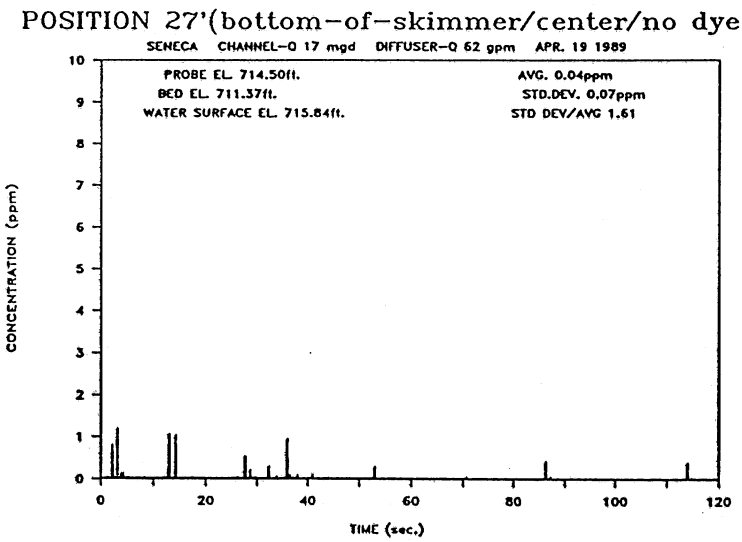
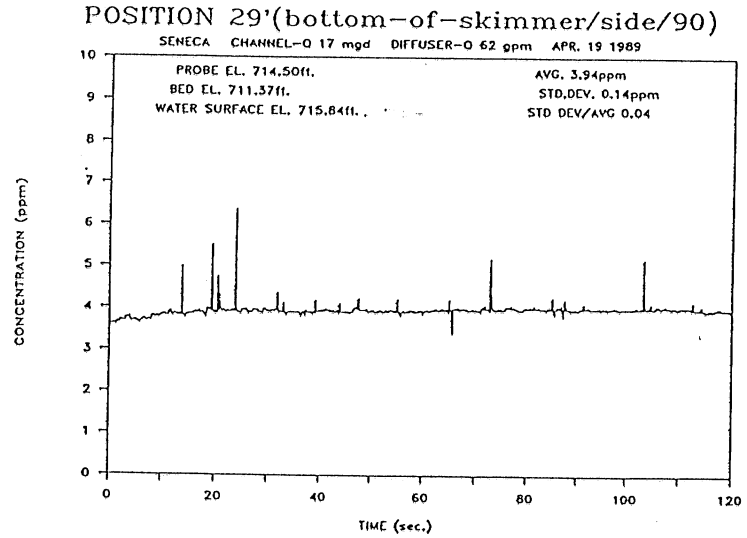
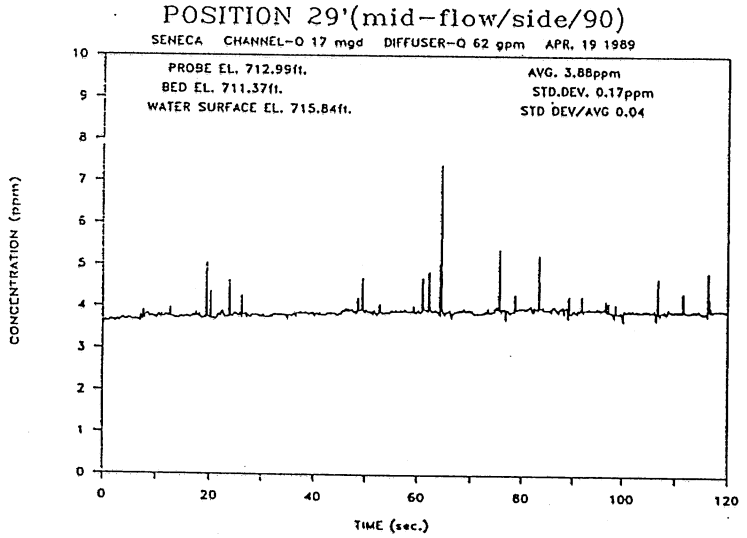

POSITION 27'(bottom-of-skimmer/center/no dye)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 714.50ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.84ft.
AVG. 0.04ppm
STD.DEV. 0.07ppm
STD DEV/AVG 1.61
CONCENTRATION (ppm)
TIME (sec.)

Fig. IV–1. Cont.


POSITION 29'(bottom-of-skimmer/side/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 714.50ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.84ft.
AVG. 3.94ppm
STD.DEV. 0.14ppm
STD DEV/AVG 0.04
CONCENTRATION (ppm)
TIME (sec.)


POSITION 29'(mid-flow/side/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 712.99ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.84ft.
AVG. 3.88ppm
STD.DEV. 0.17ppm
STD DEV/AVG 0.04
CONCENTRATION (ppm)
TIME (sec.)

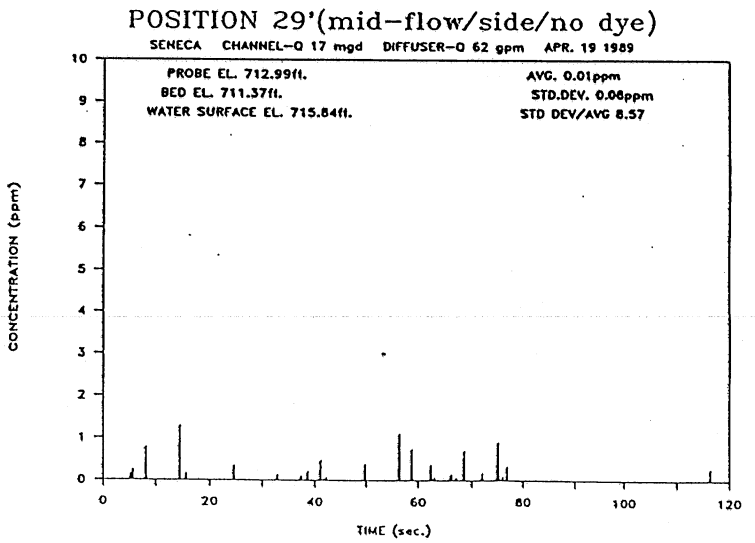
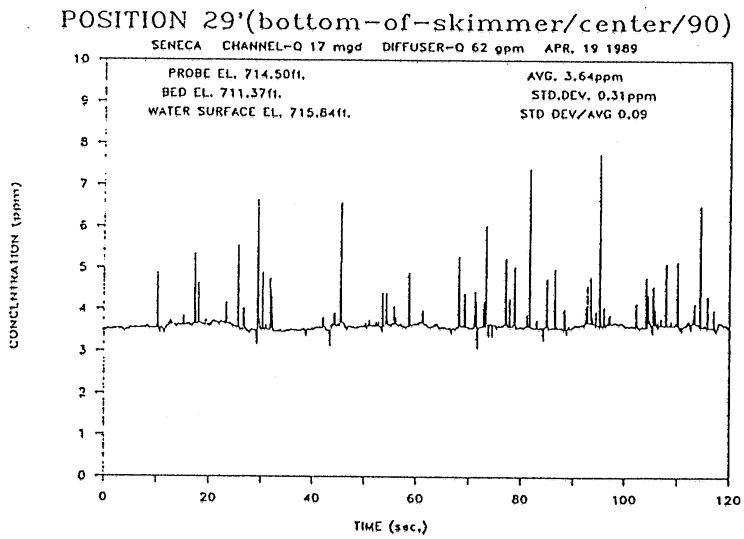
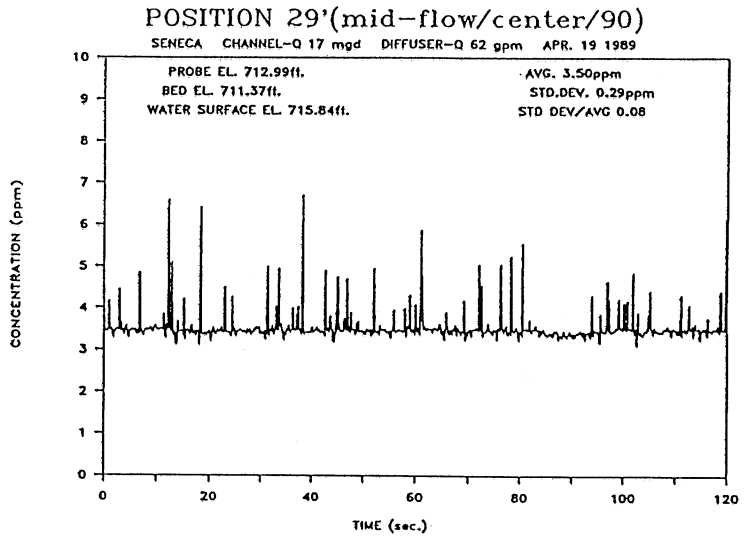

POSITION 29'(mid-flow/side/no dye)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 712.99ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.84ft.
AVG. 0.01ppm
STD.DEV. 0.08ppm
STD DEV/AVG 8.57
CONCENTRATION (ppm)
TIME (sec.)

Fig. IV–1. Cont.


POSITION 29'(bottom-of-skimmer/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 714.50ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.84ft.
AVG. 3.64ppm
STD.DEV. 0.31ppm
STD DEV/AVG 0.09
CONCENTRATION (ppm)
TIME (sec.)


POSITION 29'(mid-flow/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 712.99ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.84ft.
AVG. 3.50ppm
STD.DEV. 0.29ppm
STD DEV/AVG 0.08
CONCENTRATION (ppm)
TIME (sec.)

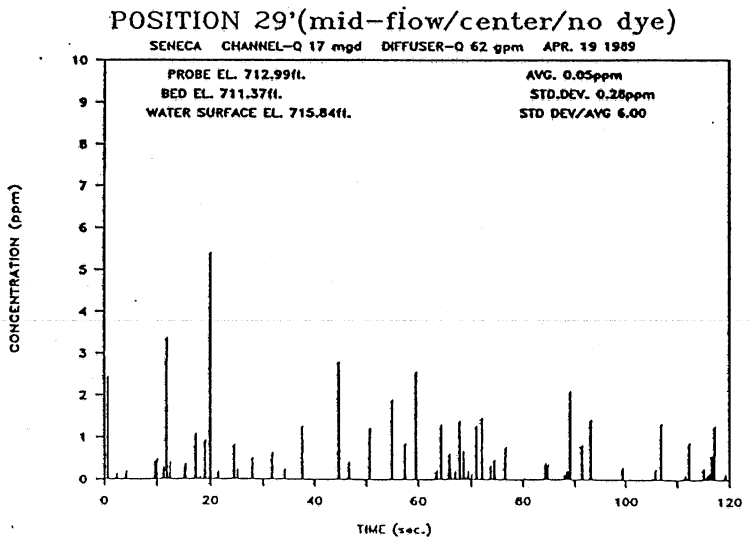
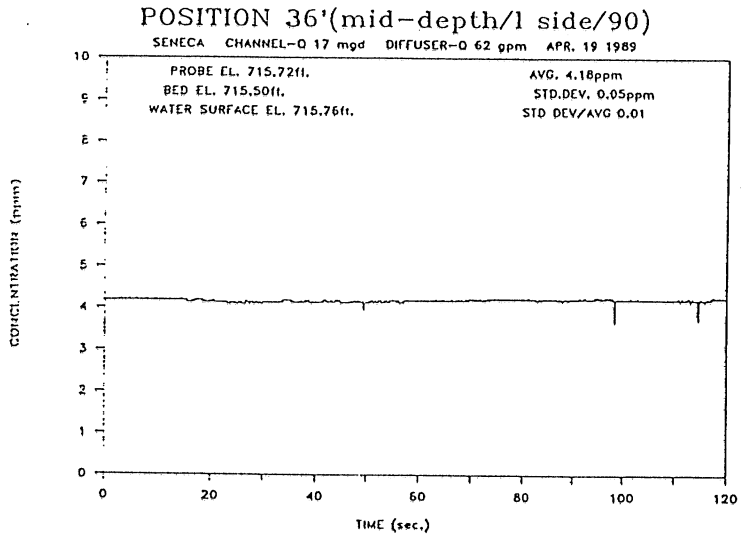
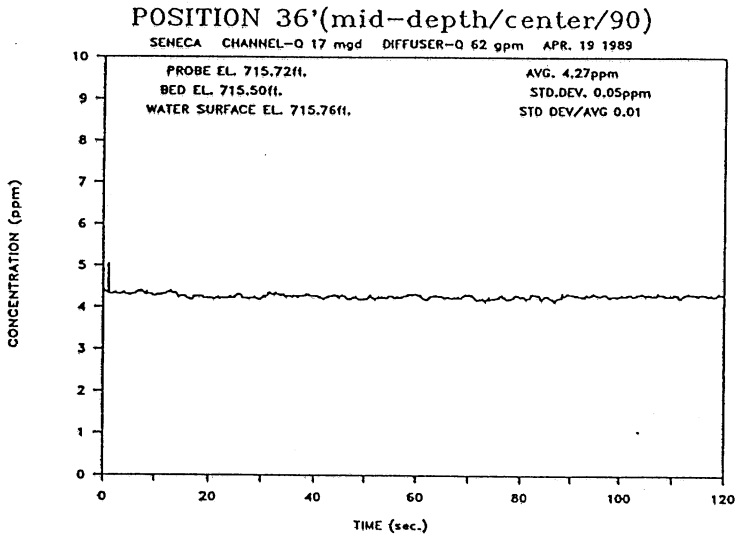

POSITION 29'(mid-flow/center/no dye)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 712.99ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.84ft.
AVG. 0.05ppm
STD.DEV. 0.28ppm
STD DEV/AVG 6.00
CONCENTRATION (ppm)
TIME (sec.)

Fig. IV–1. Cont.


POSITION 36'(mid-depth/l side/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.72ft.
BED EL. 715.50ft.
WATER SURFACE EL. 715.76ft.
AVG. 4.18ppm
STD.DEV. 0.05ppm
STD DEV/AVG 0.01
CONCENTRATION (ppm)
TIME (sec.)


POSITION 36'(mid-depth/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.72ft.
BED EL. 715.50ft.
WATER SURFACE EL. 715.76ft.
AVG. 4.27ppm
STD.DEV. 0.05ppm
STD DEV/AVG 0.01
CONCENTRATION (ppm)
TIME (sec.)

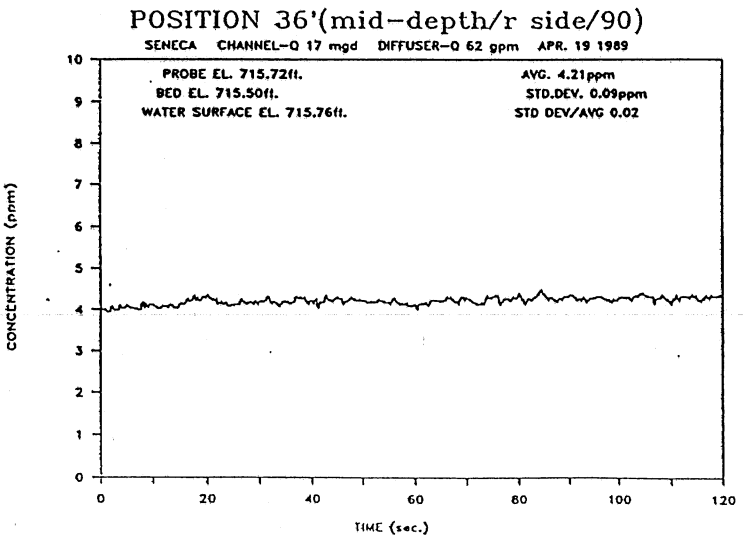

POSITION 36'(mid-depth/r side/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.72ft.
BED EL. 715.50ft.
WATER SURFACE EL. 715.76ft.
AVG. 4.21ppm
STD.DEV. 0.09ppm
STD DEV/AVG 0.02
CONCENTRATION (ppm)
TIME (sec.)

Fig. IV–1. Cont.

x = 27 ft (prior to skimmerwall): The incoming flow remains near the surface, as a surface jet, until it encounters the skimmerwall. At this point it descends and forms vortices along the side walls. Air bubbles are entrained by the turbulent action resulting from the impact of the "surface jet" on the skimmerwall and shows up as "spikes" in the concentration records.

x = 29 ft (after skimmerwall): A significant reduction of concentration fluctuations has occurred. "Spikes" still occur due to the entrained air bubbles.

x = 36 ft (at first cascade): The concentrations are very uniform.

C. DATA ANALYSIS

To condense and interpret the data further a mean concentration and a standard deviation of the concentration fluctuation around the mean were calculated. The clean river water reference values, given in Table IV–1, were subtracted from this calculation. The resulting mean concentrations were labelled C_{sr}, C_{mr}, and C_{br}. The standard deviations were called DEV_s, DEV_m, and DEV_b. The subscripts designate surface ($_s$), mid–depth ($_m$), and bottom ($_b$), respectively. The most interesting information is the ratio (DEV/C) because it relates the fluctuations of concentration to the mean concentration. Its value was also calculated for all positions, and is shown on the concentration records.

Table IV–2 compiles the above parameters for all locations under all flow conditions tested. The designations C, S, L, and R, such as in S6, R36, etc., refer to the center, side (symmetry of concentrations is assumed), left side, and right side of the channel, respectively. The progressive mixing in the downstream direction is evident from the numbers.

To facilitate the interpretation of these results, a graphical presentation of the ratios (DEV/C) is given in Fig. IV–2. The laboratory experiments indicate that mixing of the injected SO_2 solution occurs more rapidly at low flow than at high flow. At the higher channel flowrates some (DEV/C) surface values at x = 6 ft are very low. This occurs because the SO_2–jet has not yet reached the surface at this downstream location. It is not an indication of good mixing.

Depth–averaged values of (DEV/C) are summarized in Table IV–3. At x = 6 ft concentration fluctuations are still substantial. Further mixing occurs throughout the Parshall flume. Over the first cascade the fluctuations are reduced to 8 percent or less.

TABLE IV–1. Concentration Reference Values Used for River Water

Q_d (gpm)	Q_w (mgd)			
	11	17	34	42.5
62	0.152	0.082	0.093	–0.190

TABLE IV–2. Mean Concentration (ppm) and Standard Deviation of Fluctuations (ppm)

Channel Diffuser	11 mgd 62 gpm					
angle (°) x (ft)	54 S6	C6	90 S6	C6	180 S6	C6
C_{sr}	3.42	0.91	2.11	0.65	3.71	1.30
C_{mr}	2.54	2.50	2.82	2.17	3.37	2.11
C_{br}	2.04	1.86	2.90	2.41	2.35	2.75
DEV_s	1.14	1.08	0.85	0.77	1.00	1.11
DEV_m	0.97	0.86	0.93	0.77	1.13	0.82
DEV_b	1.09	0.83	1.15	0.71	0.85	0.69
DEV_s/C_{sr}	0.33	1.19	0.40	1.18	0.27	0.85
DEV_m/C_{mr}	0.38	0.35	0.33	0.36	0.33	0.39
DEV_b/C_{br}	0.54	0.45	0.40	0.29	0.36	0.25
Ave DEV/C	0.42	0.66	0.38	0.61	0.32	0.50
X–Sect Ave DEV/C	0.54		0.50		0.41	
C Ave	2.67	1.76	2.61	1.74	3.48	2.05
X–Sect Ave C	2.21		2.17		2.76	

Channel Diffuser	11 mgd 62 gpm						
angle (°) x (ft)	90 S19	54 C19	90 C19	180 C19	90 L36	C36	R36
C_{sr}	2.90	1.90	2.26	2.57			
C_{mr}	2.97	2.42	2.40	2.41	2.83	3.23	3.20
C_{br}	2.38						
DEV_s	0.40	0.67	0.53	0.52			
DEV_m	0.43	0.52	0.42	0.59	0.22	0.06	0.13
DEV_b	0.46						
DEV_s/C_{sr}	0.14	0.35	0.23	0.20			
DEV_m/C_{mr}	0.14	0.22	0.18	0.24	0.08	0.02	0.04
DEV_b/C_{br}	0.19						
Ave DEV/C	0.16	0.29	0.20	0.22	0.08	0.02	0.04
C Ave	2.75	2.16	2.33	1.74	2.83	3.23	3.20
X–Sect Ave C						3.09	

TABLE IV–2. Mean Concentration (ppm) and Standard Deviation of Fluctuations (ppm) (Cont'd)

Channel Diffuser	17 mgd 62 gpm					
angle (°) x (ft)	54 S6	C6	90 S6	C6	180 S6	C6
C_{sr}	2.83	0.55	3.62	0.64	4.16	1.08
C_{mr}	2.40	3.28	4.03	4.32	4.17	4.58
C_{br}	2.56	3.68	3.80	2.36	3.67	4.36
DEV_s	1.56	1.24	1.39	1.02	1.27	1.41
DEV_m	1.48	2.20	1.45	1.61	1.55	1.82
DEV_b	1.34	1.61	1.47	1.42	1.24	1.54
DEV_s/C_{sr}	0.55	2.27	0.38	1.60	0.30	1.31
DEV_m/C_{mr}	0.62	0.67	0.36	0.37	0.37	0.40
DEV_b/C_{br}	0.52	0.44	0.39	0.60	0.34	0.35
Ave DEV/C	0.56	1.13	0.38	0.86	0.34	0.69
X–Sect Ave DEV/C	0.84		0.62		0.51	
C Ave	2.60	2.50	3.82	2.44	4.00	3.34
X–Sect Ave C	2.55		3.13		3.67	

Channel Diffuser	17 mgd 62 gpm						
angle (°) x (ft)	90 S19	54 C19	90 C19	180 C19	90 L36	C36	R36
C_{sr}	6.52	2.15	3.58	3.58			
C_{mr}	6.33	3.99	4.49	4.18	4.18	4.27	4.21
C_{br}	5.25						
DEV_s	0.86	0.97	1.36	1.69			
DEV_m	1.08	1.30	1.31	1.44	0.05	0.05	0.09
DEV_b	0.83						
DEV_s/C_{sr}	0.13	0.45	0.38	0.47			
DEV_m/C_{mr}	0.17	0.33	0.29	0.34	0.01	0.01	0.02
DEV_b/C_{br}	0.15						
Ave DEV/C	0.15	0.39	0.34	0.40	0.01	0.01	0.02
C Ave	6.03	3.07	4.04	3.88	4.18	4.27	4.21
X–Sect Ave C						4.22	

TABLE IV–2. Mean Concentration (ppm) and Standard Deviation of Fluctuations (ppm) (Cont'd)

Channel Diffuser	34 mgd 62 gpm					
angle (°) x (ft)	54 S6	C6	90 S6	C6	180 S6	C6
C_{sr}	2.18	0.20	2.01	0.04	1.84	0.09
C_{mr}	1.35	0.47	1.30	0.45	1.26	0.75
C_{br}	1.74	2.19	1.68	1.73	1.49	2.01
DEV_s	1.10	0.30	0.77	0.09	0.61	0.07
DEV_m	0.92	0.61	0.74	0.63	0.82	0.72
DEV_b	0.90	0.84	0.81	0.78	0.81	0.71
DEV_s/C_{sr}	0.50	1.48	0.38	2.01	0.33	0.79
DEV_m/C_{mr}	0.68	1.29	0.57	1.39	0.65	0.97
DEV_b/C_{br}	0.52	0.38	0.48	0.45	0.54	0.35
Ave DEV/C	0.57	1.05	0.48	1.28	0.51	0.70
X–Sect Ave DEV/C	0.81		0.88		0.61	
C Ave	1.76	0.95	1.66	0.74	1.53	0.95
X–Sect Ave C	1.36		1.20		1.24	

Channel Diffuser	34 mgd 62 gpm						
angle (°) x (ft)	90 S19	54 C19	90 C19	180 C19	90 L36	C36	R36
C_{sr}	2.83	0.73	0.83	0.75			
C_{mr}	2.65	1.29	1.35	1.47		2.87	2.89
C_{br}	2.46						
DEV_s	0.61	0.78	0.64	0.67			
DEV_m	1.01	0.94	0.87	1.01		0.07	0.12
DEV_b	0.72						
DEV_s/C_{sr}	0.22	1.07	0.76	0.89			
DEV_m/C_{mr}	0.38	0.72	0.65	0.68		0.03	0.04
DEV_b/C_{br}	0.29						
Ave DEV/C	0.30	0.90	0.70	0.78		0.03	0.04
C Ave	2.65	1.01	1.09	1.11		2.87	2.89
X–Sect Ave C						2.88	

TABLE IV–2. Mean Concentration (ppm) and Standard Deviation of Fluctuations (ppm) (Cont'd)

Channel	42.5 mgd					
Diffuser	62 gpm					
angle (°)	54		90		180	
x (ft)	S6	C6	S6	C6	S6	C6
C_{sr}	3.60	0.23	1.13	0.24	1.11	0.26
C_{mr}	1.98	0.45	0.69	0.47	0.62	0.57
C_{br}	1.25	5.97	1.17	3.75	0.90	4.11
DEV_s	1.88	0.01	0.53	0.04	0.54	0.35
DEV_m	1.61	0.63	0.50	0.81	0.38	0.98
DEV_b	0.71	3.05	0.74	1.95	0.60	1.57
DEV_s/C_{sr}	0.52	0.06	0.47	0.17	0.48	1.35
DEV_m/C_{mr}	0.82	1.42	0.73	1.72	0.61	1.71
DEV_b/C_{br}	0.57	0.51	0.64	0.52	0.67	0.38
Ave DEV/C	0.64	0.66	0.61	0.80	0.59	1.15
X–Sect Ave DEV/C	0.65		0.71		0.87	
C Ave	2.28	2.22	1.00	1.49	0.88	1.65
X–Sect Ave C	2.25		1.24		1.26	

Channel	42.5 mgd						
Diffuser	62 gpm						
angle (°)	90	54	90	180	90		
x (ft)	S19	C19	C19	C19	L36	C36	R36
C_{sr}	2.32	0.72	0.89	0.83			
C_{mr}	2.14	0.73	0.72	0.91		1.30	
C_{br}							
DEV_s	0.58	0.97	0.55	0.60			
DEV_m	0.68	0.54	0.51	0.62		0.07	
DEV_b							
DEV_s/C_{sr}	0.25	0.45	0.62	0.72			
DEV_m/C_{mr}	0.32	0.75	0.71	0.68		0.05	
DEV_b/C_{br}							
Ave DEV/C	0.28	0.60	0.66	0.70		0.05	
C Ave	2.23	0.72	0.80	0.87		1.30	

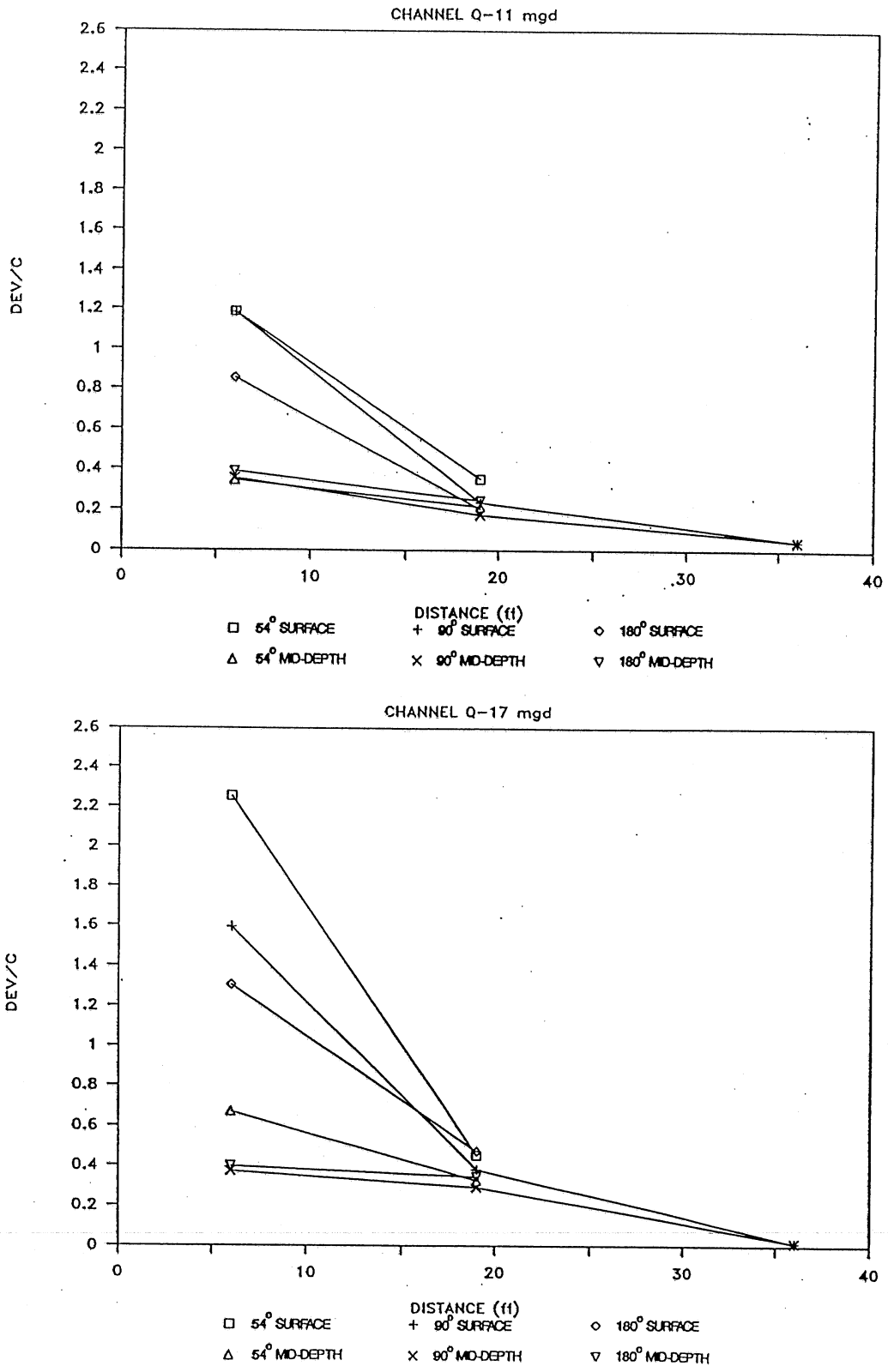
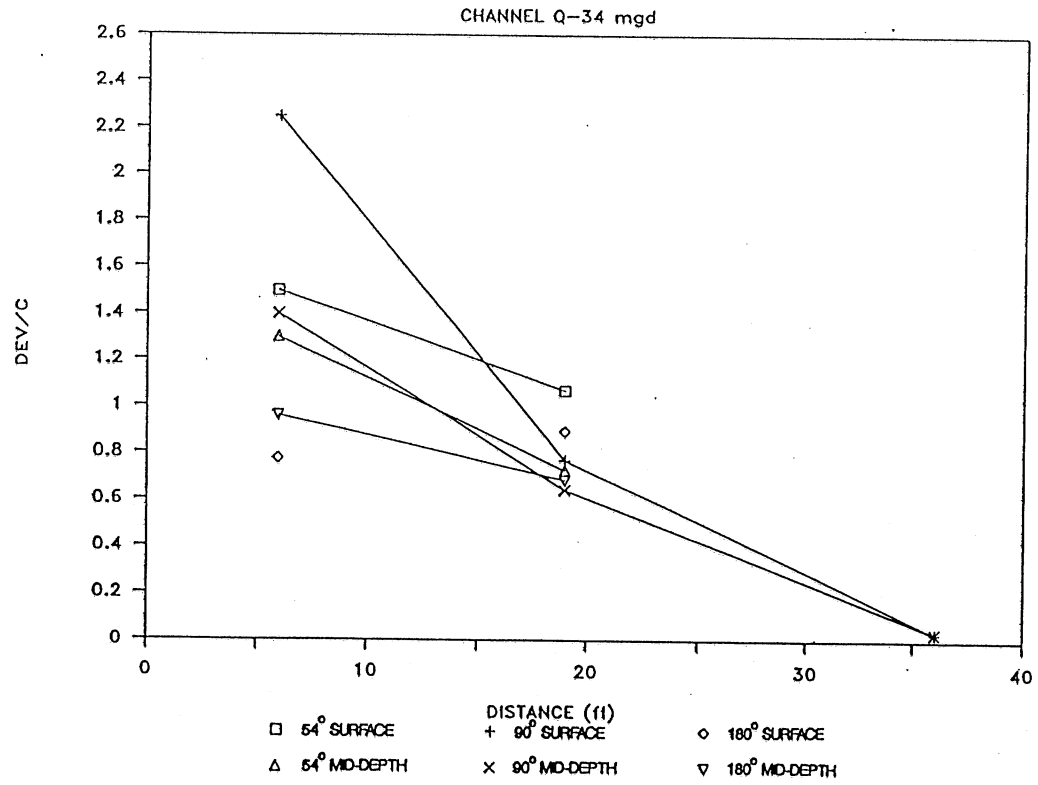


Fig. IV–2. (DEV/C) values versus distance.


CHANNEL Q-34 mgd
DEV/C
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
DISTANCE (ft)
□ 54° SURFACE
+ 90° SURFACE
◇ 180° SURFACE
△ 54° MID-DEPTH
× 90° MID-DEPTH
▽ 180° MID-DEPTH

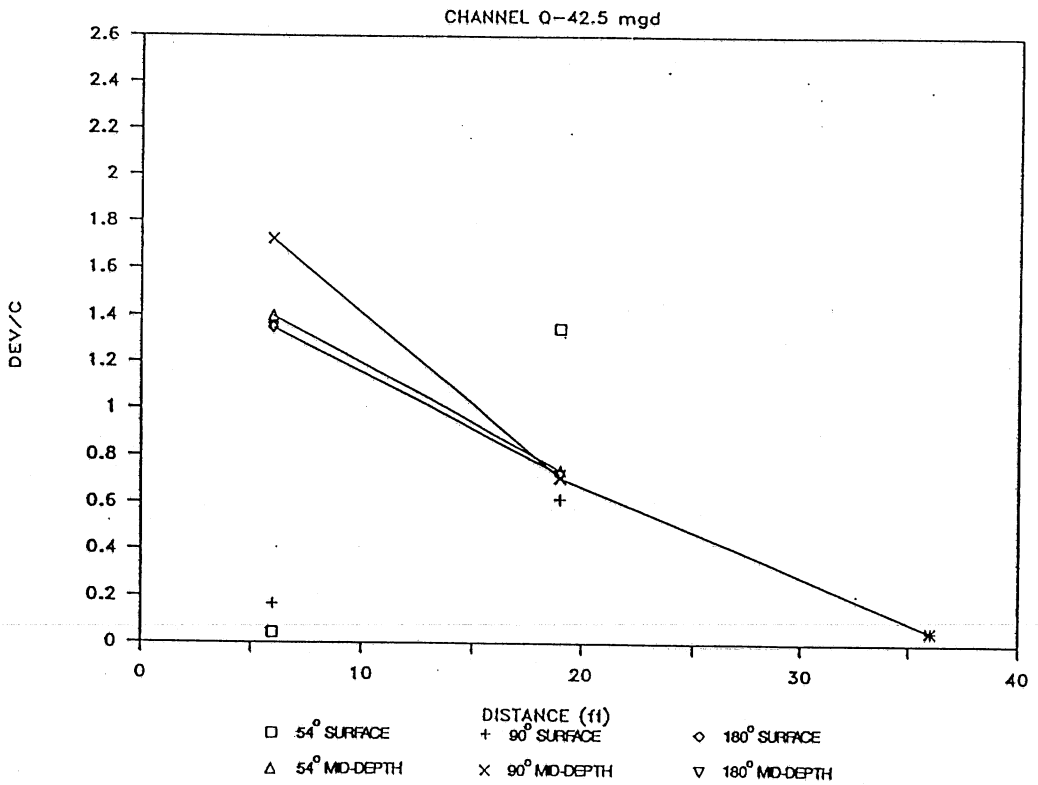

CHANNEL Q-42.5 mgd
DEV/C
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
DISTANCE (ft)
□ 54° SURFACE
+ 90° SURFACE
◇ 180° SURFACE
△ 54° MID-DEPTH
× 90° MID-DEPTH
▽ 180° MID-DEPTH

Fig. IV–2. Cont.

TABLE IV–3. Depth–Averaged (DEV/C) Symmetrical Flow

Angle	Q_w (mgd)			
(°)	11	17	34	42.5
At x = 6 ft				
		Left Side		
54	.42	.56	.57	.64
90	.38	.38	.48	.61
180	.32	.34	.51	.59
		Center		
54	.66	1.33	1.05	.66
90	.61	.86	1.28	.80
180	.50	.69	.70	1.15
At x = 19 ft				
		Left Side		
90	.16	.15	.30	.28
		Center		
54	.29	.39	.90	.60
90	.20	.34	.70	.66
180	.22	.40	.78	.70
At x = 36 ft				
		Left Side		
90	.08	.01		
		Center		
90	.02	.01	.03	.05
		Right Side		
90	.04	.02	.04	

V. OBSERVATIONS OF MIXING MECHANISMS

The dye concentrations (representing SO_2) measured and reported in the previous section are the result of several interacting or sequential processes which can be observed and better understood if dye is injected in the experimental facility and its spreading and mixing are observed visually. Such experiments were conducted using a single point dye injection at various locations in addition to the dye release from the manifold system representing the SO_2 diffuser. The following qualitative observations were made.

Starting at the diffuser and moving in a downstream direction, the following flow features contribute to turbulence and mixing:

1) Vertical diffuser jets discharged into a crossflow.

2) Flow separation at the leading edge of the channel.

3) Channel flow with turbulence generated on bed and side walls.

4) Flow through contraction and expansion of the Parshall flume.

5) Flow under skimmerwall forming a flow contraction and expansion.

A. VERTICAL DIFFUSER JETS

The vertical jets are turbulent. Their trajectories depend on the discharge to crossflow velocity ratios. The velocity ratios are approximately as given in the Table V–1. Figures V–1, V–2, and V–3 show the vertical mixing of the jets versus distance. Figures V–1, V–2, and V–3 are for 54°, 90°, and 180° injection angles, respectively. Also the top and bottom pictures of each figure are for channel flow rates of 11 and 42.5 mgd, respectively. All three figures are at an SO_2 flow rate of 62 gpm.

Table V–1. Jet Velocity to Cross–Flow Velocity Ratio (R)

Q_d (gpm)	Q_w (mgd)			
	11	17	34	42.5
62	12.87	9.15	5.93	5.16

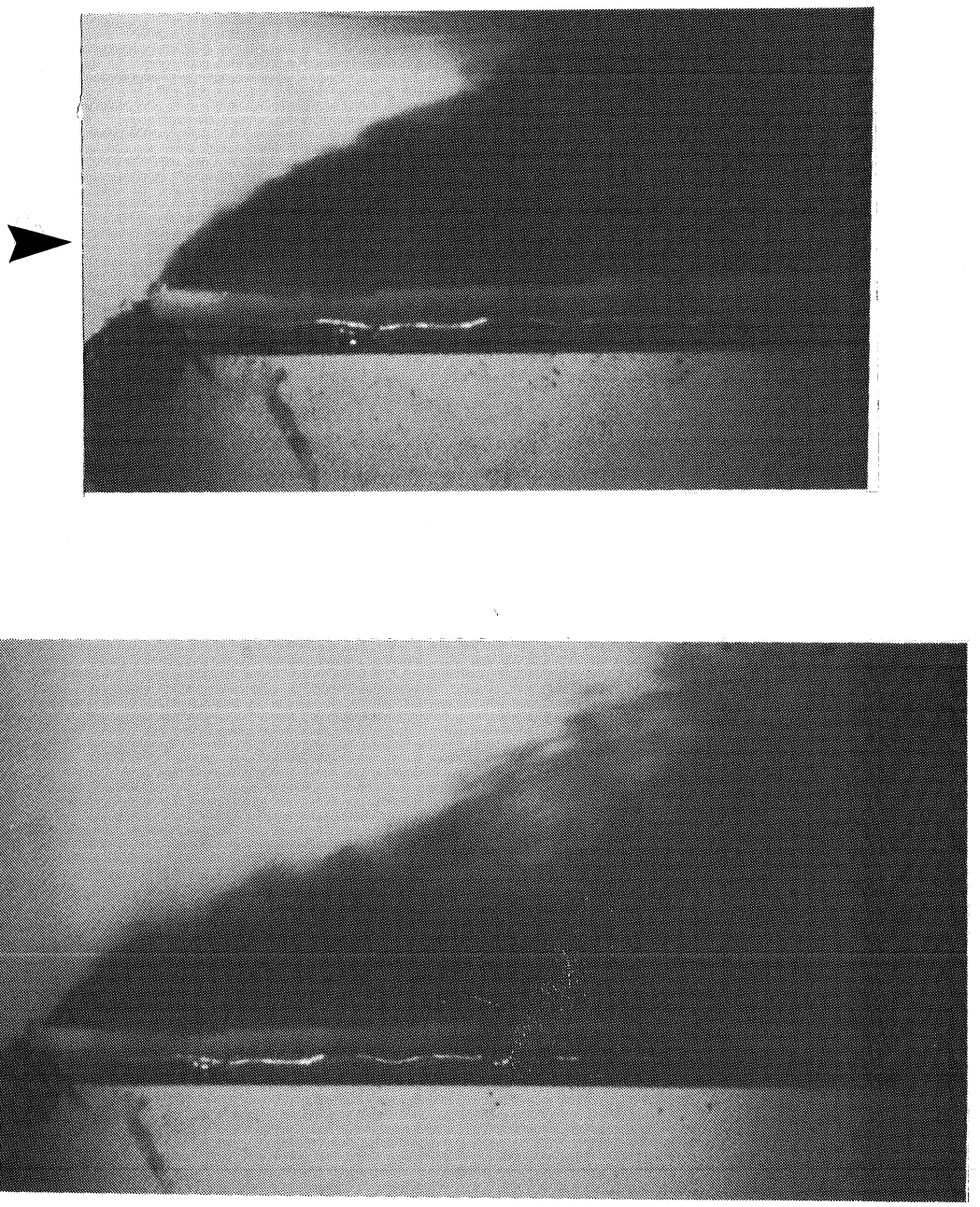


Fig. V–1. Side view of dye injection (54°).

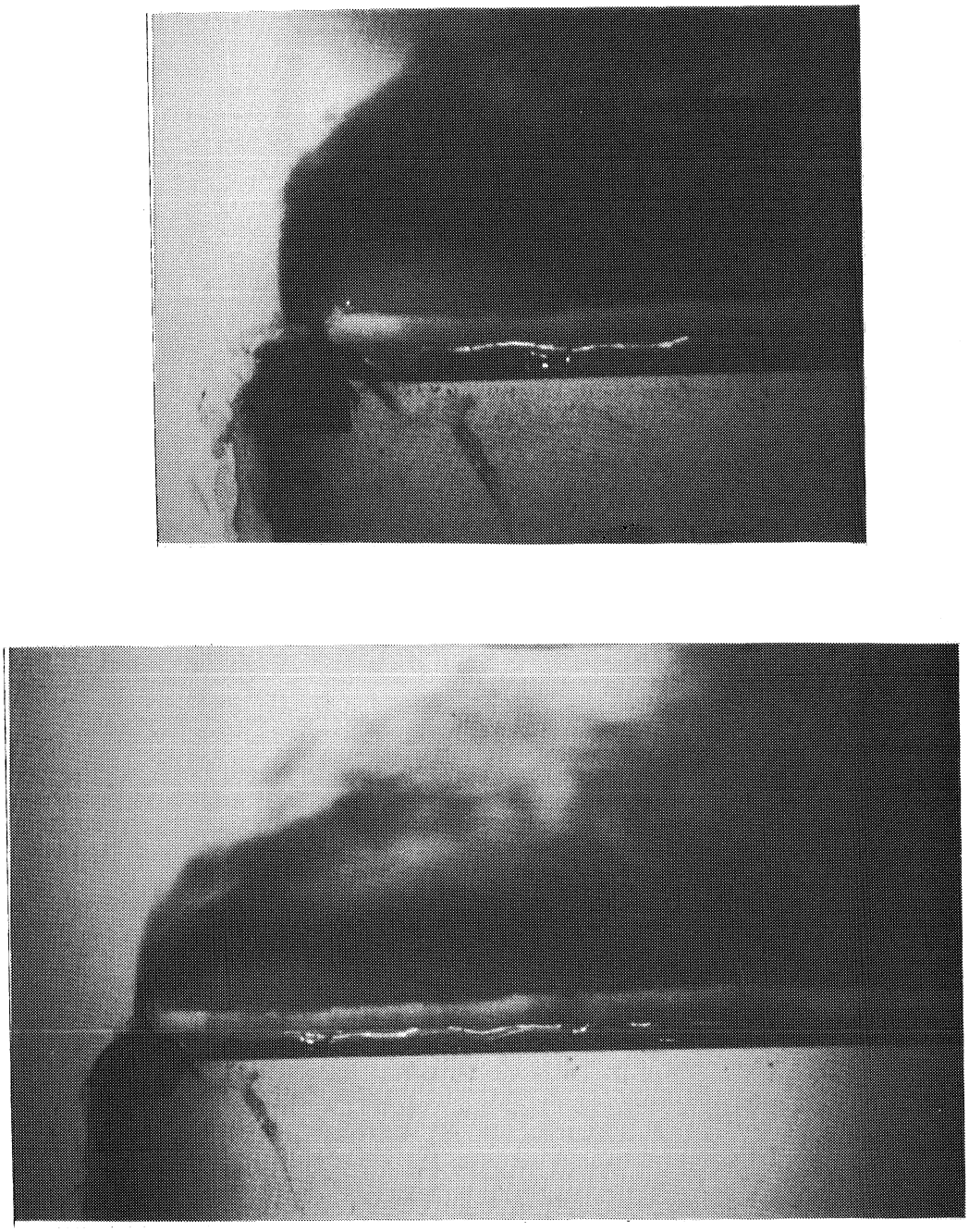


Fig. V–2. Side view of dye injection (90°).

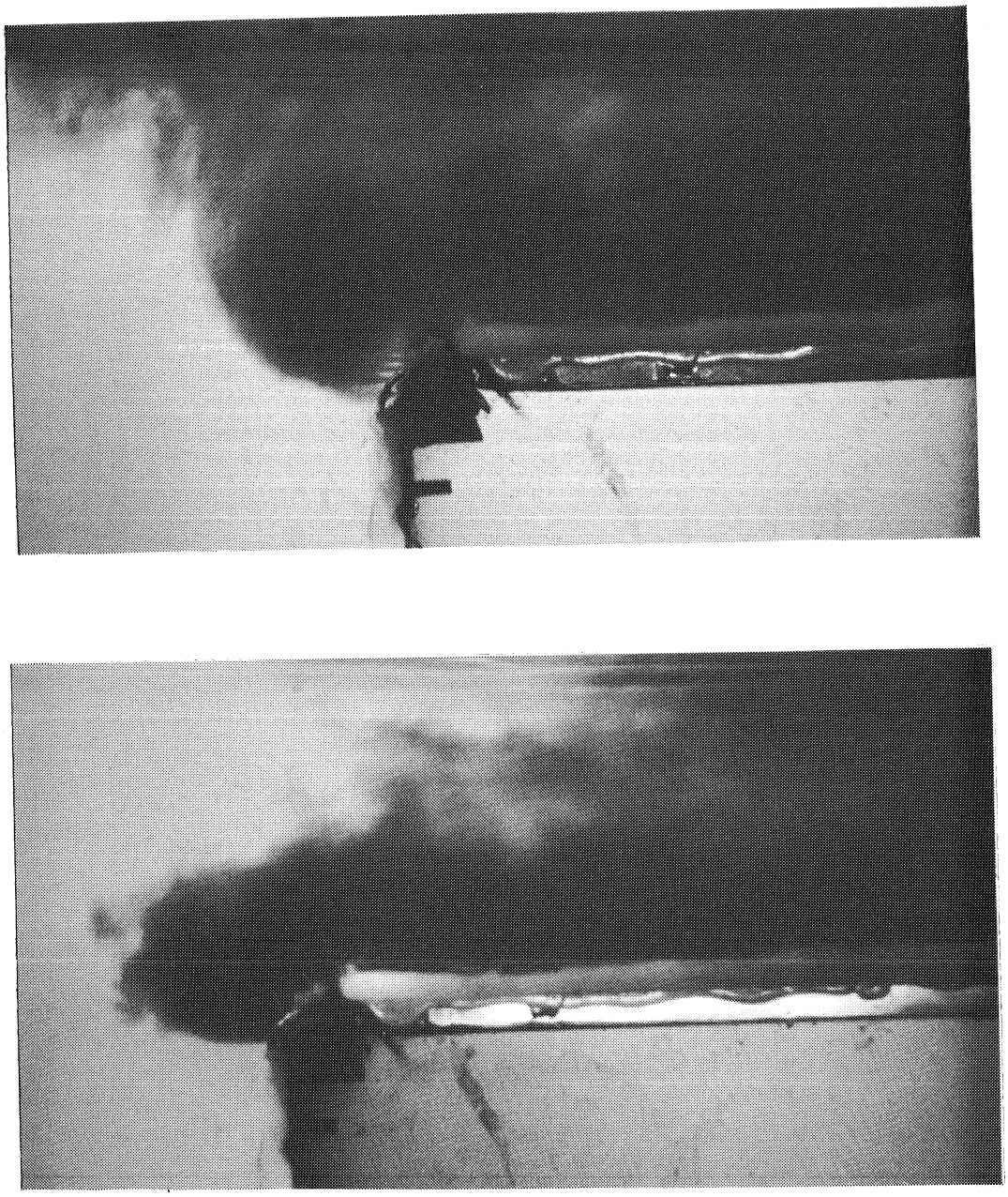


Fig. V–3. Side view of dye injection (180°).

It is very evident that the vertical distribution of the SO_2 is a) not uniform and b) highly variable with channel flow rate. At virtually all wastewater discharges tested, the SO_2 jets do not reach the water surface. This was already indicated by the concentration measurements. The SO_2 remains essentially near the channel bottom and is mixed vertically by the channel flow. Along the side of the channel the dye is more evenly distributed in the vertical direction due to a separation zone caused by the downstream contraction into the Parshall flume. This mode of SO_2 introduction is not ideal.

At high diffuser flow to channel flow ratios, the diffuser jet momentum is enough to distribute the dye (SO_2) vertically in the channel flow, before it reaches the x = 6 ft position. At lower diffuser flow to channel flow ratios, the jet momentum is not enough to accomplish the vertical distribution before the x = 6 ft position.

B. FRONT EDGE FLOW SEPARATION

The turbulence created by the front edge separation on the contact channel floor assists in the vertical mixing to ensure a good distribution of average concentrations by the x = 19 ft position (see concentration data). Although the average concentrations from bottom to surface are nearly the same, there remain, at this position, strong fluctuations of concentrations in time which are present for all flow rates.

The lateral distribution of dye (SO_2) is well accomplished by the diffuser. At high channel flow rates, there is visual evidence of lateral mixing under the jets caused by the separated flow region at the front edge of the channel.

C. CONTACT CHANNEL

In the channel, mixing is caused mainly by turbulence created by bed shear. Because the bed is fairly smooth, the turbulent mixing in the channel, both vertical and horizontal, is not impressive. This is shown in the concentration data for the 6 ft cross section. As a result the flow enters the Parshall flume not fully mixed.

Figures V–4, V–5, and V–6 show the mixing in the first 8 ft of the channel. With Q_w of 11 mgd for the top picture, and Q_w of 17 mgd for the bottom picture. Figure V–4 is for a 54° injection, while Figs. V–5 and V–6 are for 90° and 180° injections, respectively.

D. PARSHALL FLUME

In the contracting portion of the Parshall flume, turbulence is strained. In the expanding portion there is flow separation from the walls. There are standing waves on the surface. These regions contribute to transverse

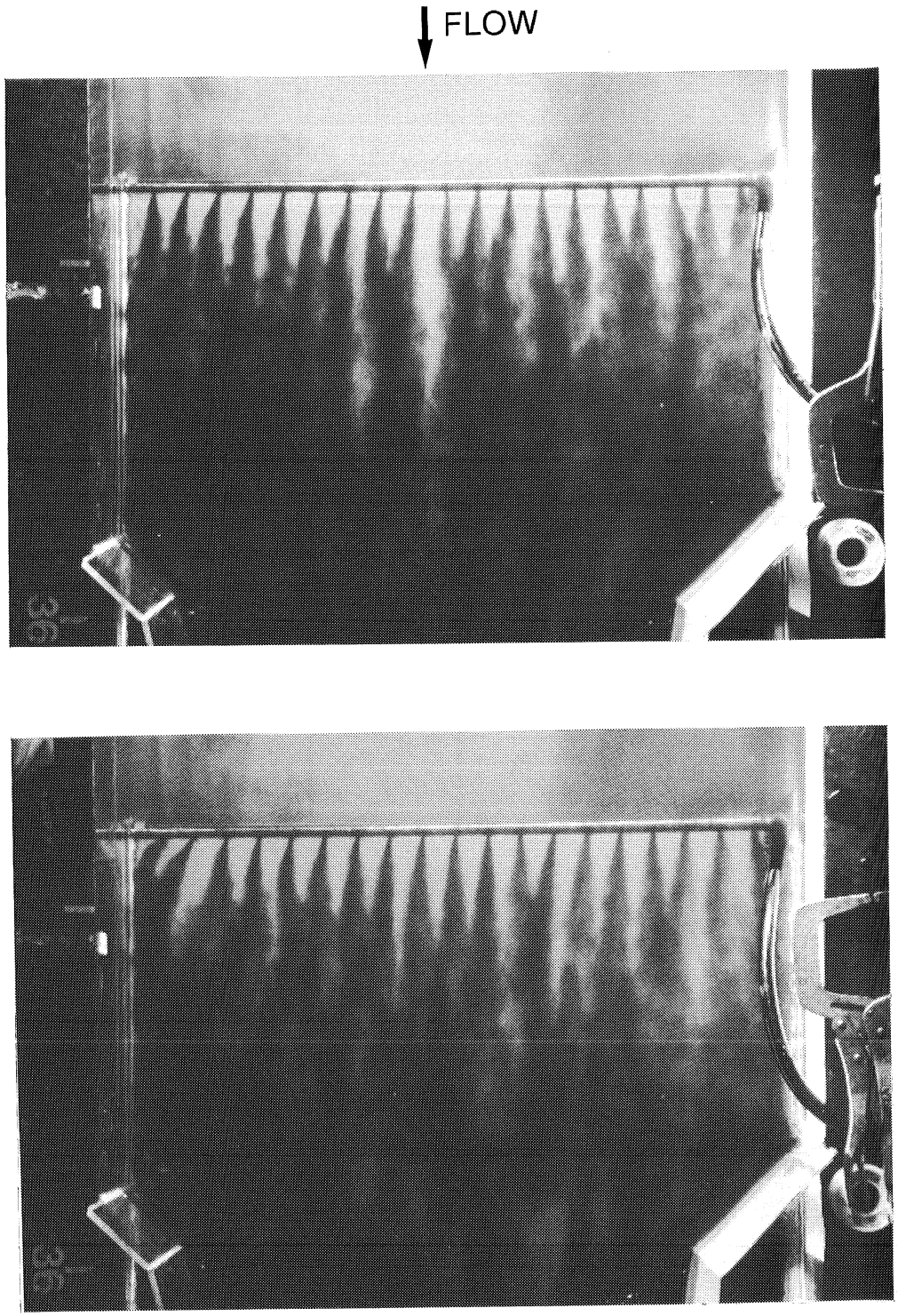


Fig. V–4. Top view of dye injection (54°).

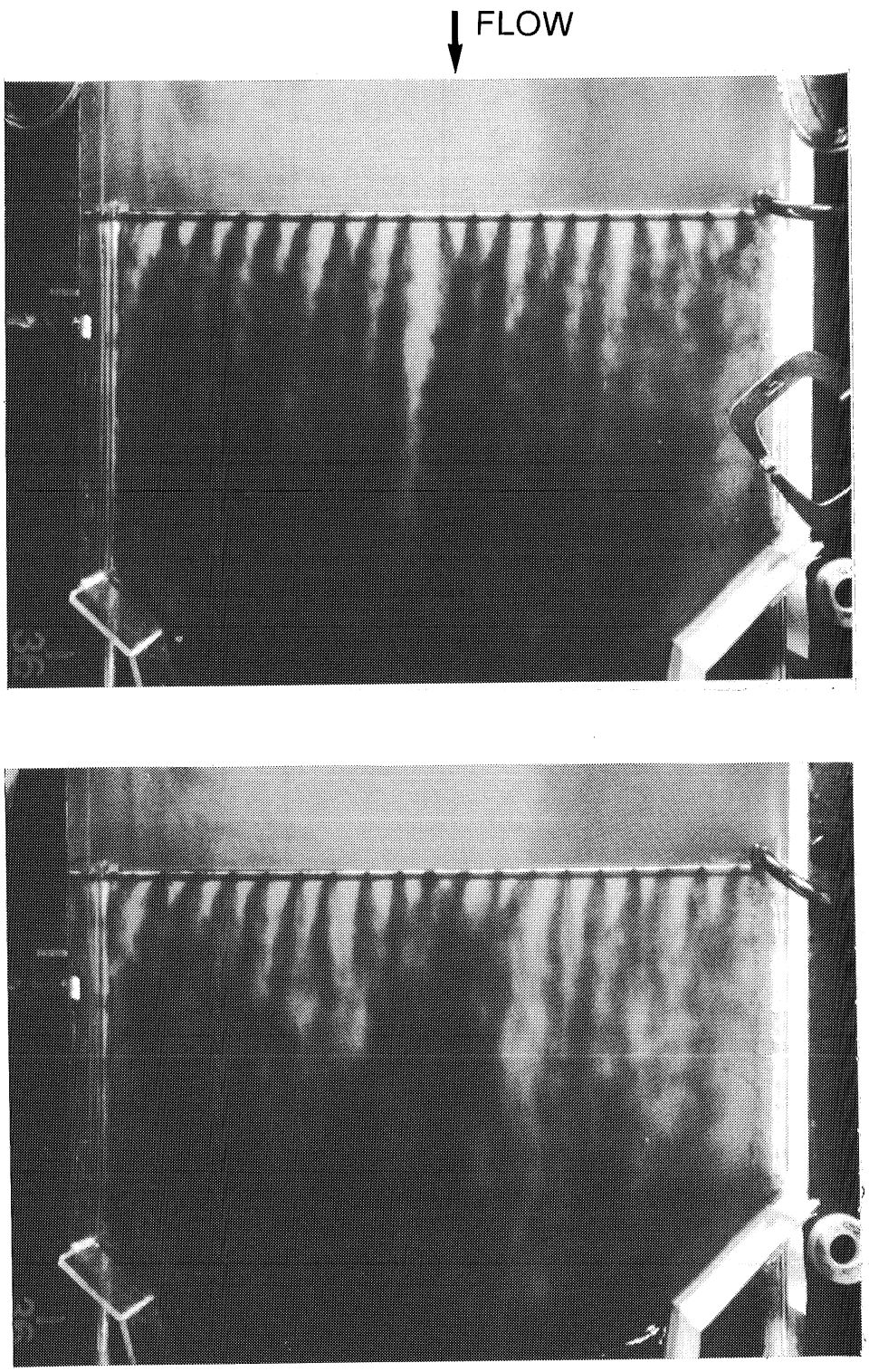


Fig. V–5. Top view of dye injection (90°).

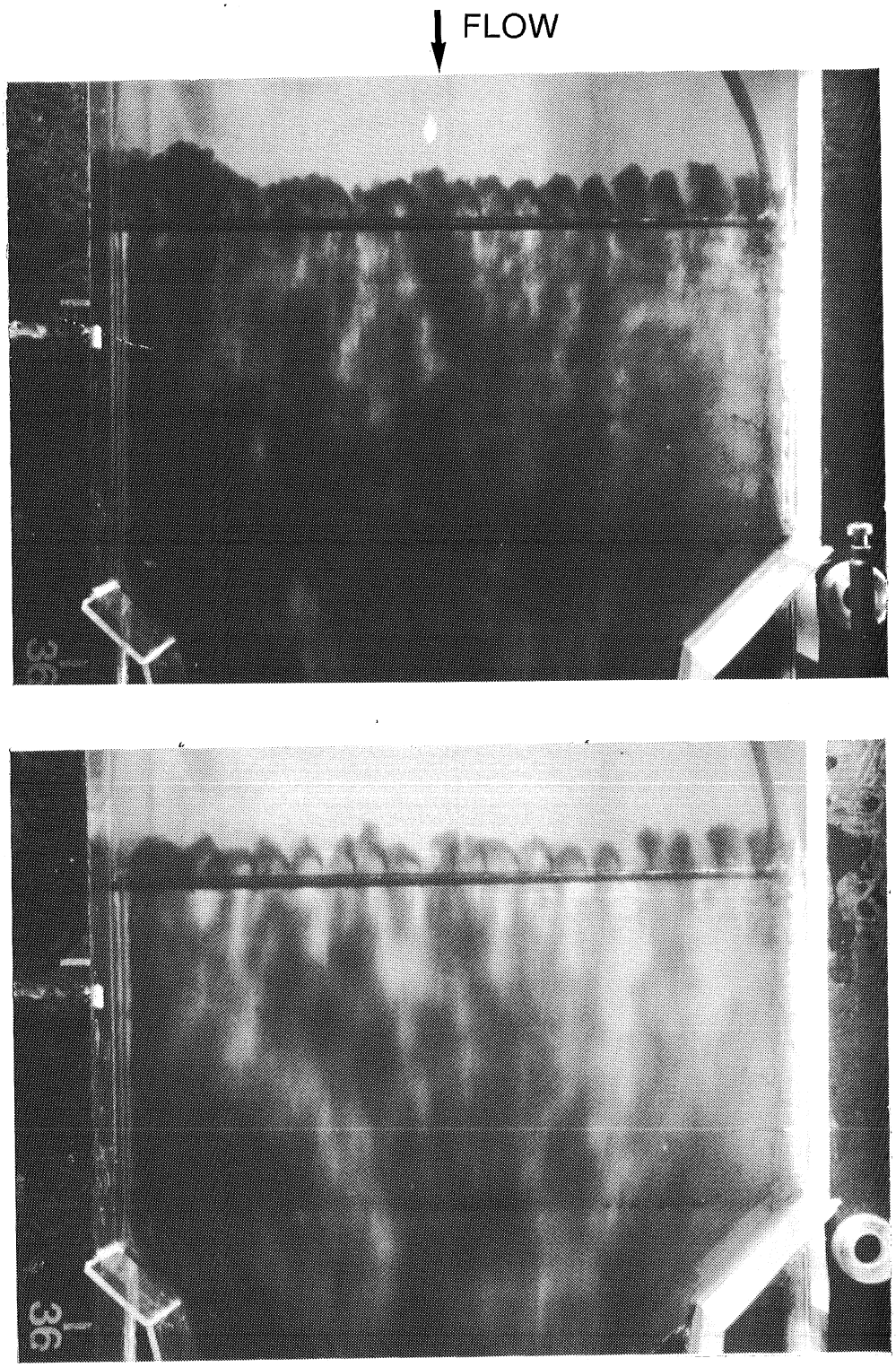


Fig. V–6. Top view of dye injection (180°).

distribution of dye and fine mixing in the vertical direction. The primary mechanisms for lateral mixing in this part of the channel are the separated flow regions created by the expansion at the 45 degree wing walls and the drop at the end of the Parshall flume expansion (Fig. V–7). A single jet of dye that is injected near the wall upstream from the separated regions, is distributed across half of the channel before reaching the skimmerwall. Additional observations have shown that a single jet of dye, when injected into the center of the Parshall flume section, is not as widely distributed before reaching the skimmerwall

E. CONTROL STRUCTURE

The control structure, or skimmerwall as it has been previously referred to, is of primary importance for mixing. The flow comes out of the Parshall flume along the surface until it is deflected downward by the skimmerwall. This mechanism forms a large roller in the basin between the Parshall flume and the skimmerwall. Associated with this are intense turbulent disturbances that lead to thorough mixing. A visual experiment was performed without the control structure in which case the flow continued uninterrupted across the top until it reached the first cascade. The presence of the control structure is important to deflect the surface flow downward and to create recirculation prior to any expansion in the channel. Under steady state flow conditions this provides a uniform flow towards the weir and greatly reduces concentration fluctuations in the cascade basin.

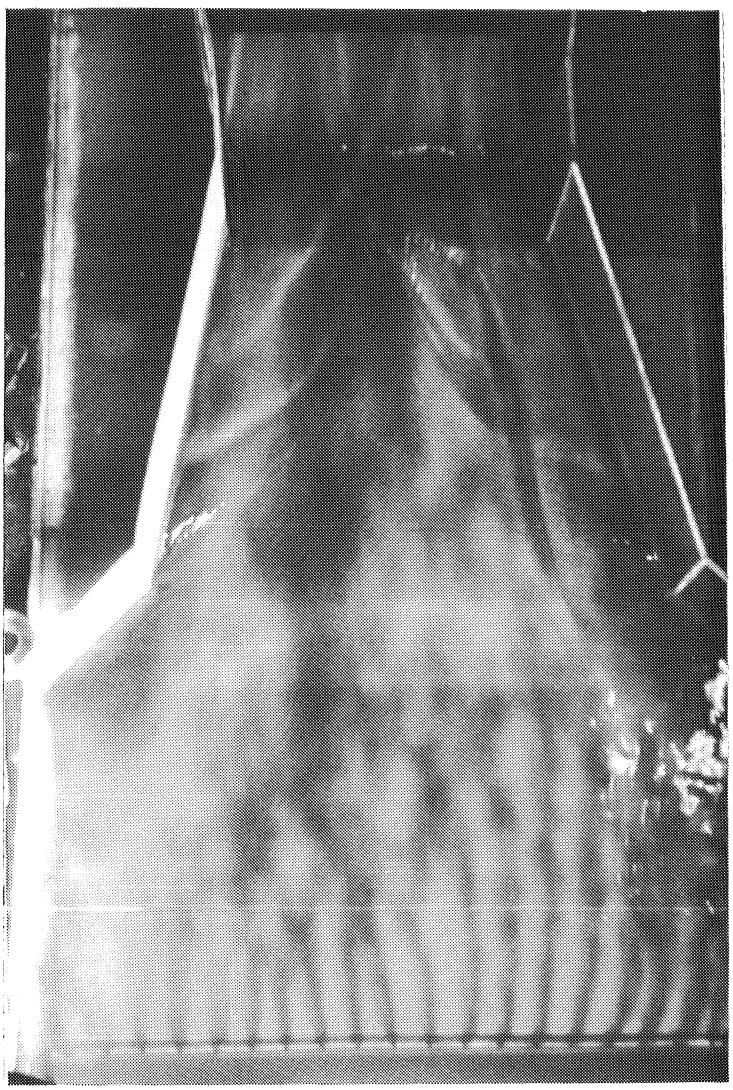


Fig. V–7. Flow in Parshall flume section.

VI. SUMMARY

1. Model experiments were conducted in a 1:5.8 geometrical scale model to determine the mixing of the SO_2 solution injected into the wastewater flow through a multiport diffuser. Dye was used to simulate the SO_2.

2. The manifold injection system provides a good lateral distribution of the SO_2 solution, but provides only a limited amount of mixing. At high wasteewater flows the SO_2 jets do not reach the water surface. When the SO_2 injection angle was adjusted from 54° to 90° and to 180°, mixing was improved slightly for most flows (Table IV–3).

3. Further mixing occurs in the Parshall flume, but at its exit (x = 19 ft) the standard deviation of the concentration fluctuations is still in a range from 20 to 90 percent of the mean value (Table IV–3). This indicates incomplete mixing in the Parshall flume.

4. At the first cascade (x = 36 ft) the dimensionless standard deviations of concentration fluctuations were reduced to 1 to 8 percent of mean concentrations indicating that mixing was near completion.

5. It would be possible to achieve complete mixing in the dechlorination channel. To do this the velocity of the jet discharged from the SO_2–manifold should be increased and roughness elements could be added to the channel. Without such measures, the Parshall flume and the following skimmerwall section can be relied upon for the mixing of the SO_2 with the wastewater. The skimmerwall is the most crucial element and its dimensions must not be altered without additional study.

APPENDIX A

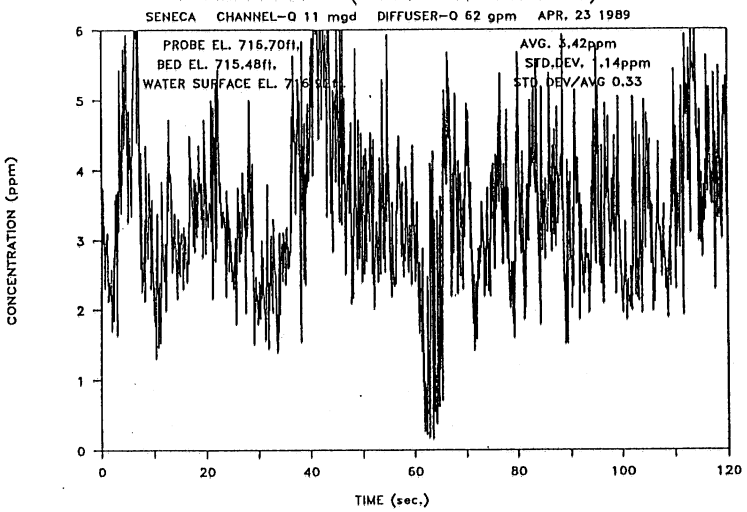
CONCENTRATION RECORDS

CONCENTRATION RECORDS

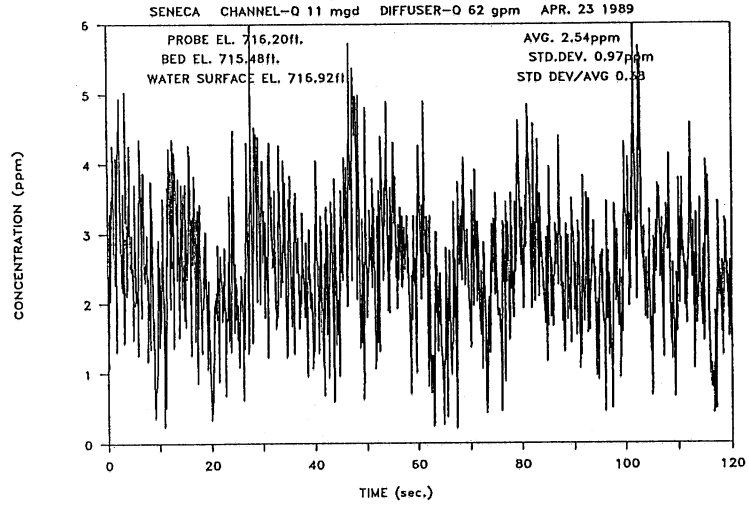
FOR

Q_w = 11 mgd

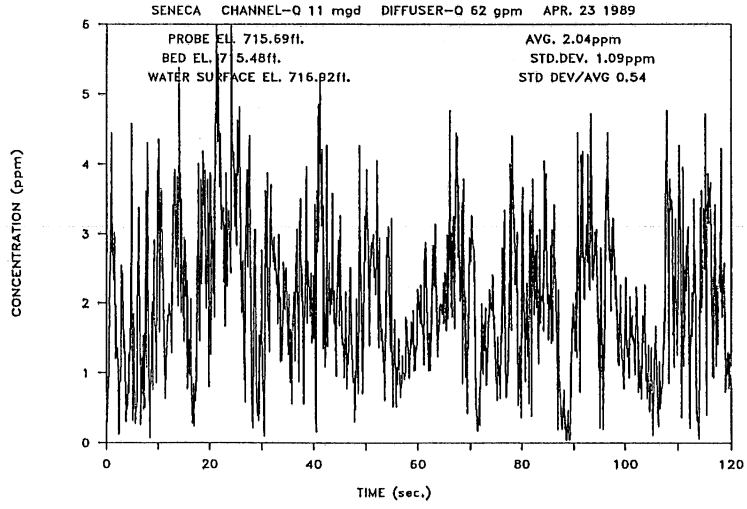
POSITION 6'(surface/side/54)



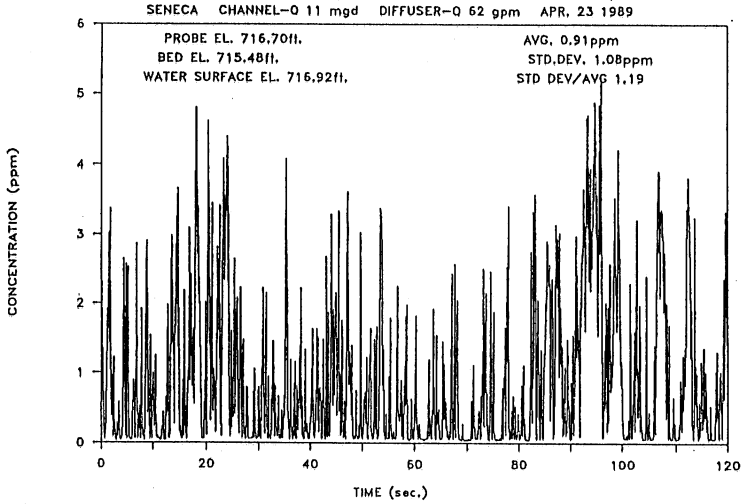
POSITION 6'(mid-depth/side/54)



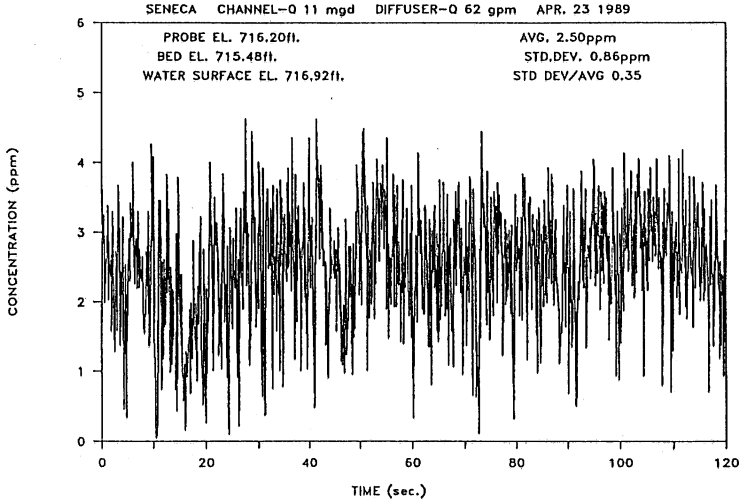
POSITION 6'(bottom/side/54)



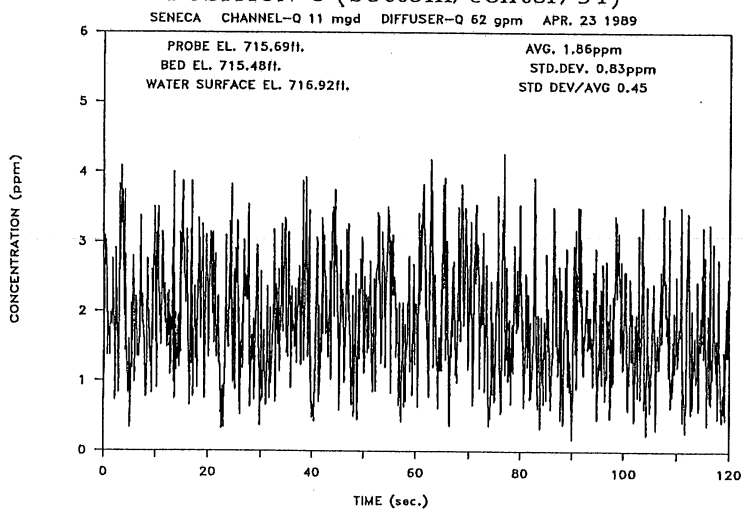
POSITION 6'(surface/center/54)

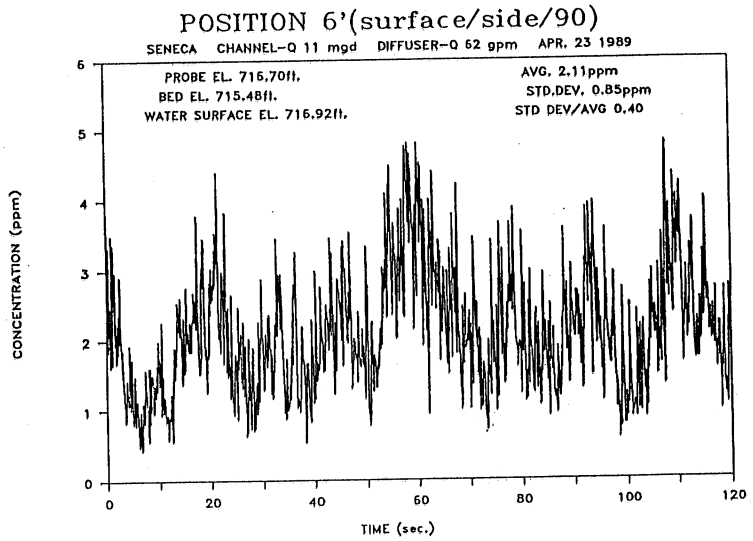


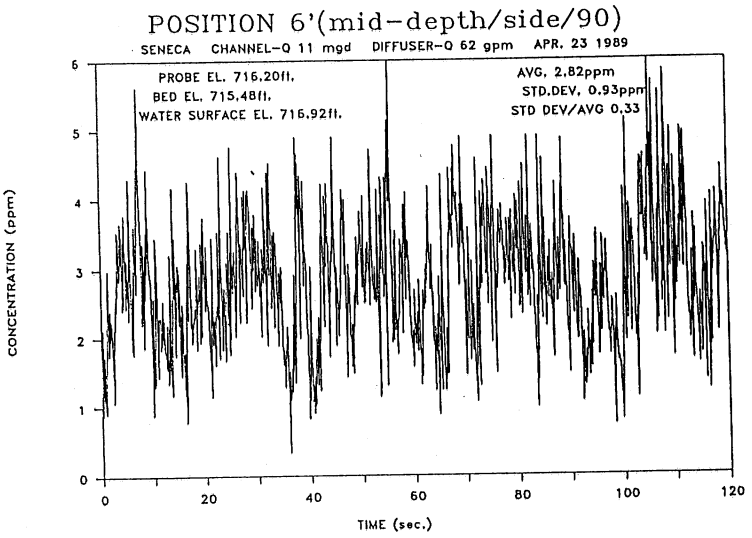
POSITION 6'(mid-depth/center/54)

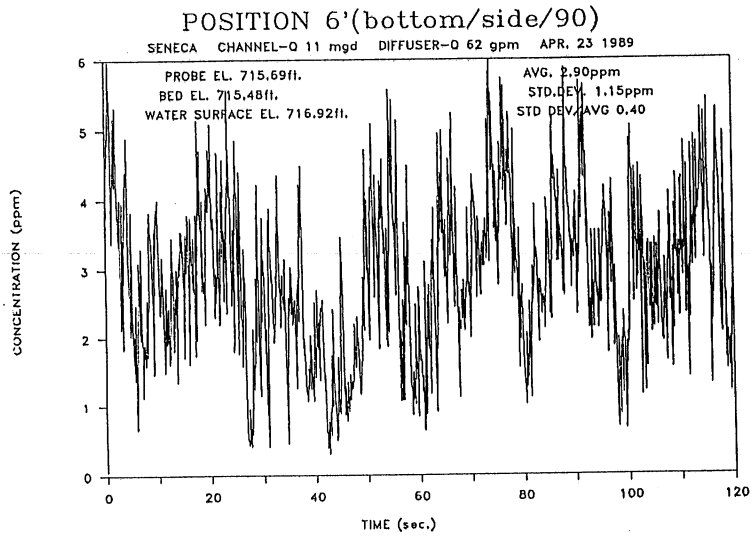


POSITION 6'(bottom/center/54)




POSITION 6'(surface/side/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 716.70ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
AVG. 2.11ppm
STD.DEV. 0.85ppm
STD DEV/AVG 0.40
CONCENTRATION (ppm)
TIME (sec.)


POSITION 6'(mid-depth/side/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 716.20ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
AVG. 2.82ppm
STD.DEV. 0.93ppm
STD DEV/AVG 0.33
CONCENTRATION (ppm)
TIME (sec.)


POSITION 6'(bottom/side/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.69ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
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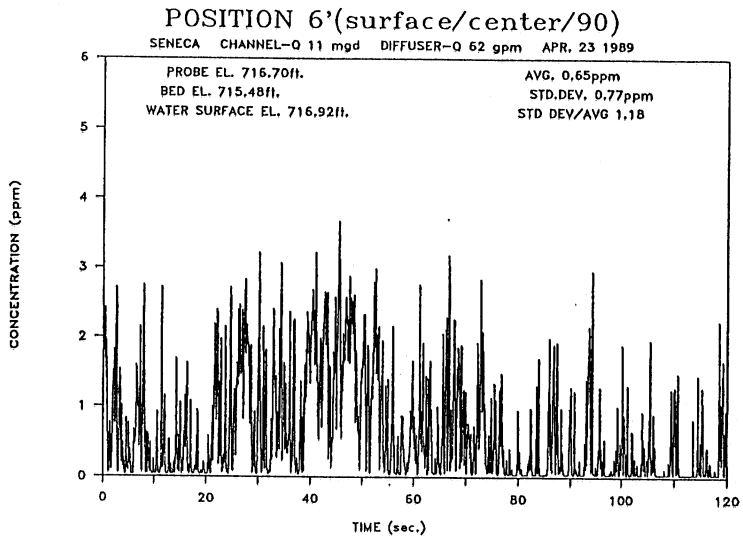
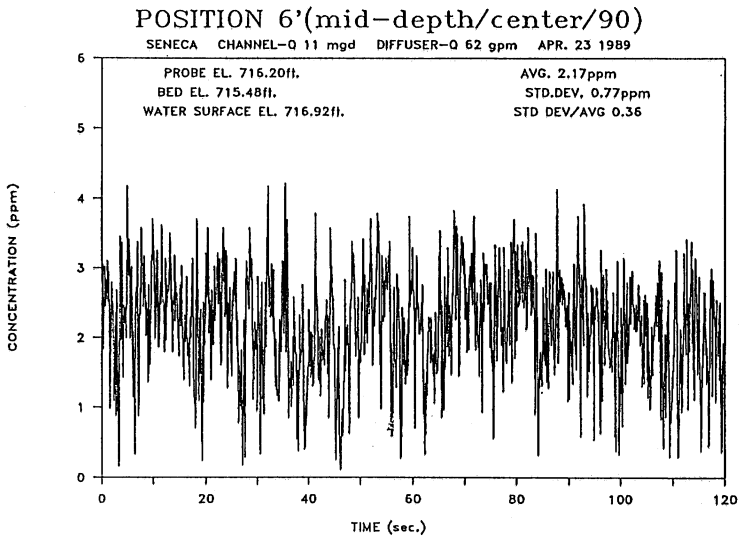
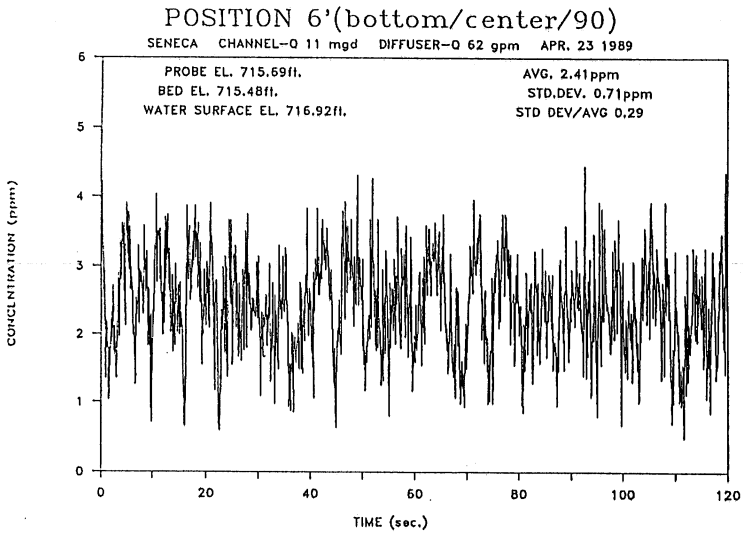
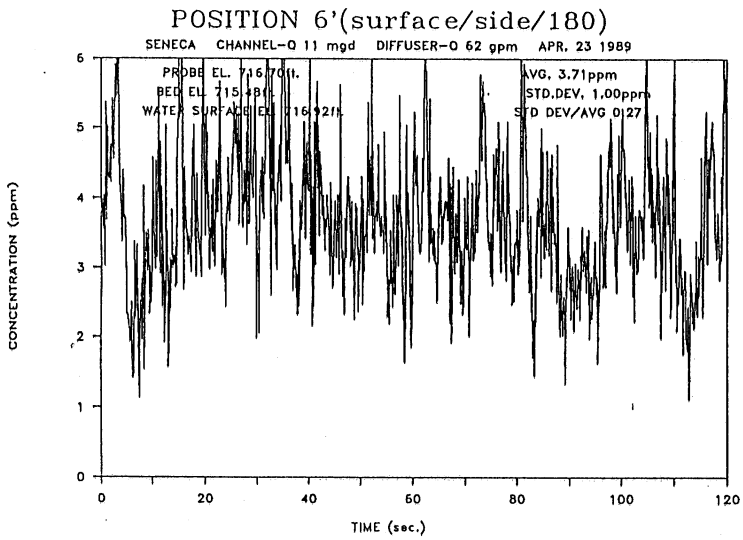
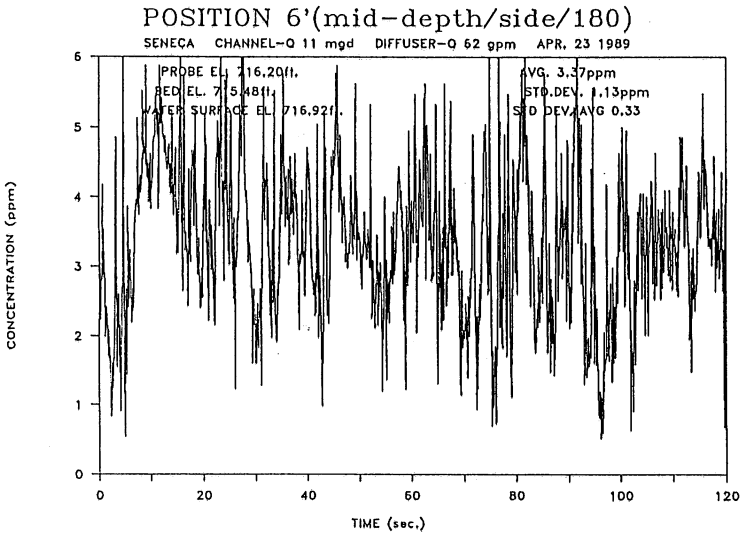
STD.DEV. 1.15ppm
STD DEV/AVG 0.40
CONCENTRATION (ppm)
TIME (sec.)

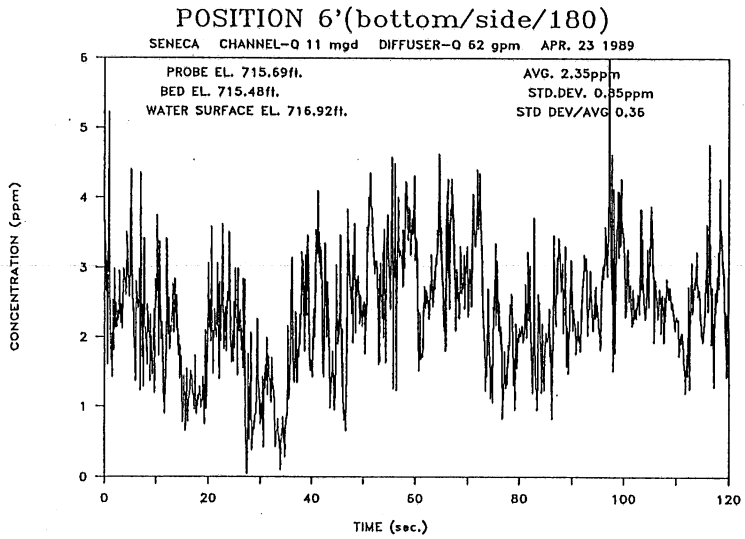

POSITION 6'(surface/center/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 716.70ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
AVG. 0.65ppm
STD.DEV. 0.77ppm
STD DEV/AVG 1.18
CONCENTRATION (ppm)
TIME (sec.)

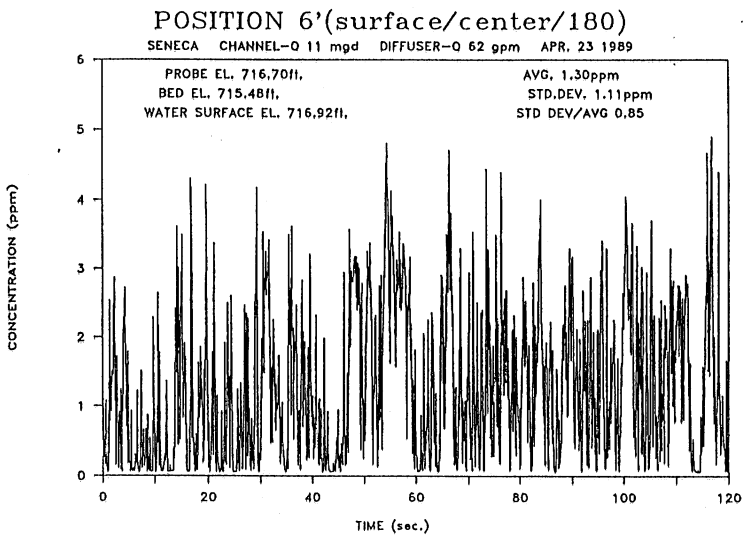

POSITION 6'(mid-depth/center/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 716.20ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
AVG. 2.17ppm
STD.DEV. 0.77ppm
STD DEV/AVG 0.36
CONCENTRATION (ppm)
TIME (sec.)

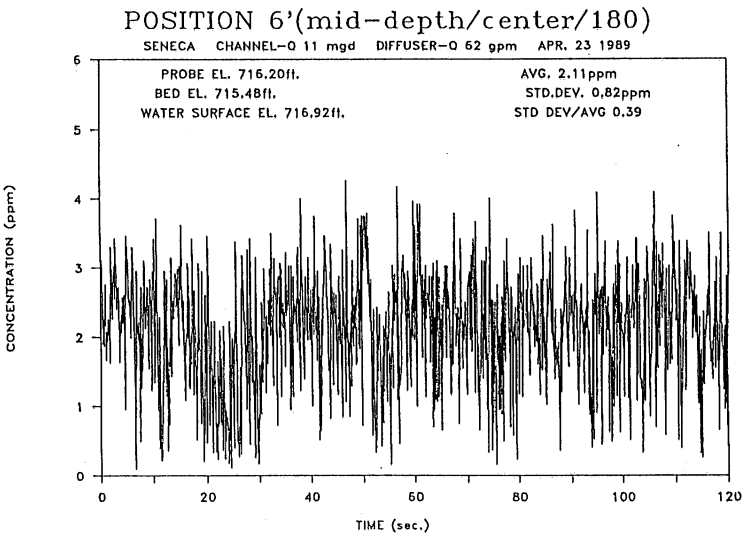

POSITION 6'(bottom/center/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.69ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
AVG. 2.41ppm
STD.DEV. 0.71ppm
STD DEV/AVG 0.29
CONCENTRATION (ppm)
TIME (sec.)

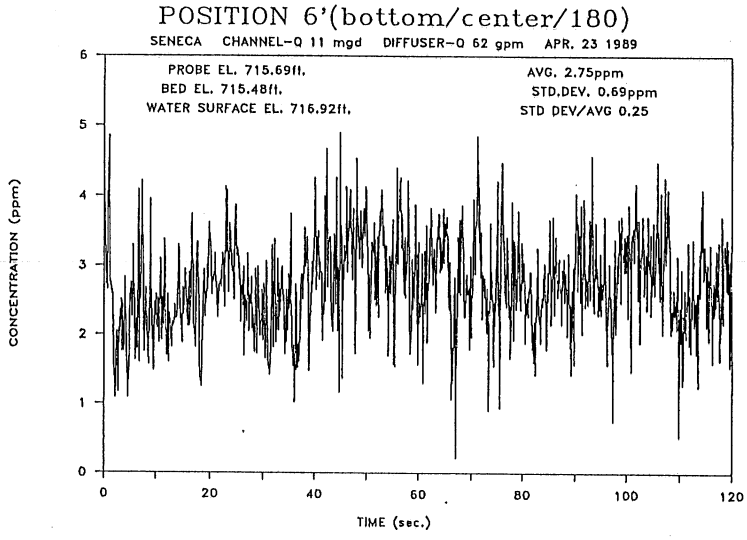

POSITION 6'(surface/side/180)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 716.70ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
AVG. 3.71ppm
STD.DEV. 1.00ppm
STD DEV/AVG 0.27
CONCENTRATION (ppm)
TIME (sec.)

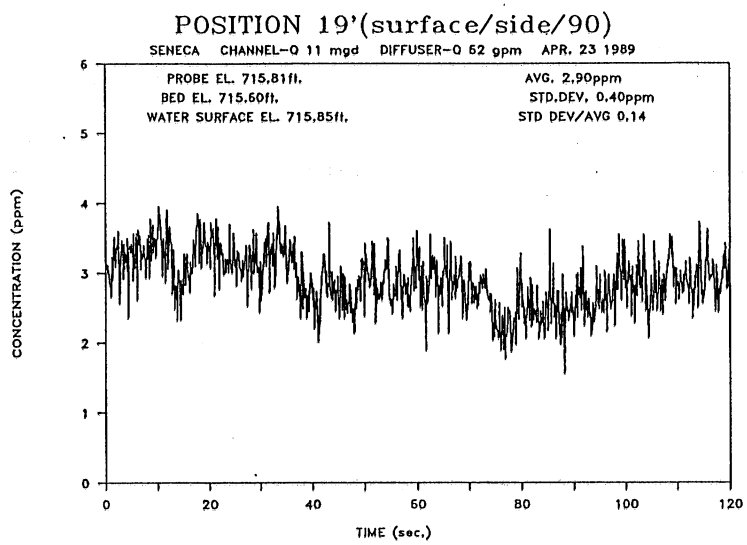

POSITION 6'(mid-depth/side/180)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 716.20ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
AVG. 3.37ppm
STD.DEV. 1.13ppm
STD DEV/AVG 0.33
CONCENTRATION (ppm)
TIME (sec.)

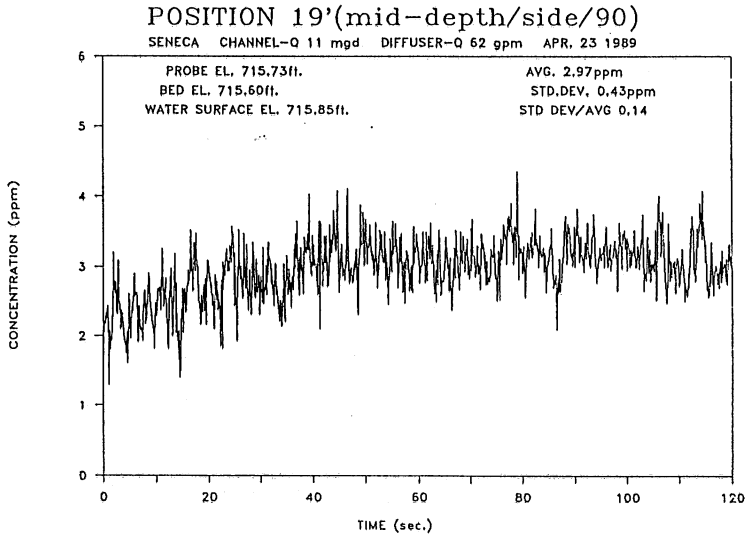

POSITION 6'(bottom/side/180)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.69ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
AVG. 2.35ppm
STD.DEV. 0.85ppm
STD DEV/AVG 0.36
CONCENTRATION (ppm)
TIME (sec.)

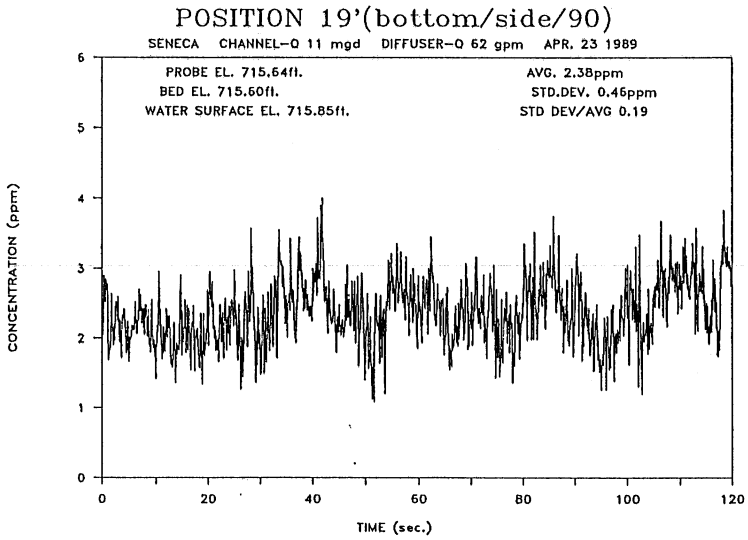

POSITION 6'(surface/center/180)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 716.70ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
AVG. 1.30ppm
STD.DEV. 1.11ppm
STD DEV/AVG 0.85
CONCENTRATION (ppm)
TIME (sec.)

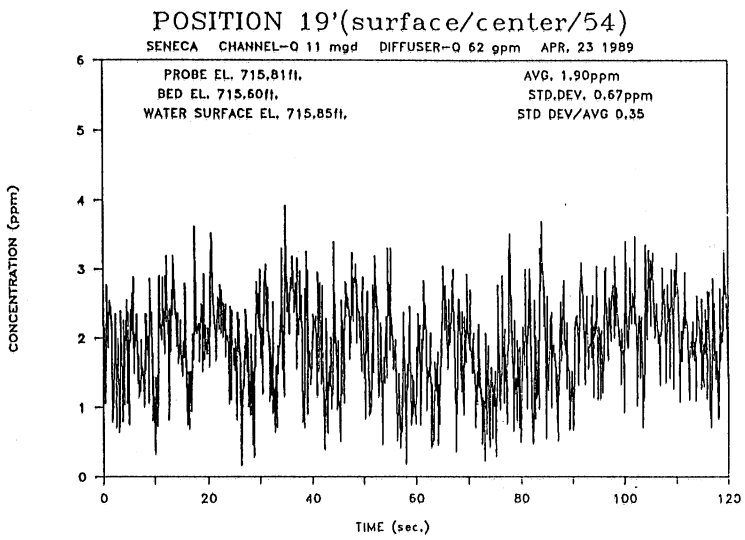

POSITION 6'(mid-depth/center/180)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 716.20ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
AVG. 2.11ppm
STD.DEV. 0.82ppm
STD DEV/AVG 0.39
CONCENTRATION (ppm)
TIME (sec.)

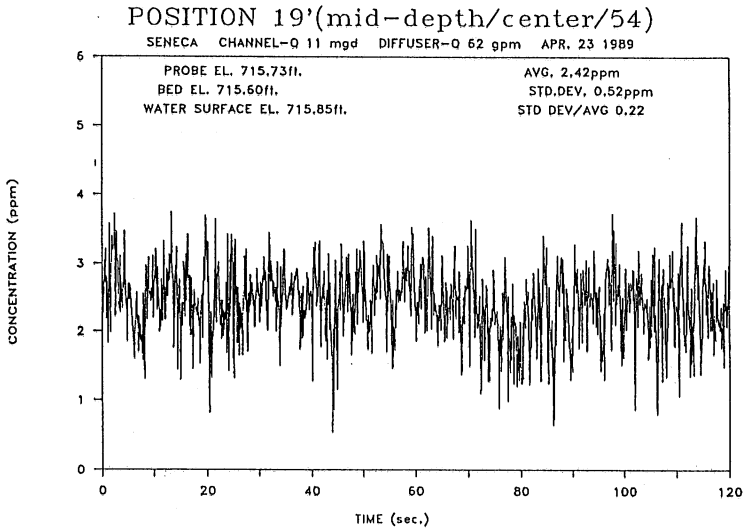

POSITION 6'(bottom/center/180)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.69ft.
BED EL. 715.48ft.
WATER SURFACE EL. 716.92ft.
AVG. 2.75ppm
STD.DEV. 0.69ppm
STD DEV/AVG 0.25
CONCENTRATION (ppm)
TIME (sec.)

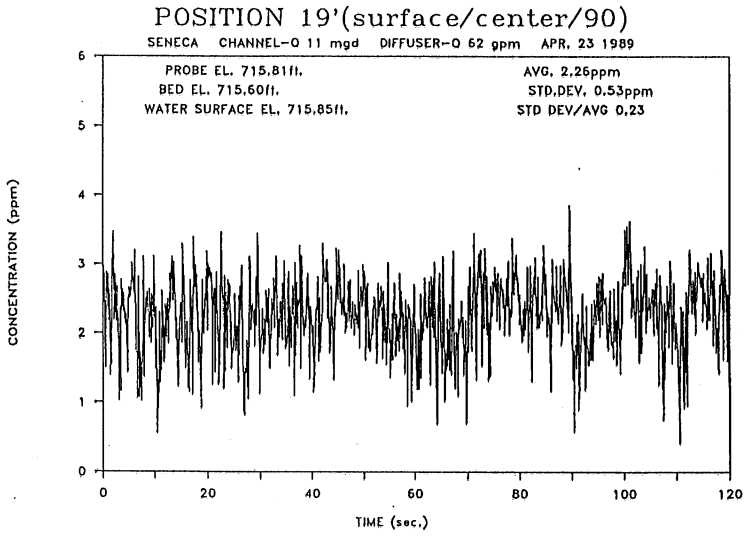

POSITION 19'(surface/side/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.81ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.85ft.
AVG. 2.90ppm
STD.DEV. 0.40ppm
STD DEV/AVG 0.14
CONCENTRATION (ppm)
TIME (sec.)

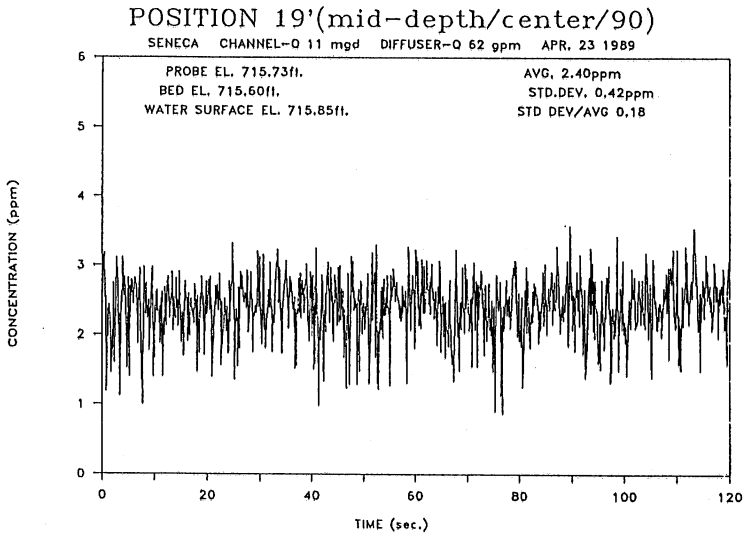

POSITION 19'(mid-depth/side/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.73ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.85ft.
AVG. 2.97ppm
STD.DEV. 0.43ppm
STD DEV/AVG 0.14
CONCENTRATION (ppm)
TIME (sec.)

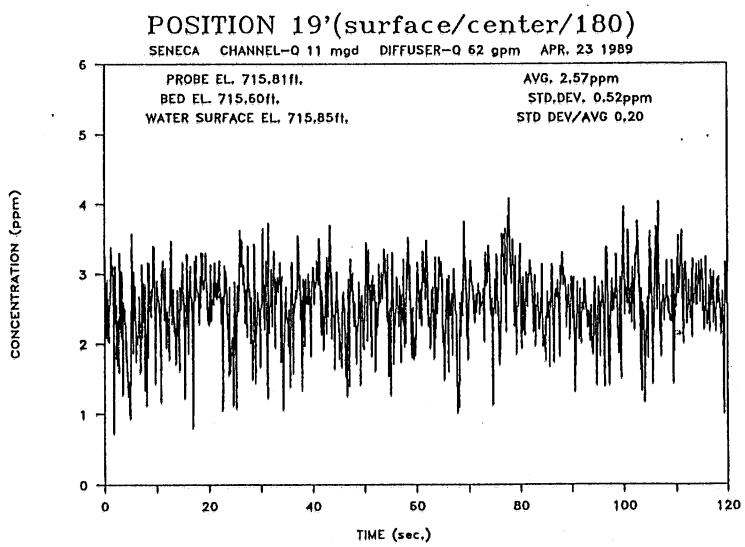

POSITION 19'(bottom/side/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.64ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.85ft.
AVG. 2.38ppm
STD.DEV. 0.46ppm
STD DEV/AVG 0.19
CONCENTRATION (ppm)
TIME (sec.)

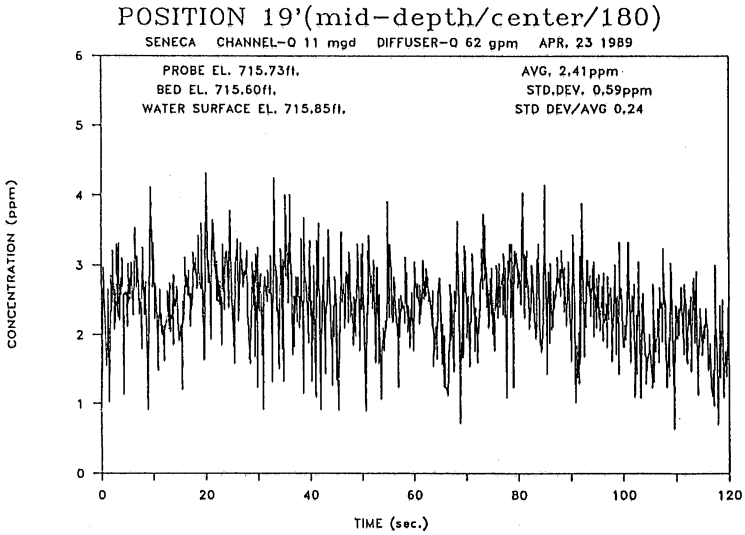

POSITION 19'(surface/center/54)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.81ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.85ft.
AVG. 1.90ppm
STD.DEV. 0.67ppm
STD DEV/AVG 0.35
CONCENTRATION (ppm)
TIME (sec.)


POSITION 19'(mid-depth/center/54)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.73ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.85ft.
AVG. 2.42ppm
STD.DEV. 0.52ppm
STD DEV/AVG 0.22
CONCENTRATION (ppm)
TIME (sec.)

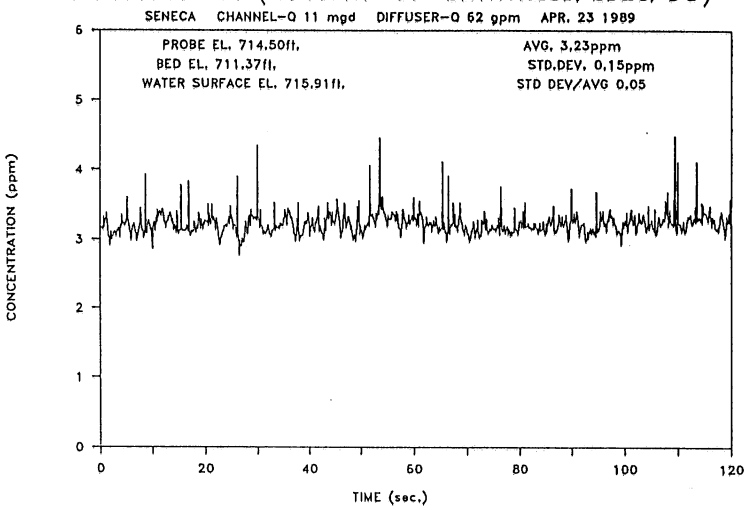

POSITION 19'(surface/center/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR, 23 1989
PROBE EL. 715.81ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.85ft.
AVG, 2.26ppm
STD.DEV, 0.53ppm
STD DEV/AVG 0.23
CONCENTRATION (ppm)
TIME (sec.)


POSITION 19'(mid-depth/center/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR, 23 1989
PROBE EL. 715.73ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.85ft.
AVG, 2.40ppm
STD.DEV. 0.42ppm
STD DEV/AVG 0.18
CONCENTRATION (ppm)
TIME (sec.)

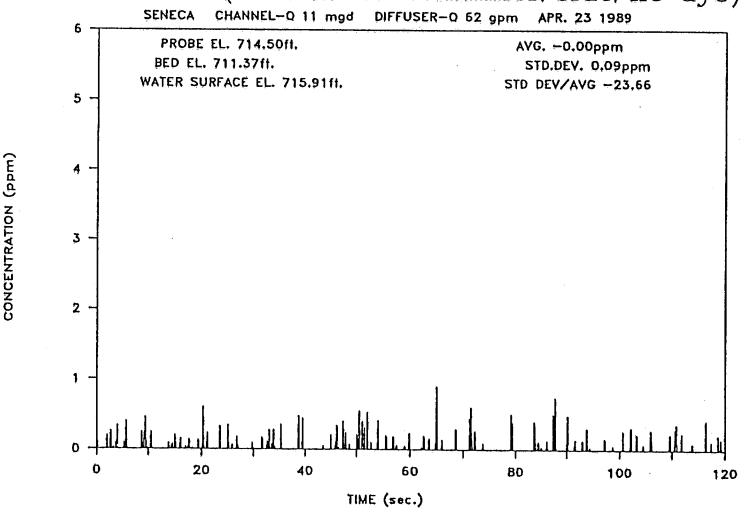

POSITION 19'(surface/center/180)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.81ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.85ft.
AVG. 2.57ppm
STD.DEV. 0.52ppm
STD DEV/AVG 0.20
CONCENTRATION (ppm)
TIME (sec.)


POSITION 19'(mid-depth/center/180)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.73ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.85ft.
AVG. 2.41ppm
STD.DEV. 0.59ppm
STD DEV/AVG 0.24
CONCENTRATION (ppm)
TIME (sec.)

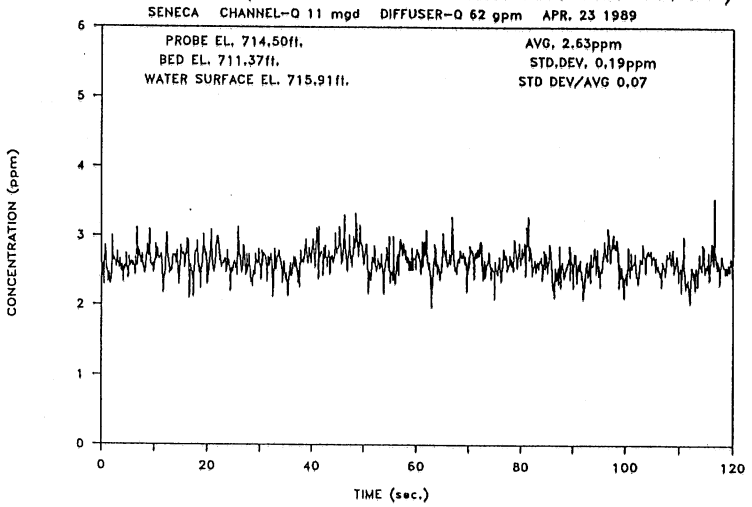
POSITION 27'(bottom-of-skimmer/side/90)



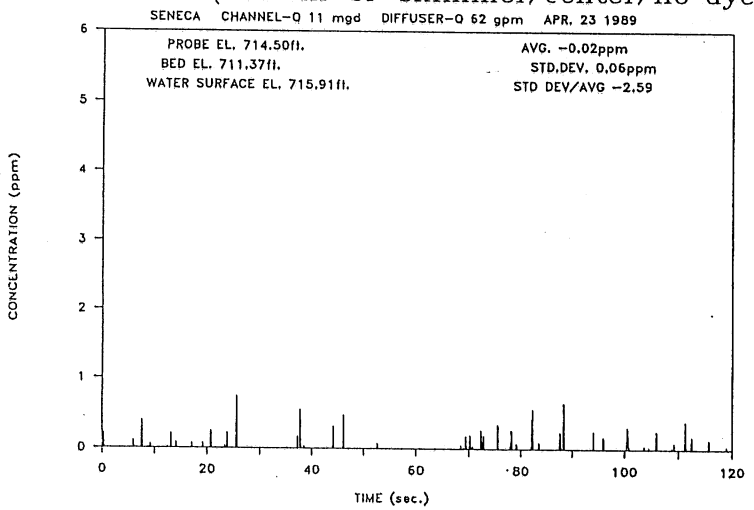
POSITION 27'(bottom-of-skimmer/side/no dye)

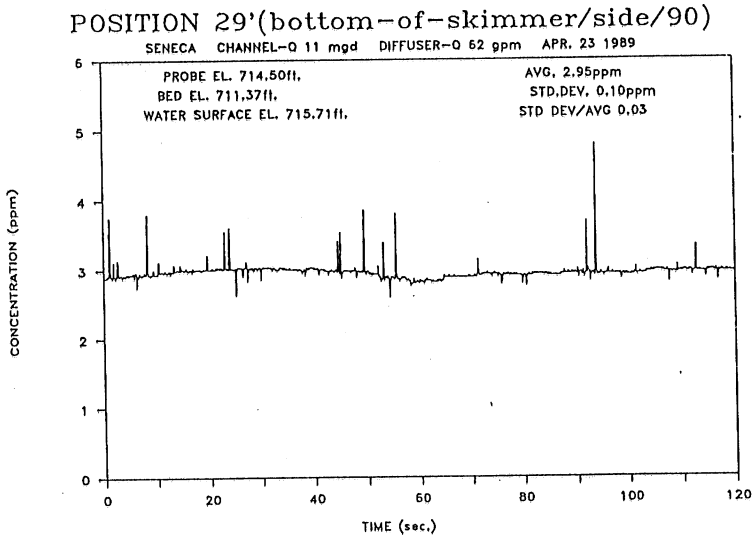


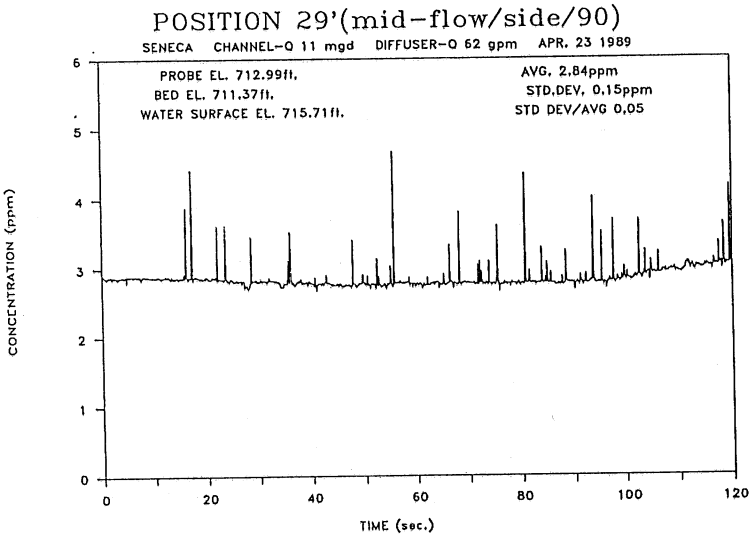
POSITION 27'(bottom-of-skimmer/center/90)

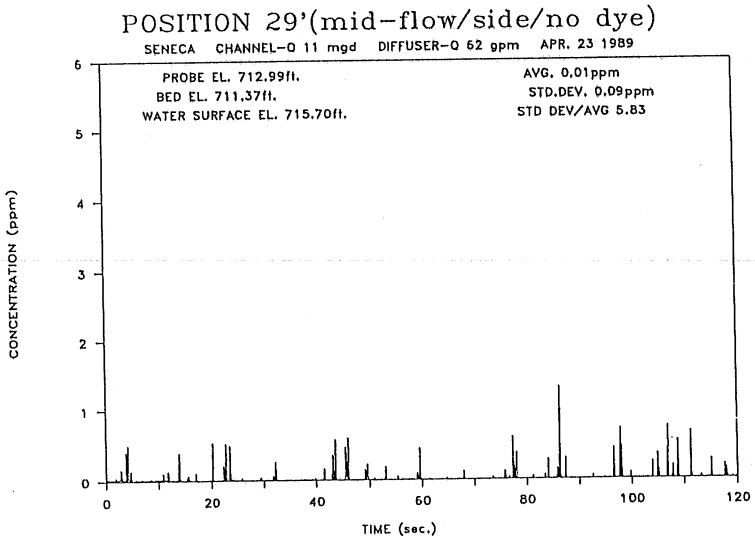


POSITION 27'(bottom-of-skimmer/center/no dye)

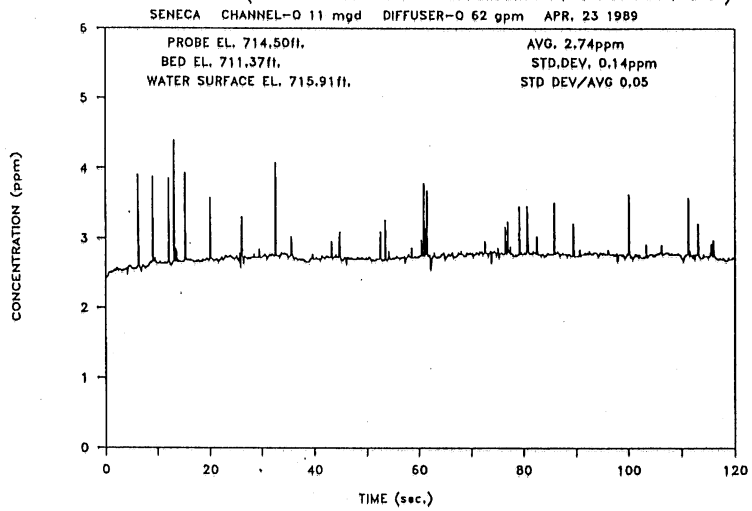



POSITION 29'(bottom-of-skimmer/side/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 714.50ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.71ft.
AVG, 2.95ppm
STD.DEV, 0.10ppm
STD DEV/AVG 0.03
CONCENTRATION (ppm)
TIME (sec.)

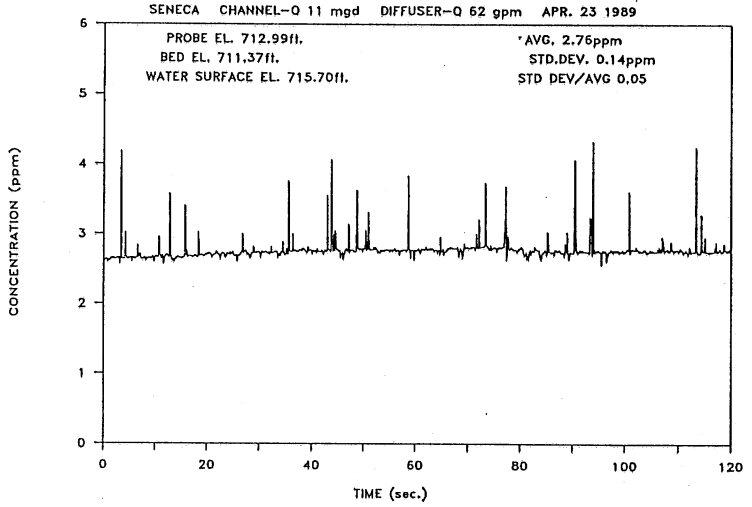

POSITION 29'(mid-flow/side/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 712.99ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.71ft.
AVG, 2.84ppm
STD.DEV, 0.15ppm
STD DEV/AVG 0.05
CONCENTRATION (ppm)
TIME (sec.)


POSITION 29'(mid-flow/side/no dye)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 712.99ft.
BED EL. 711.37ft.
WATER SURFACE EL. 715.70ft.
AVG, 0.01ppm
STD.DEV, 0.09ppm
STD DEV/AVG 5.83
CONCENTRATION (ppm)
TIME (sec.)

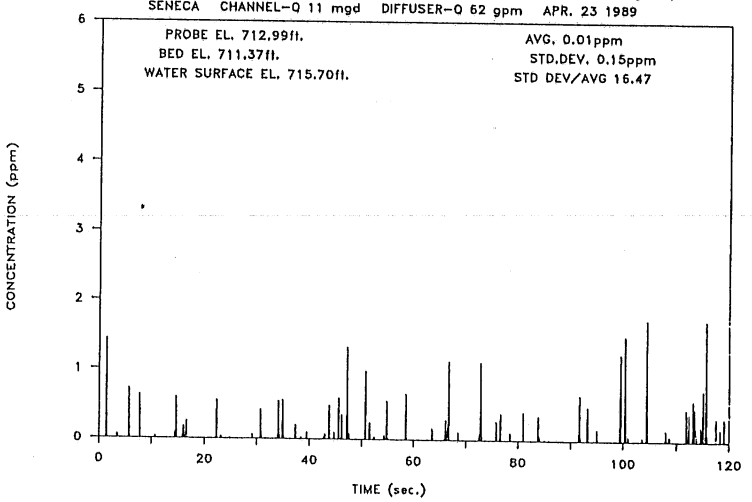
POSITION 29'(bottom-of-skimmer/center/90)

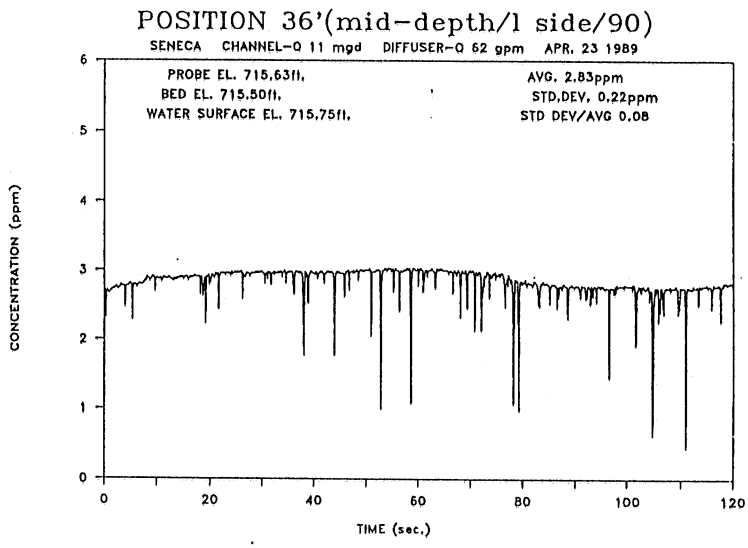


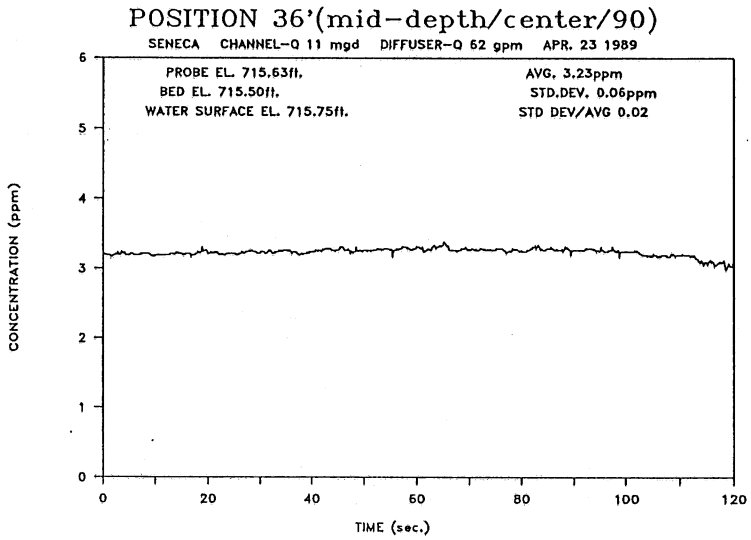
POSITION 29'(mid-flow/center/90)

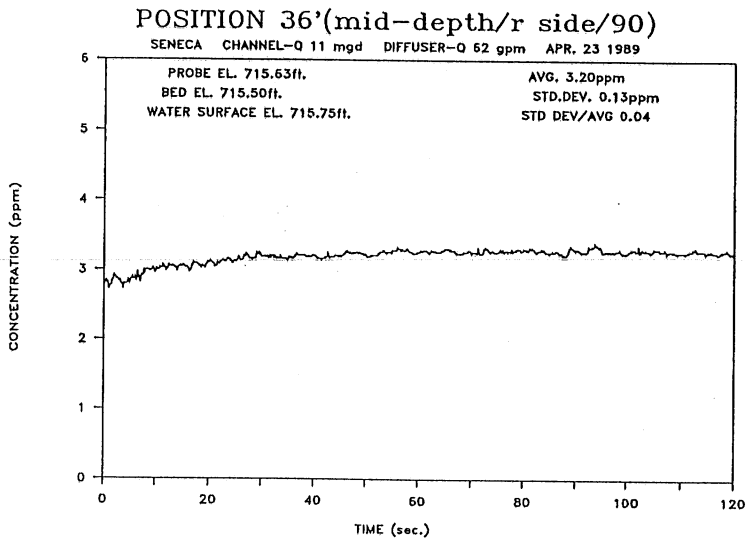


POSITION 29'(mid-flow/center/no dye)




POSITION 36'(mid-depth/l side/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.63ft.
BED EL. 715.50ft.
WATER SURFACE EL. 715.75ft.
AVG. 2.83ppm
STD.DEV. 0.22ppm
STD DEV/AVG 0.08
CONCENTRATION (ppm)
TIME (sec.)

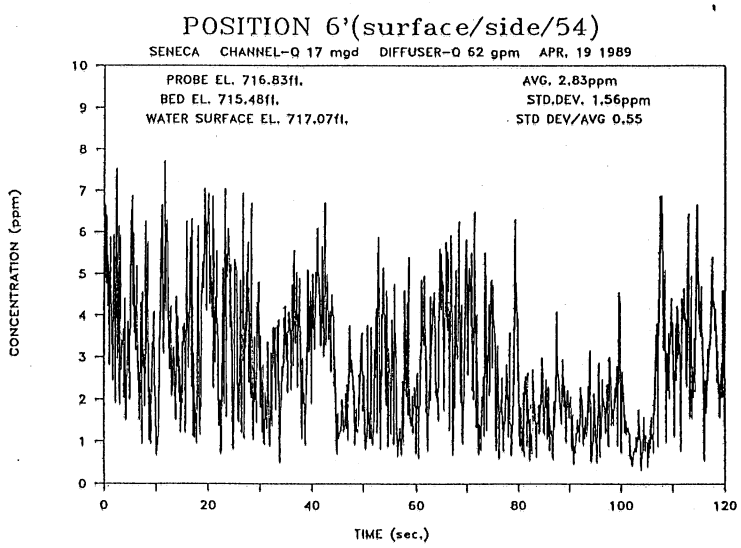

POSITION 36'(mid-depth/center/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.63ft.
BED EL. 715.50ft.
WATER SURFACE EL. 715.75ft.
AVG. 3.23ppm
STD.DEV. 0.06ppm
STD DEV/AVG 0.02
CONCENTRATION (ppm)
TIME (sec.)

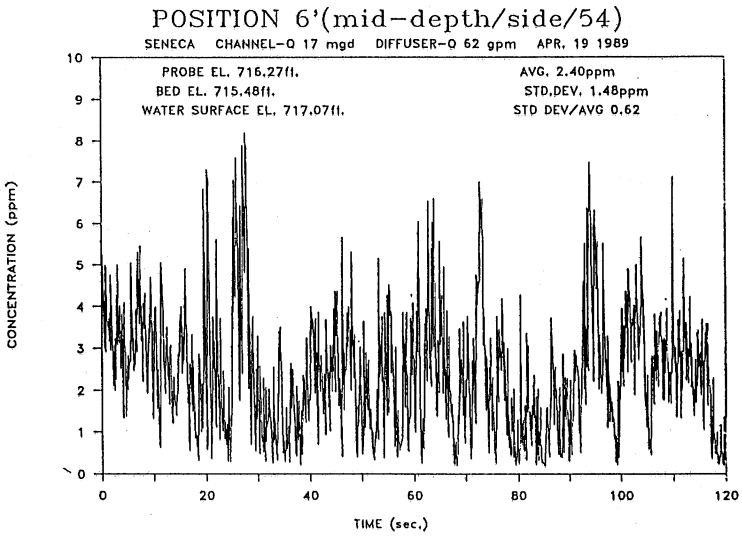

POSITION 36'(mid-depth/r side/90)
SENECA CHANNEL-Q 11 mgd DIFFUSER-Q 62 gpm APR. 23 1989
PROBE EL. 715.63ft.
BED EL. 715.50ft.
WATER SURFACE EL. 715.75ft.
AVG. 3.20ppm
STD.DEV. 0.13ppm
STD DEV/AVG 0.04
CONCENTRATION (ppm)
TIME (sec.)

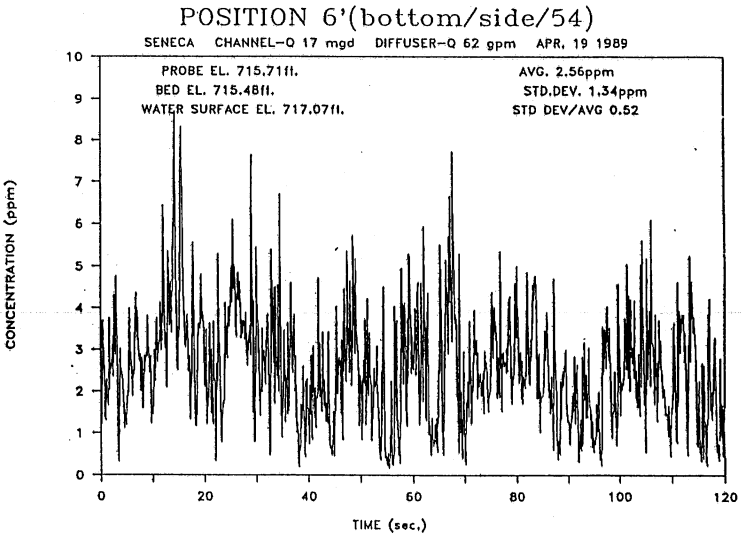
CONCENTRATION RECORDS

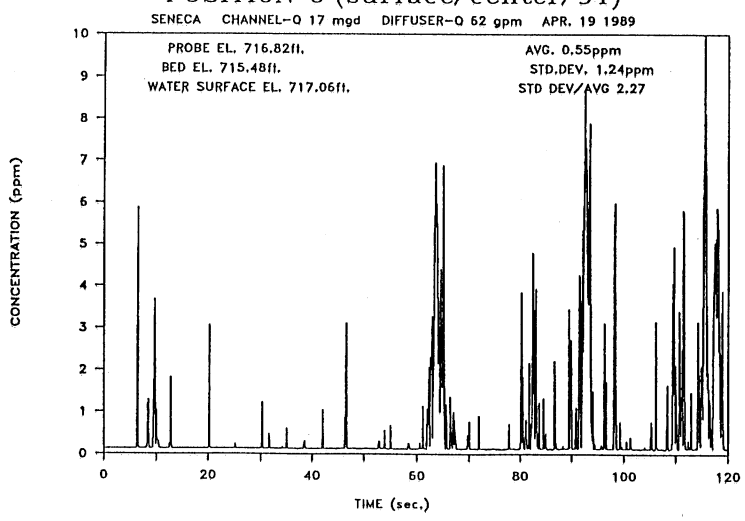
FOR

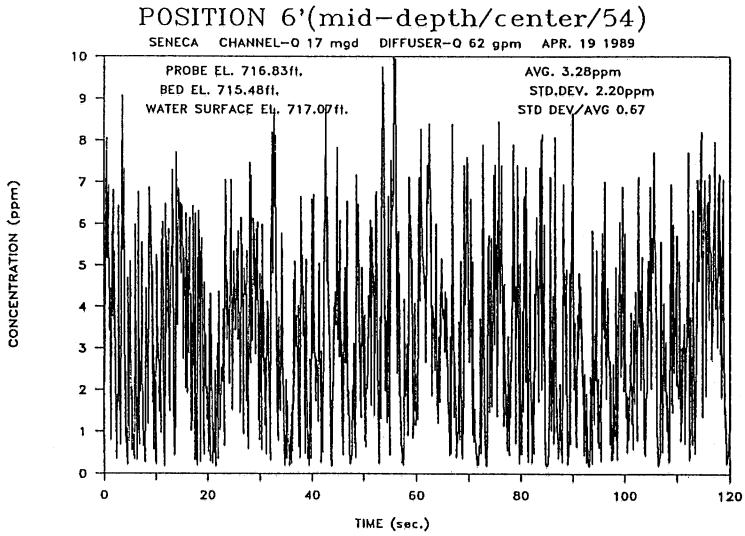
Q_w = 17 mgd

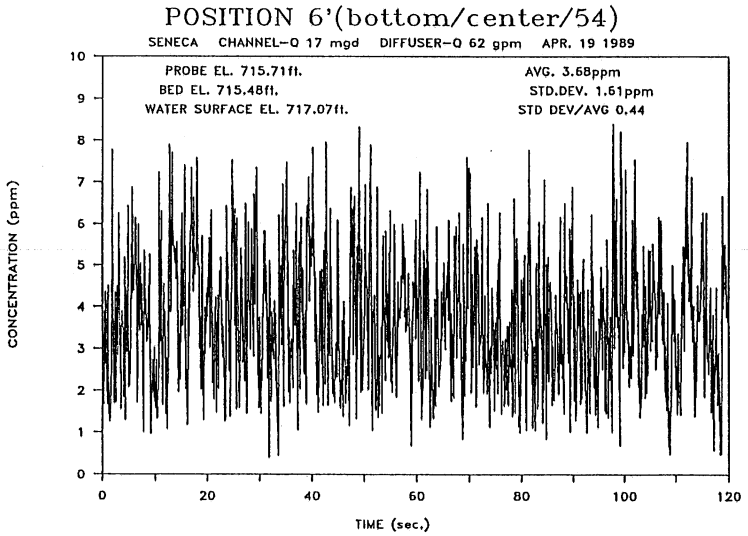

POSITION 6'(surface/side/54)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR, 19 1989
PROBE EL. 716.83ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 2.83ppm
STD.DEV. 1.56ppm
STD DEV/AVG 0.55
CONCENTRATION (ppm)
TIME (sec.)

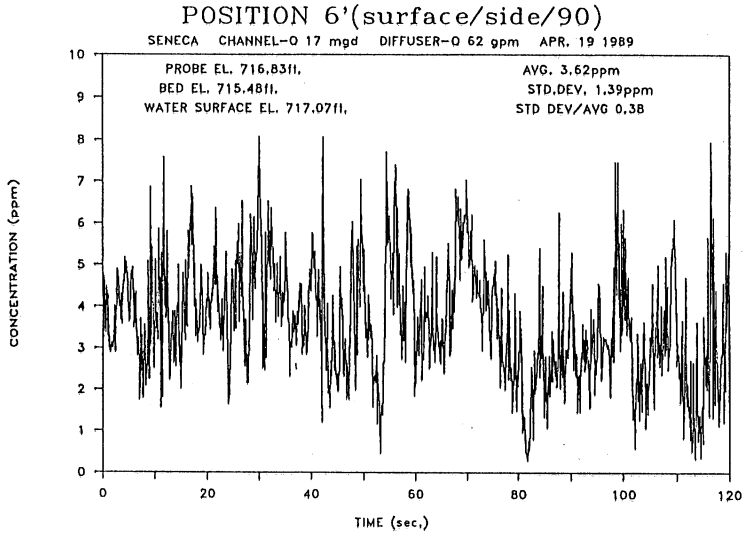

POSITION 6'(mid-depth/side/54)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR, 19 1989
PROBE EL. 716.27ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 2.40ppm
STD.DEV. 1.48ppm
STD DEV/AVG 0.62
CONCENTRATION (ppm)
TIME (sec.)

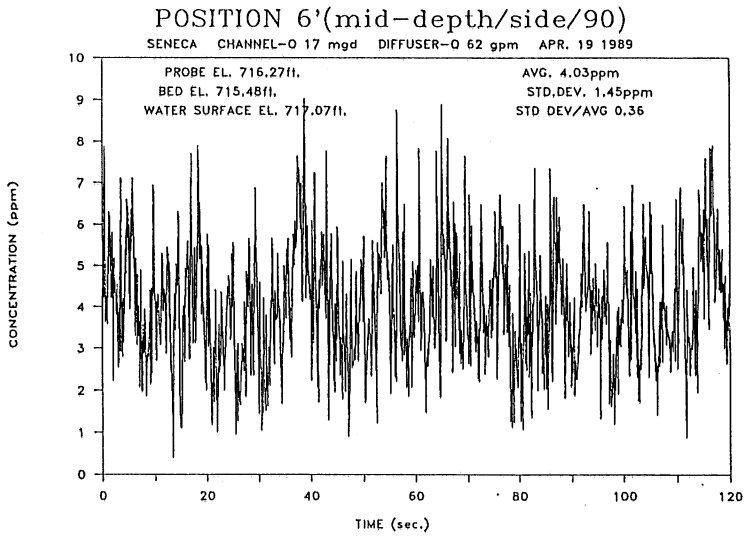

POSITION 6'(bottom/side/54)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR, 19 1989
PROBE EL. 715.71ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 2.56ppm
STD.DEV. 1.34ppm
STD DEV/AVG 0.52
CONCENTRATION (ppm)
TIME (sec.)

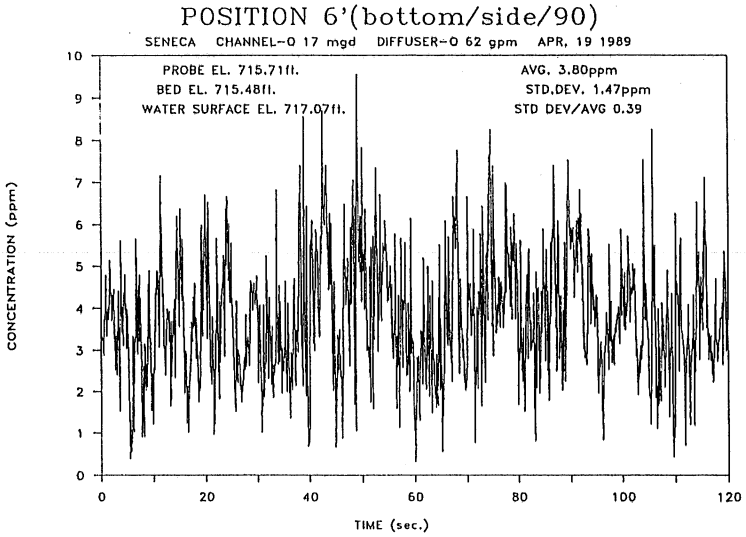

POSITION 6'(surface/center/54)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 716.82ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.06ft.
AVG. 0.55ppm
STD.DEV. 1.24ppm
STD DEV/AVG 2.27
CONCENTRATION (ppm)
TIME (sec.)

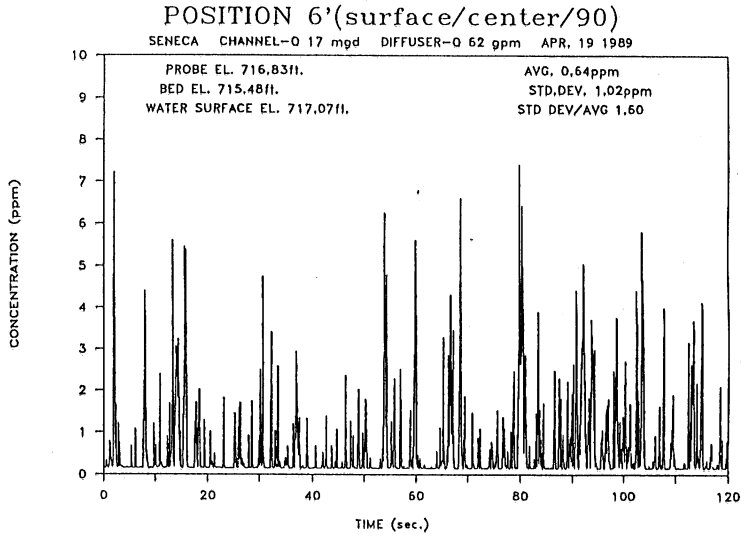

POSITION 6'(mid-depth/center/54)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 716.83ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 3.28ppm
STD.DEV. 2.20ppm
STD DEV/AVG 0.67
CONCENTRATION (ppm)
TIME (sec.)

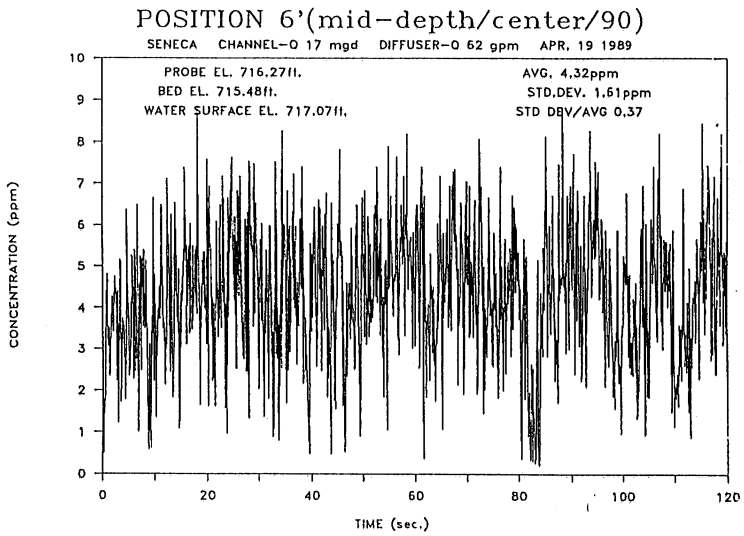

POSITION 6'(bottom/center/54)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.71ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 3.68ppm
STD.DEV. 1.61ppm
STD DEV/AVG 0.44
CONCENTRATION (ppm)
TIME (sec.)

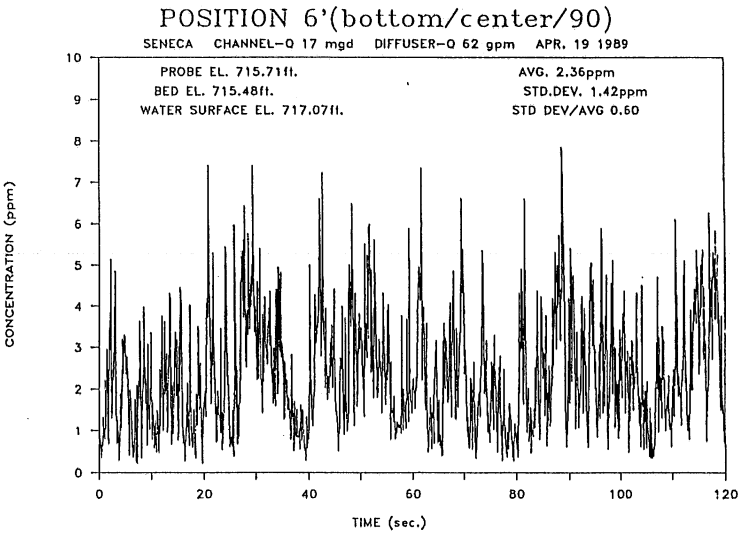

POSITION 6'(surface/side/90)
SENECA CHANNEL-O 17 mgd DIFFUSER-O 62 gpm APR. 19 1989
PROBE EL. 716.83ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 3.62ppm
STD.DEV. 1.39ppm
STD DEV/AVG 0.38
CONCENTRATION (ppm)
TIME (sec.)

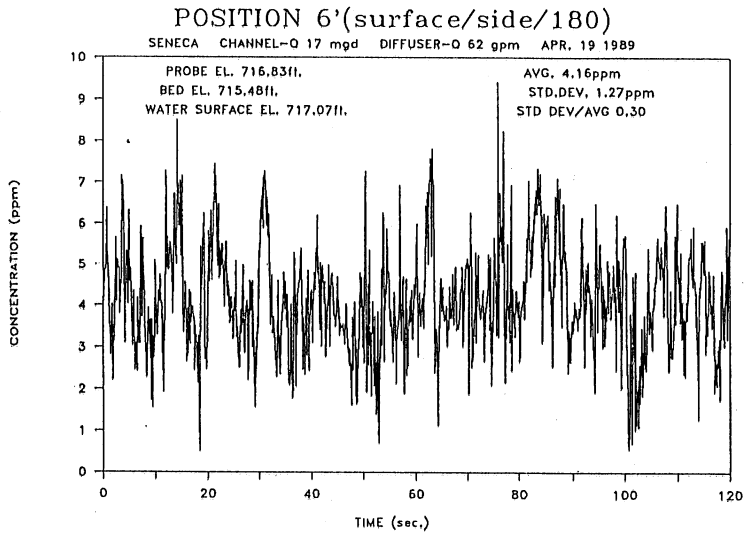

POSITION 6'(mid-depth/side/90)
SENECA CHANNEL-O 17 mgd DIFFUSER-O 62 gpm APR. 19 1989
PROBE EL. 716.27ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 4.03ppm
STD.DEV. 1.45ppm
STD DEV/AVG 0.36
CONCENTRATION (ppm)
TIME (sec.)

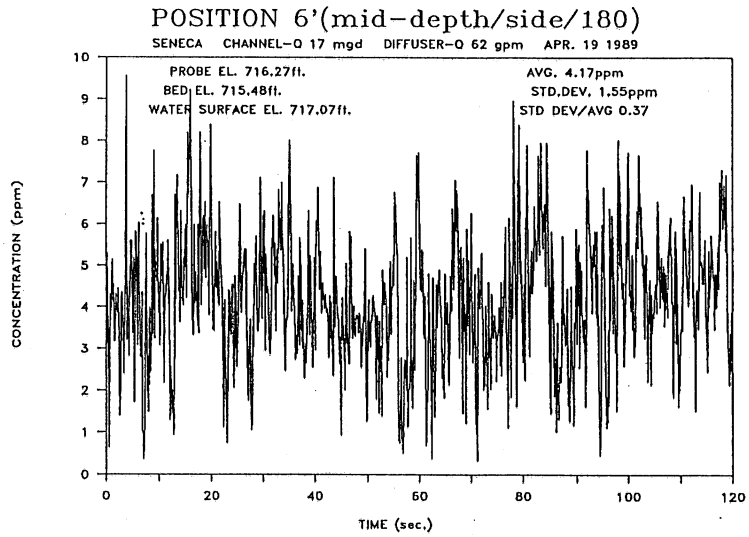

POSITION 6'(bottom/side/90)
SENECA CHANNEL-O 17 mgd DIFFUSER-O 62 gpm APR. 19 1989
PROBE EL. 715.71ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 3.80ppm
STD.DEV. 1.47ppm
STD DEV/AVG 0.39
CONCENTRATION (ppm)
TIME (sec.)

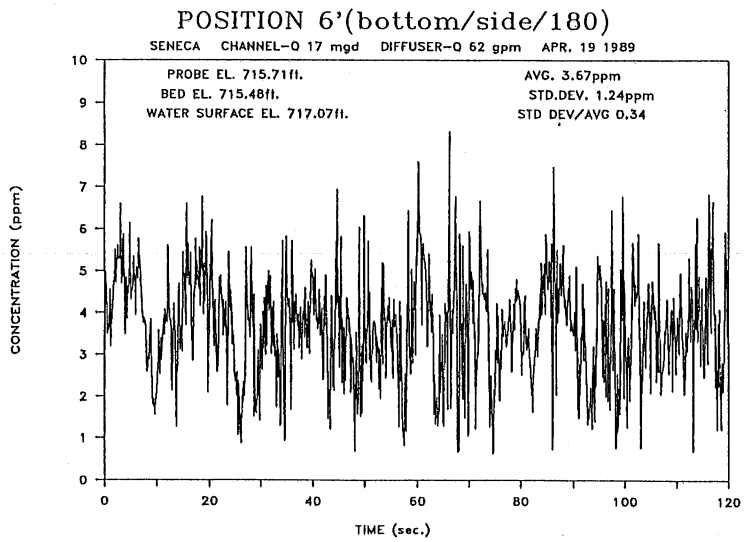

POSITION 6'(surface/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR, 19 1989
PROBE EL. 716.83ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG, 0.64ppm
STD.DEV, 1.02ppm
STD DEV/AVG 1.60
CONCENTRATION (ppm)
TIME (sec.)

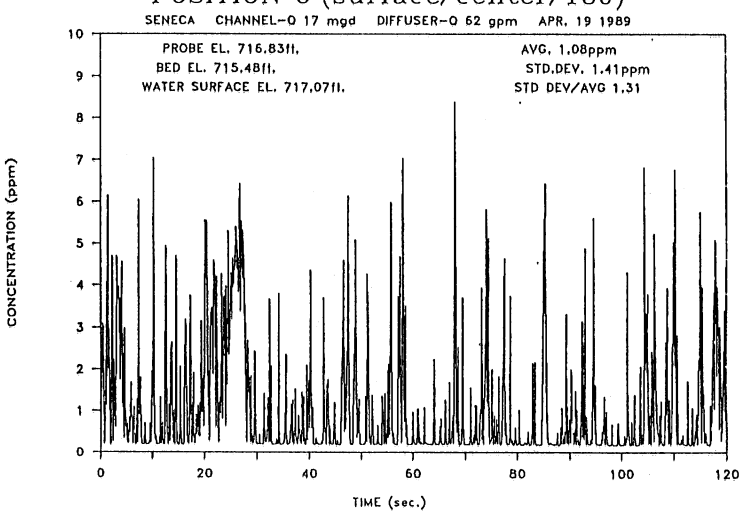

POSITION 6'(mid-depth/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR, 19 1989
PROBE EL. 716.27ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG, 4.32ppm
STD.DEV. 1.61ppm
STD DEV/AVG 0.37
CONCENTRATION (ppm)
TIME (sec.)

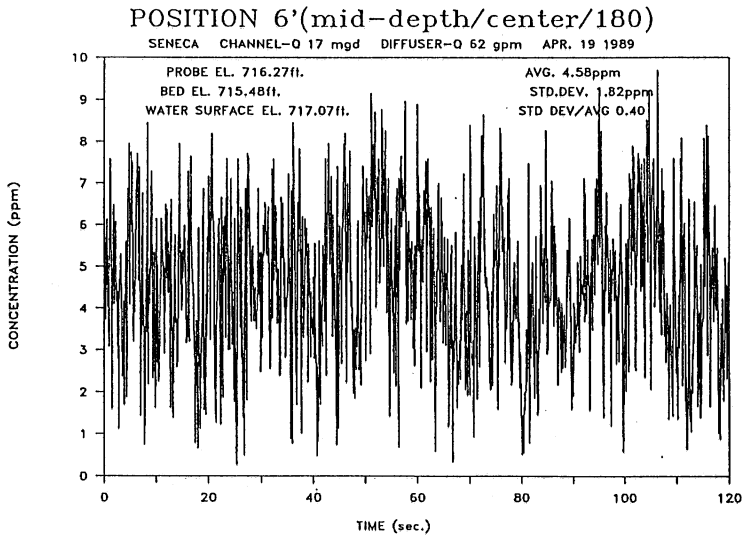

POSITION 6'(bottom/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR, 19 1989
PROBE EL. 715.71ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG, 2.36ppm
STD.DEV. 1.42ppm
STD DEV/AVG 0.60
CONCENTRATION (ppm)
TIME (sec.)

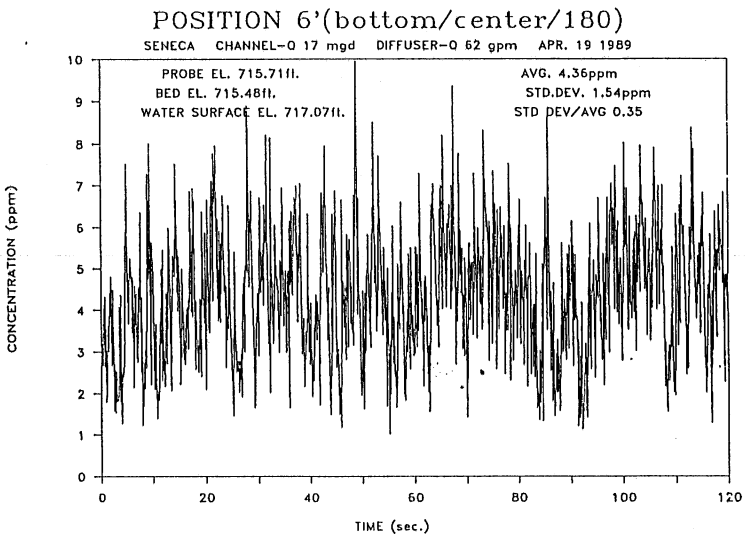

POSITION 6'(surface/side/180)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 716.83ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 4.16ppm
STD.DEV. 1.27ppm
STD DEV/AVG 0.30
CONCENTRATION (ppm)
TIME (sec.)

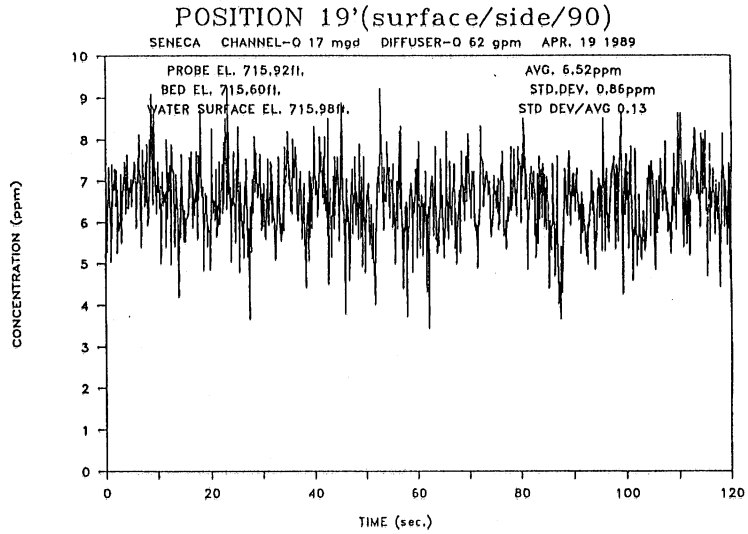

POSITION 6'(mid-depth/side/180)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 716.27ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 4.17ppm
STD.DEV. 1.55ppm
STD DEV/AVG 0.37
CONCENTRATION (ppm)
TIME (sec.)

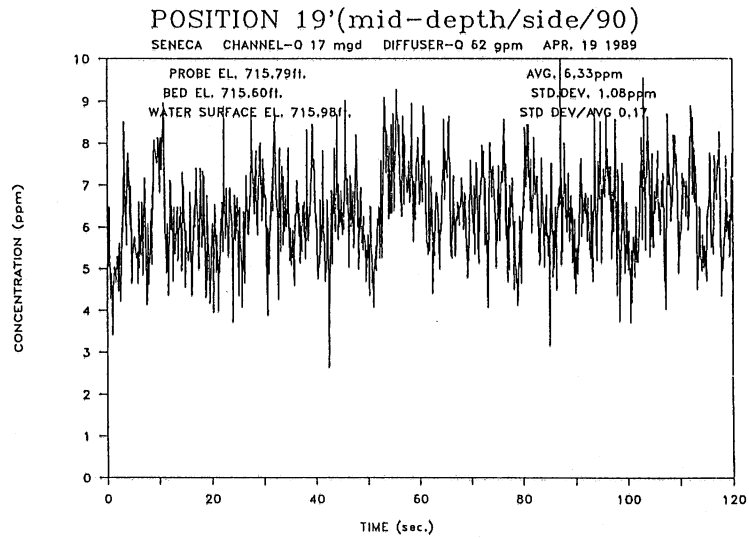

POSITION 6'(bottom/side/180)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.71ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 3.67ppm
STD.DEV. 1.24ppm
STD DEV/AVG 0.34
CONCENTRATION (ppm)
TIME (sec.)

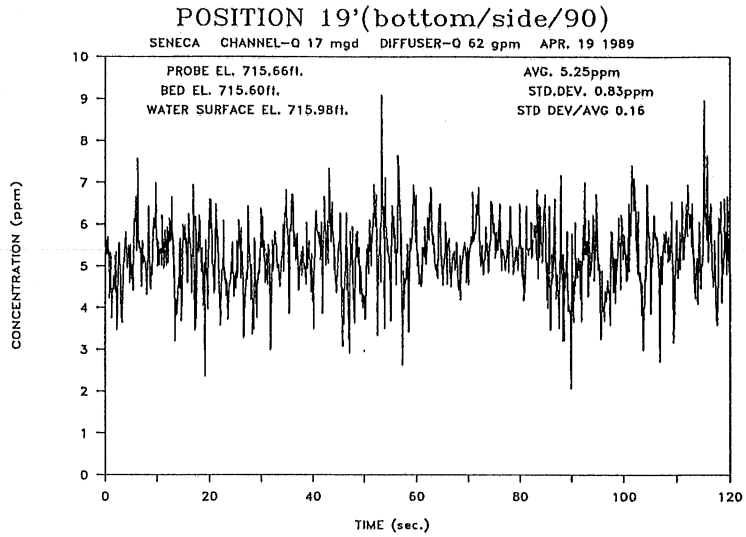

POSITION 6'(surface/center/180)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 716.83ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 1.08ppm
STD.DEV. 1.41ppm
STD DEV/AVG 1.31
CONCENTRATION (ppm)
TIME (sec.)

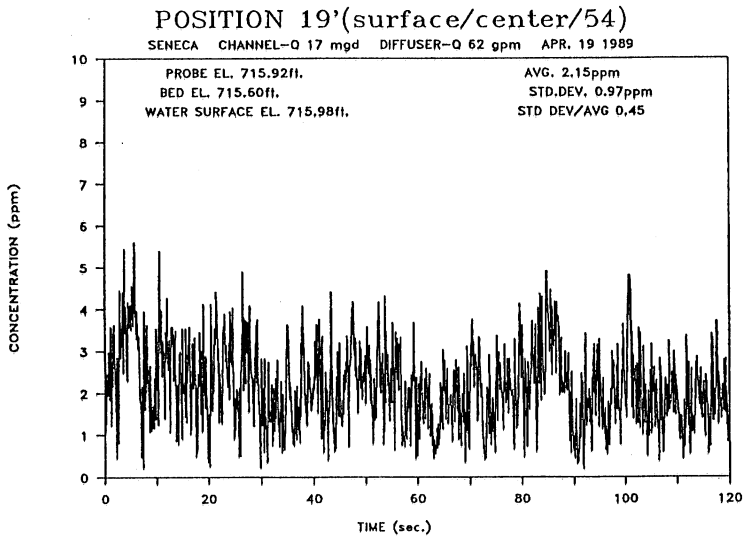

POSITION 6'(mid-depth/center/180)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 716.27ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 4.58ppm
STD.DEV. 1.82ppm
STD DEV/AVG 0.40
CONCENTRATION (ppm)
TIME (sec.)

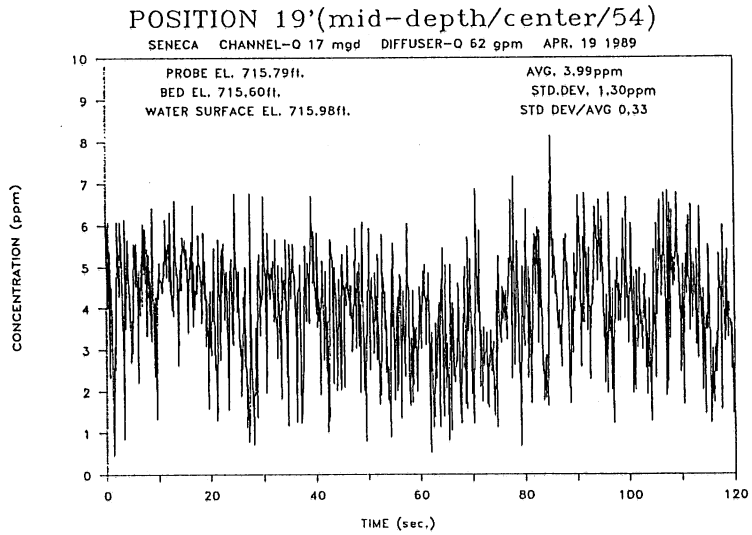

POSITION 6'(bottom/center/180)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.71ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.07ft.
AVG. 4.36ppm
STD.DEV. 1.54ppm
STD DEV/AVG 0.35
CONCENTRATION (ppm)
TIME (sec.)

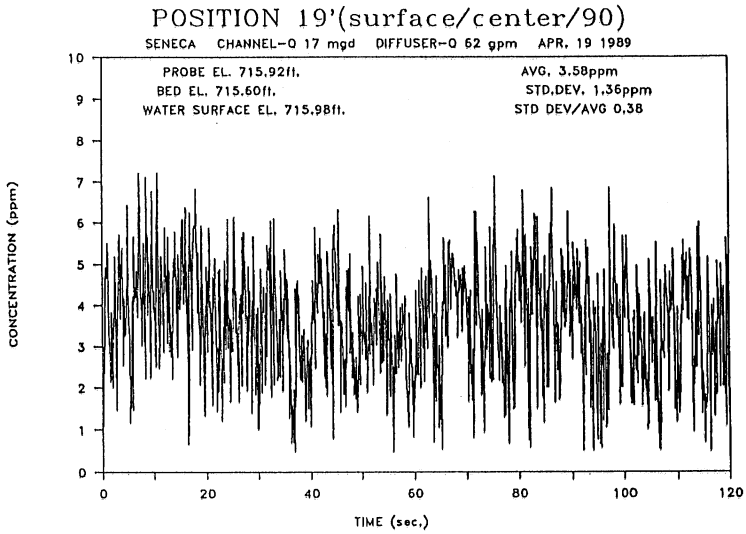

POSITION 19'(surface/side/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.92ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 6.52ppm
STD.DEV. 0.86ppm
STD DEV/AVG 0.13
CONCENTRATION (ppm)
TIME (sec.)

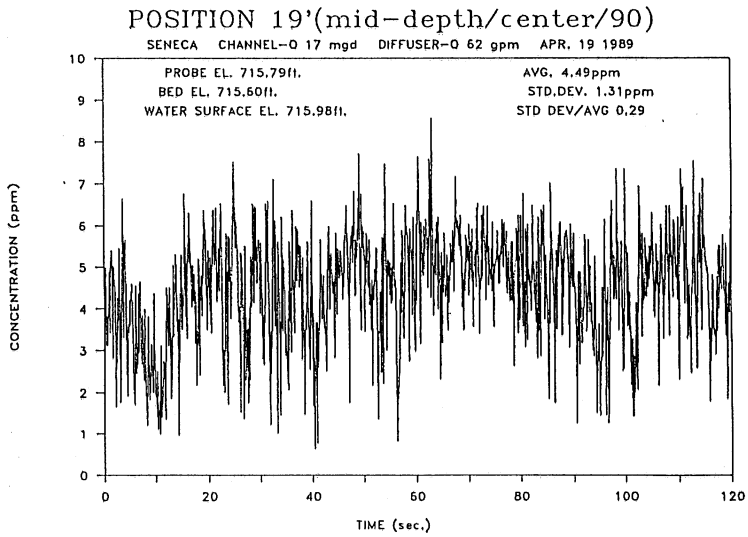

POSITION 19'(mid-depth/side/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.79ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 6.33ppm
STD.DEV. 1.08ppm
STD DEV/AVG 0.17
CONCENTRATION (ppm)
TIME (sec.)

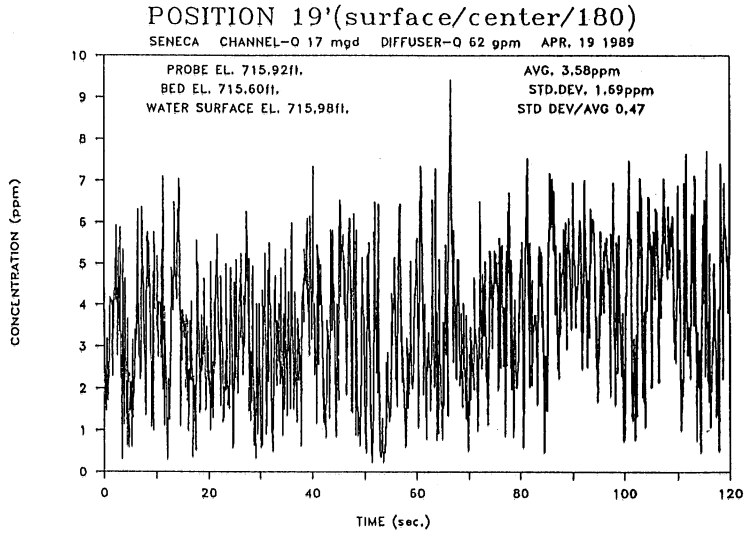

POSITION 19'(bottom/side/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.66ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 5.25ppm
STD.DEV. 0.83ppm
STD DEV/AVG 0.16
CONCENTRATION (ppm)
TIME (sec.)

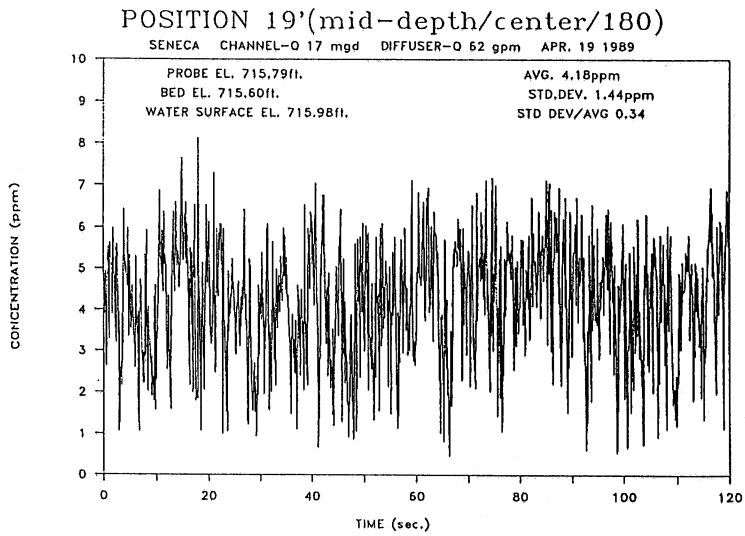

POSITION 19'(surface/center/54)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.92ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 2.15ppm
STD.DEV. 0.97ppm
STD DEV/AVG 0.45
CONCENTRATION (ppm)
TIME (sec.)


POSITION 19'(mid-depth/center/54)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.79ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 3.99ppm
STD.DEV. 1.30ppm
STD DEV/AVG 0.33
CONCENTRATION (ppm)
TIME (sec.)

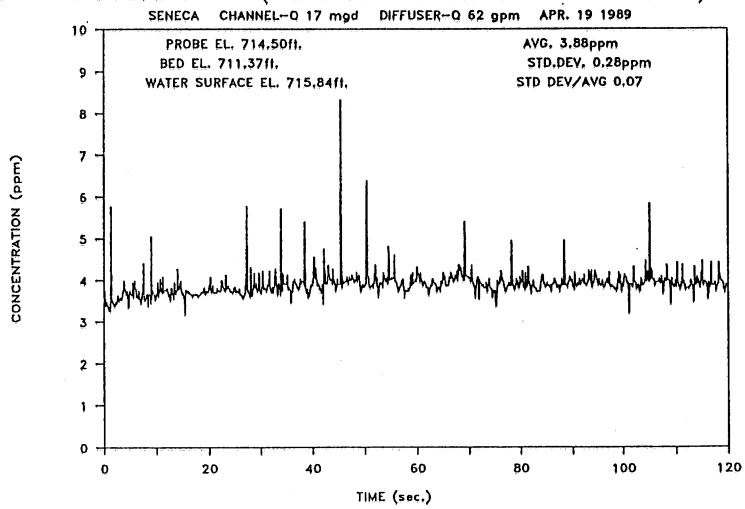

POSITION 19'(surface/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.92ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 3.58ppm
STD.DEV. 1.36ppm
STD DEV/AVG 0.38
CONCENTRATION (ppm)
TIME (sec.)


POSITION 19'(mid-depth/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.79ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 4.49ppm
STD.DEV. 1.31ppm
STD DEV/AVG 0.29
CONCENTRATION (ppm)
TIME (sec.)

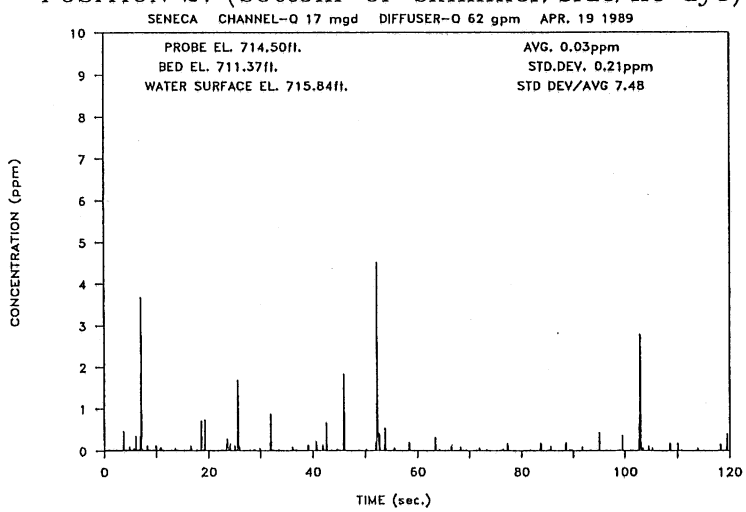

POSITION 19'(surface/center/180)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.92ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 3.58ppm
STD.DEV. 1.69ppm
STD DEV/AVG 0.47
CONCENTRATION (ppm)
TIME (sec.)


POSITION 19'(mid-depth/center/180)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.79ft.
BED EL. 715.60ft.
WATER SURFACE EL. 715.98ft.
AVG. 4.18ppm
STD.DEV. 1.44ppm
STD DEV/AVG 0.34
CONCENTRATION (ppm)
TIME (sec.)

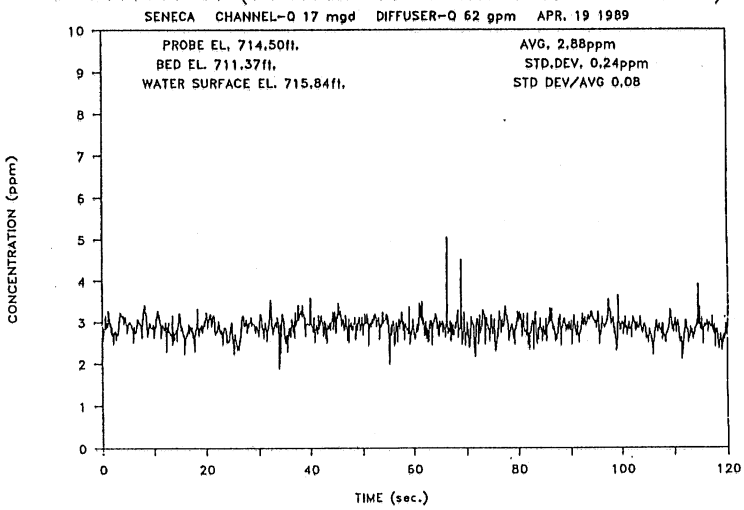
POSITION 27'(bottom-of-skimmer/side/90)



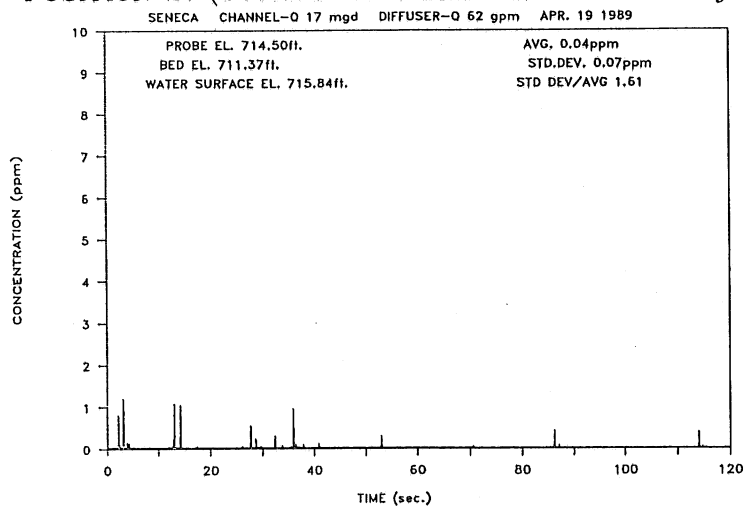
POSITION 27'(bottom-of-skimmer/side/no dye)



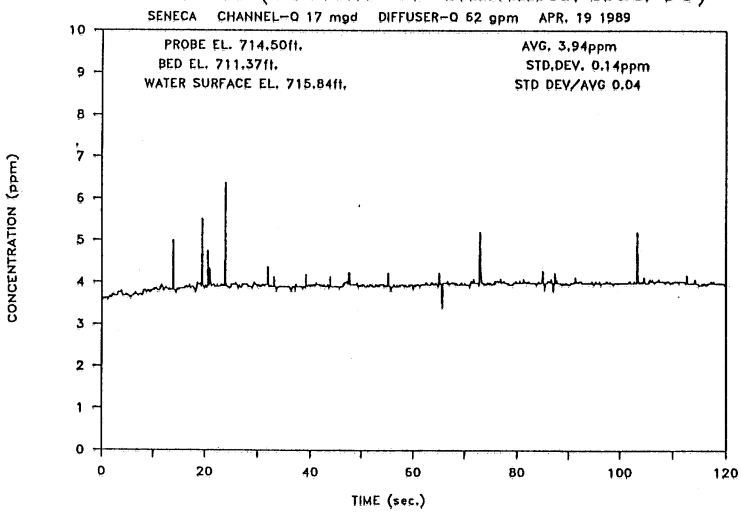
POSITION 27'(bottom-of-skimmer/center/90)



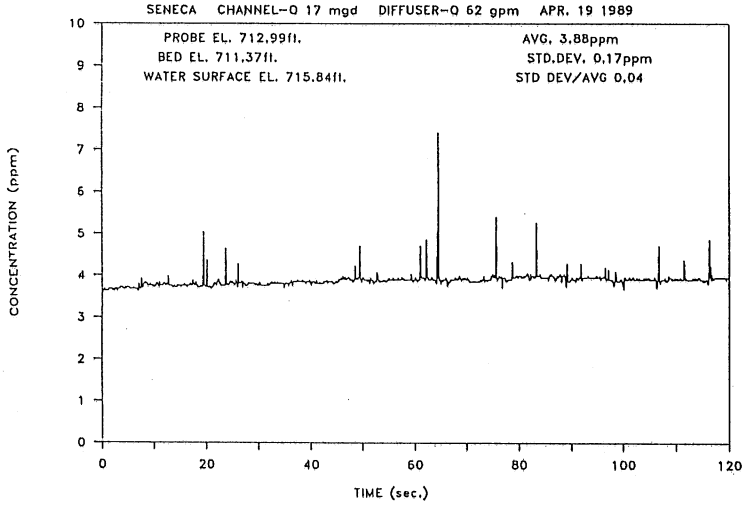
POSITION 27'(bottom-of-skimmer/center/no dye)



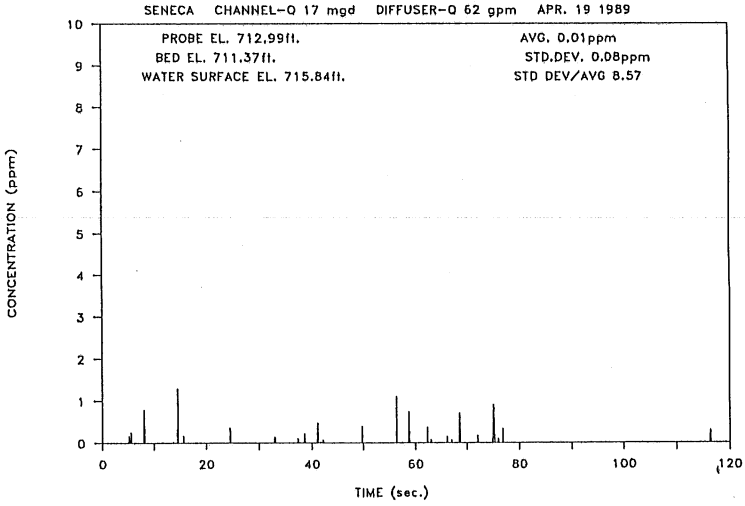
POSITION 29'(bottom-of-skimmer/side/90)



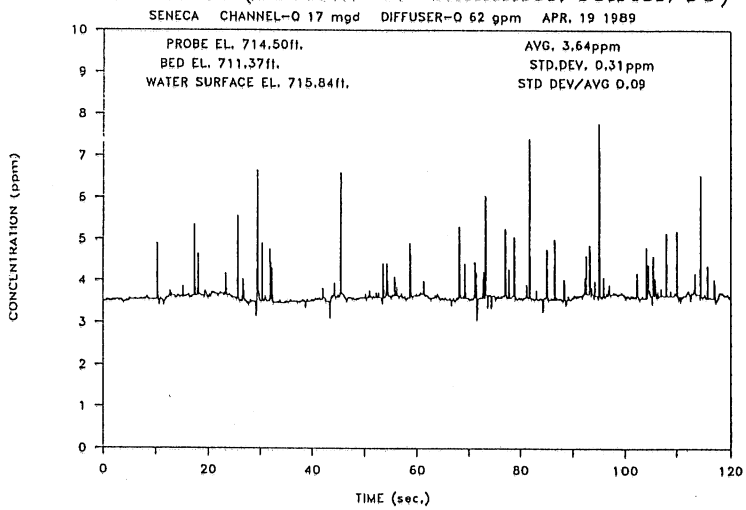
POSITION 29'(mid-flow/side/90)



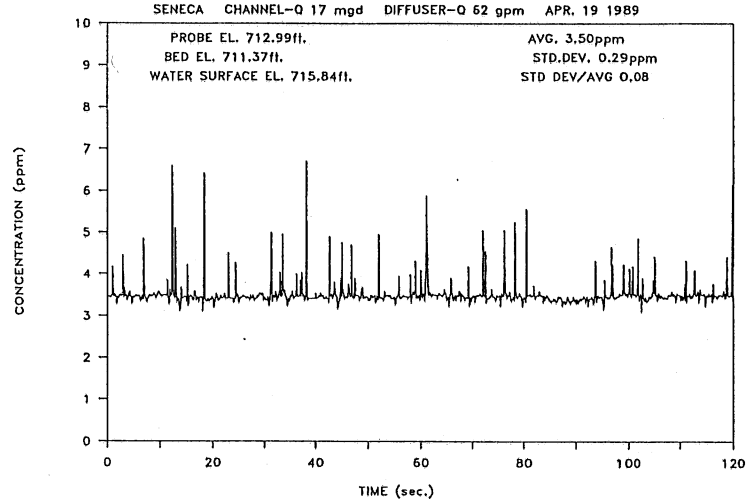
POSITION 29'(mid-flow/side/no dye)



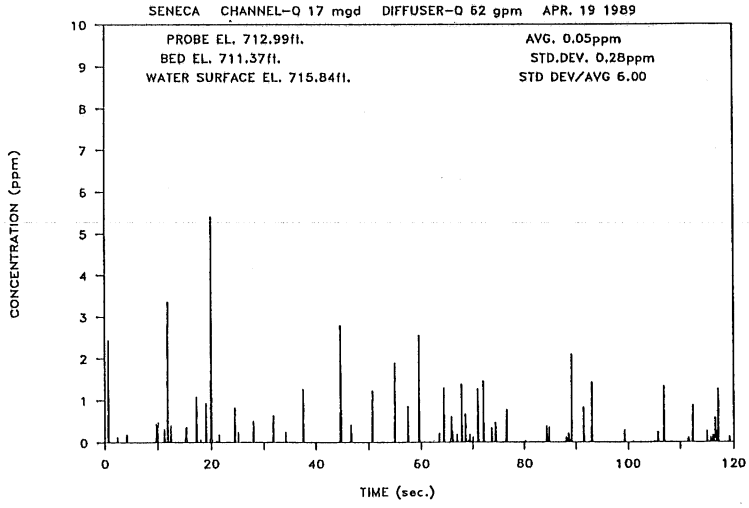
POSITION 29'(bottom-of-skimmer/center/90)

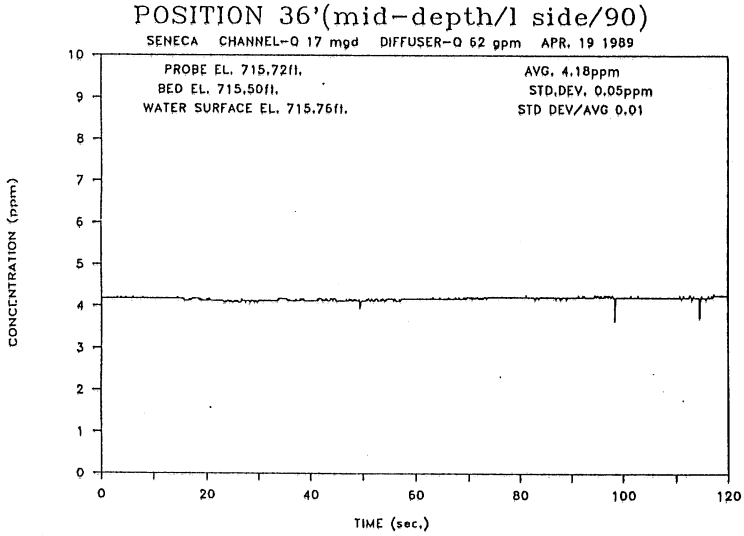


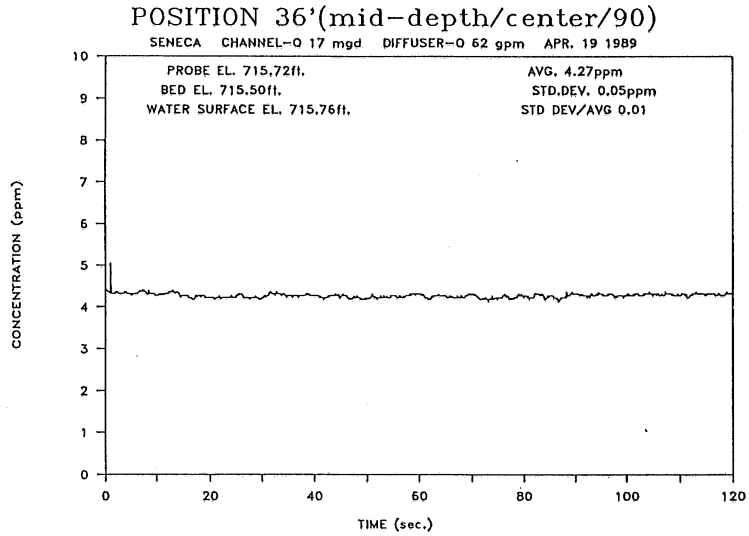
POSITION 29'(mid-flow/center/90)

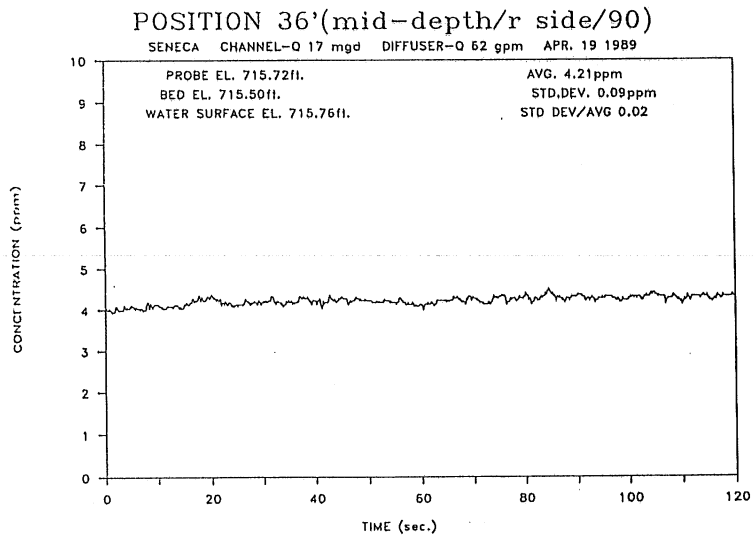


POSITION 29'(mid-flow/center/no dye)




POSITION 36'(mid-depth/l side/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.72ft.
BED EL. 715.50ft.
WATER SURFACE EL. 715.76ft.
AVG. 4.18ppm
STD.DEV. 0.05ppm
STD DEV/AVG 0.01
CONCENTRATION (ppm)
TIME (sec.)


POSITION 36'(mid-depth/center/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.72ft.
BED EL. 715.50ft.
WATER SURFACE EL. 715.76ft.
AVG. 4.27ppm
STD.DEV. 0.05ppm
STD DEV/AVG 0.01
CONCENTRATION (ppm)
TIME (sec.)

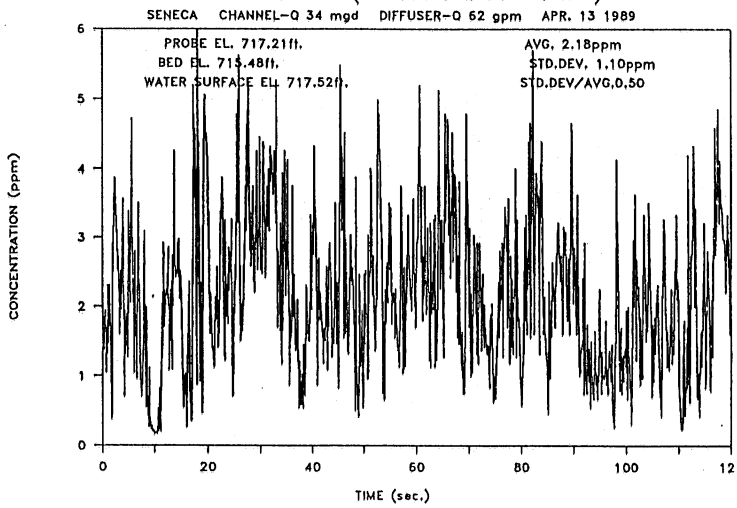

POSITION 36'(mid-depth/r side/90)
SENECA CHANNEL-Q 17 mgd DIFFUSER-Q 62 gpm APR. 19 1989
PROBE EL. 715.72ft.
BED EL. 715.50ft.
WATER SURFACE EL. 715.76ft.
AVG. 4.21ppm
STD.DEV. 0.09ppm
STD DEV/AVG 0.02
CONCENTRATION (ppm)
TIME (sec.)

CONCENTRATION RECORDS

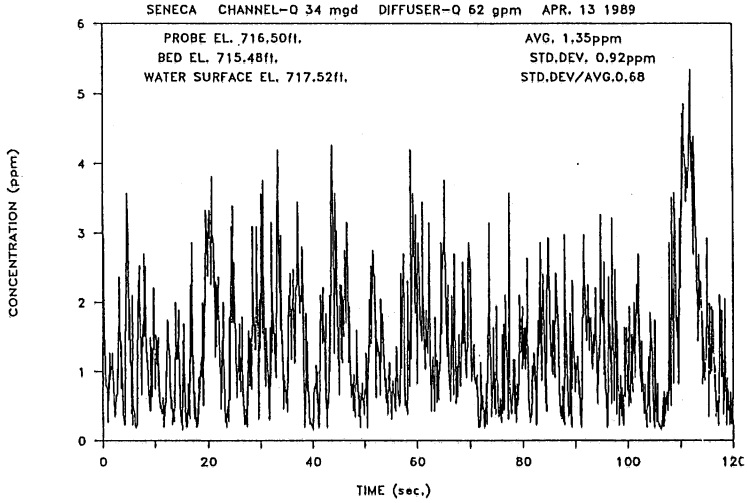
FOR

Q_w = 34 mgd

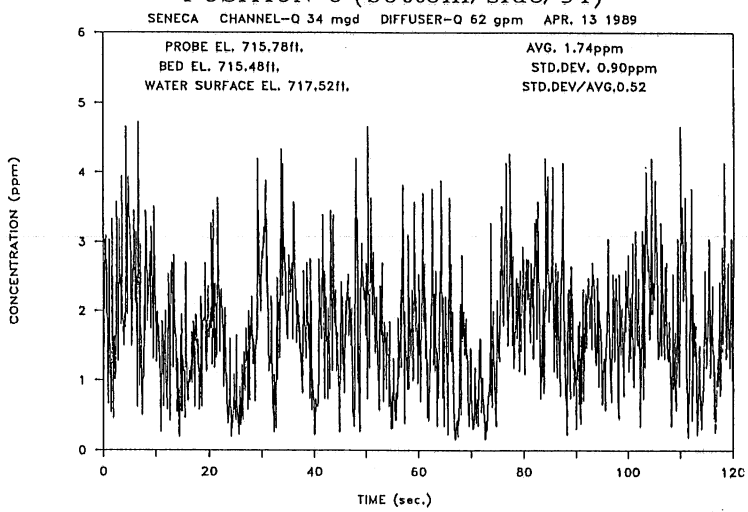
POSITION 6'(surface/side/54)

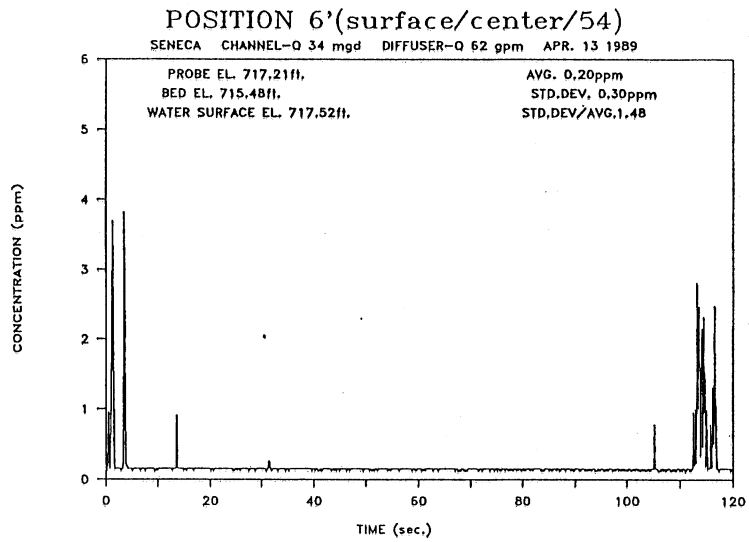


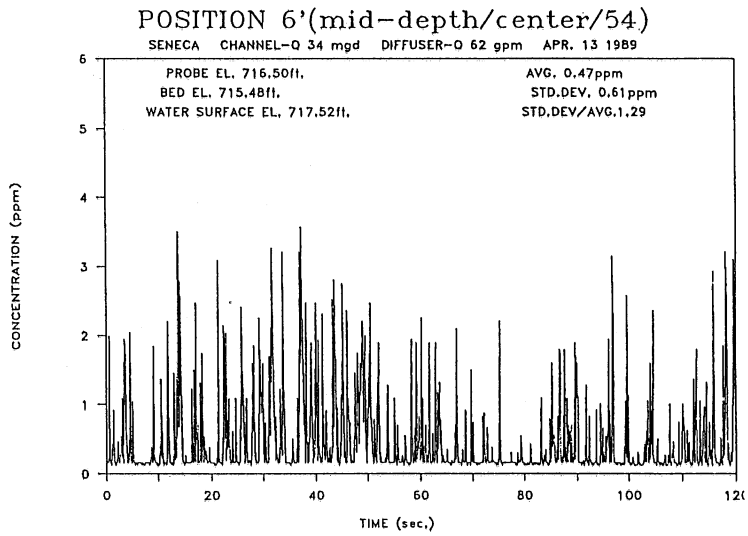
POSITION 6'(mid-depth/side/54)

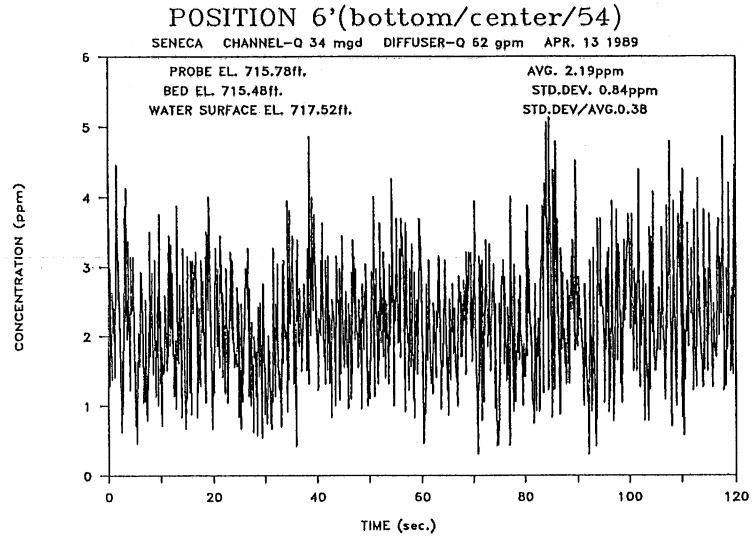


POSITION 6'(bottom/side/54)

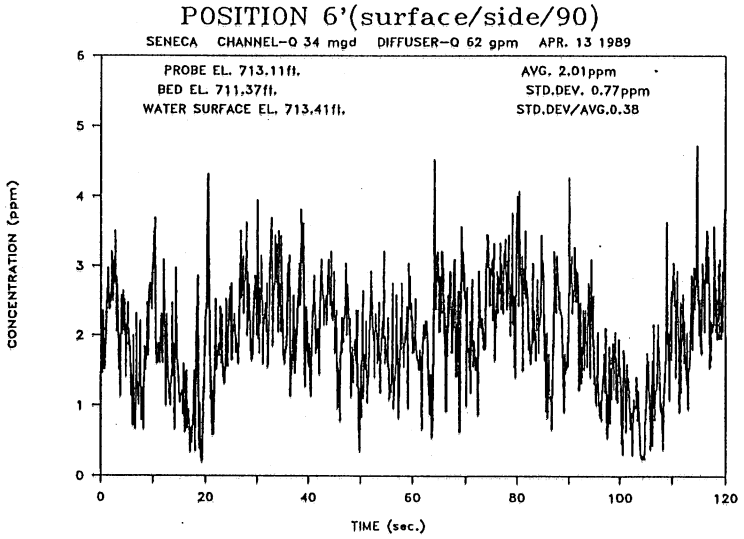



POSITION 6'(surface/center/54)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 717.21ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.52ft.
AVG. 0.20ppm
STD.DEV. 0.30ppm
STD.DEV/AVG.1.48
CONCENTRATION (ppm)
TIME (sec.)

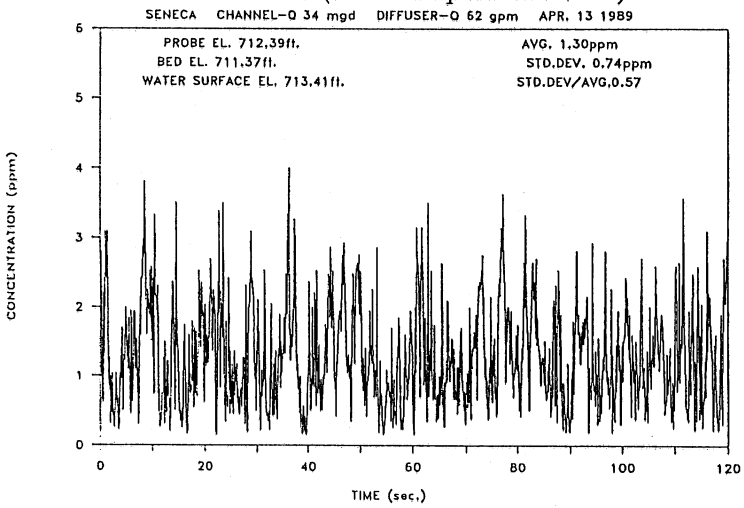

POSITION 6'(mid-depth/center/54)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 716.50ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.52ft.
AVG. 0.47ppm
STD.DEV. 0.61ppm
STD.DEV/AVG.1.29
CONCENTRATION (ppm)
TIME (sec.)


POSITION 6'(bottom/center/54)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 715.78ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.52ft.
AVG. 2.19ppm
STD.DEV. 0.84ppm
STD.DEV/AVG.0.38
CONCENTRATION (ppm)
TIME (sec.)

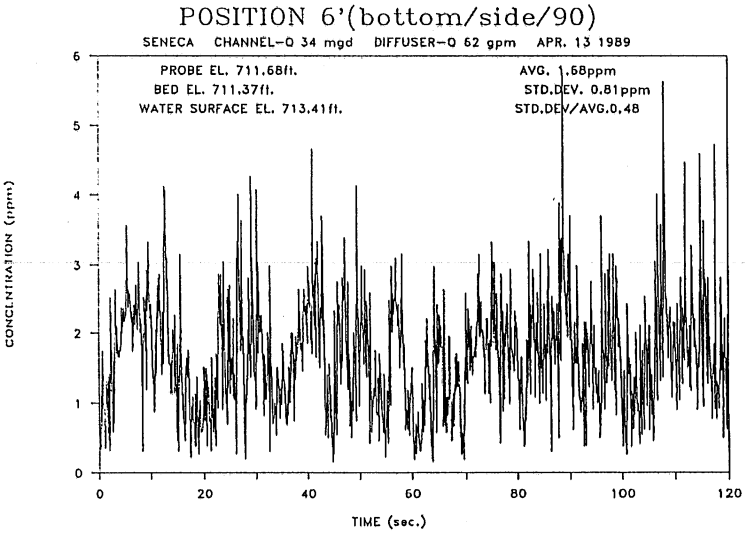
POSITION 6'(surface/side/90)



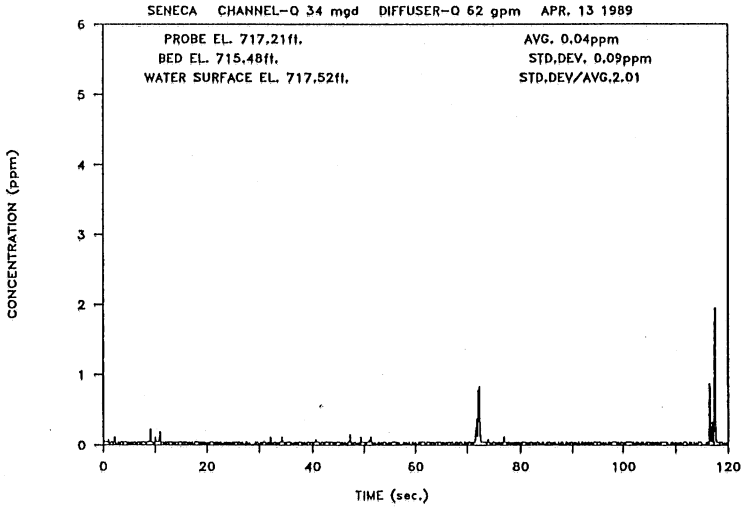
POSITION 6'(mid-depth/side/90)



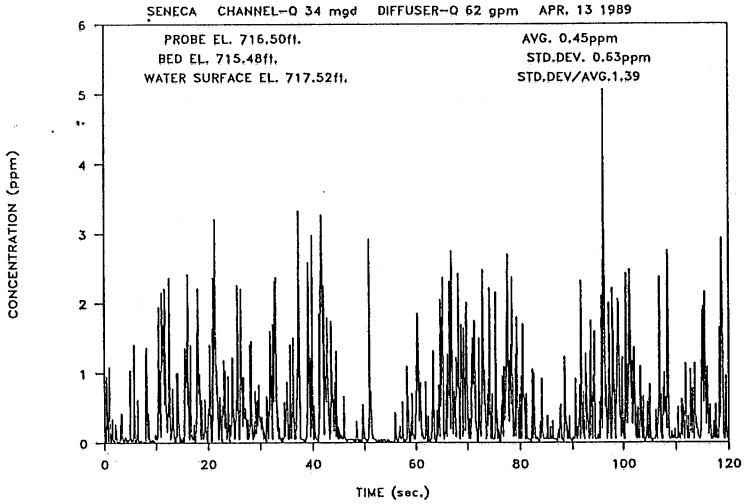
POSITION 6'(bottom/side/90)



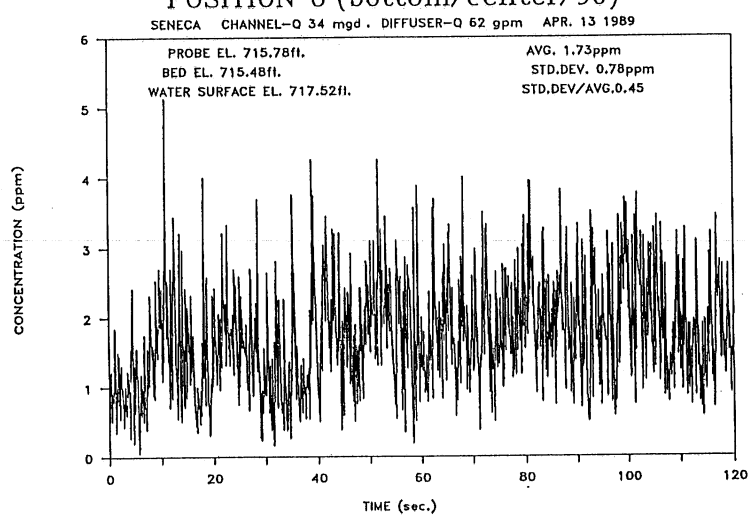
POSITION 6'(surface/center/90)

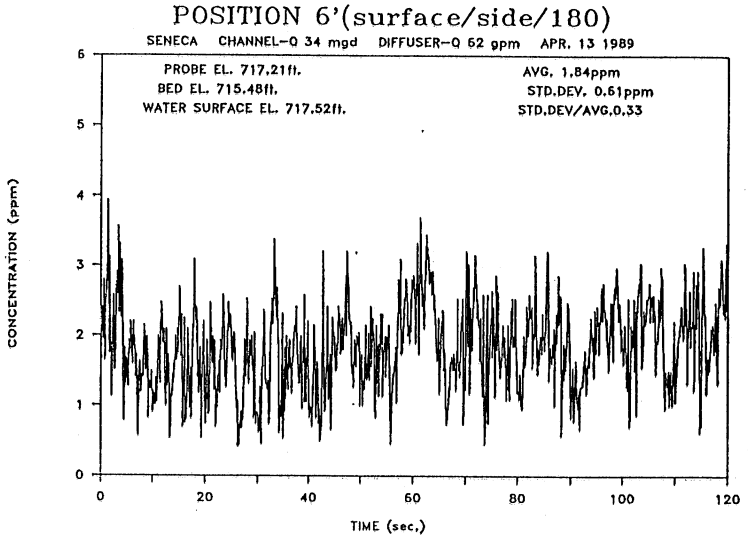


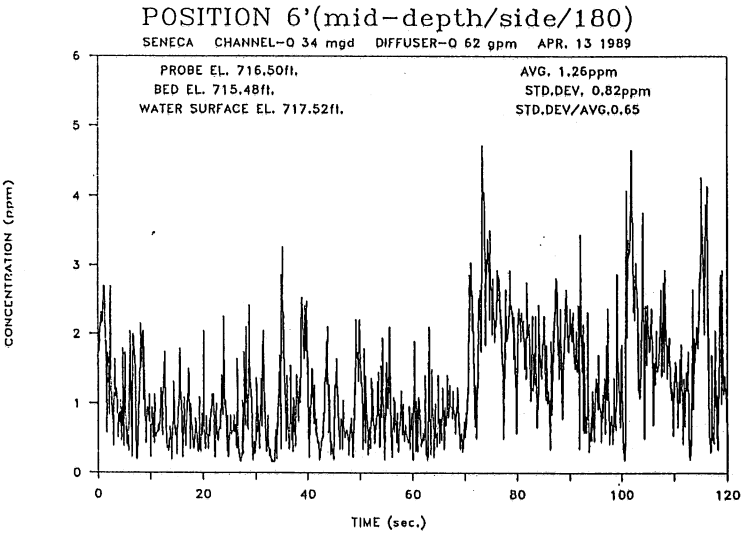
POSITION 6'(mid-depth/center/90)

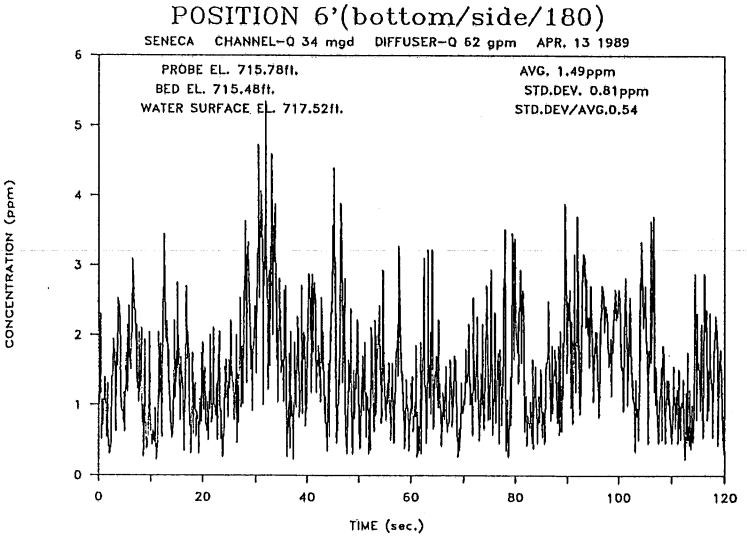


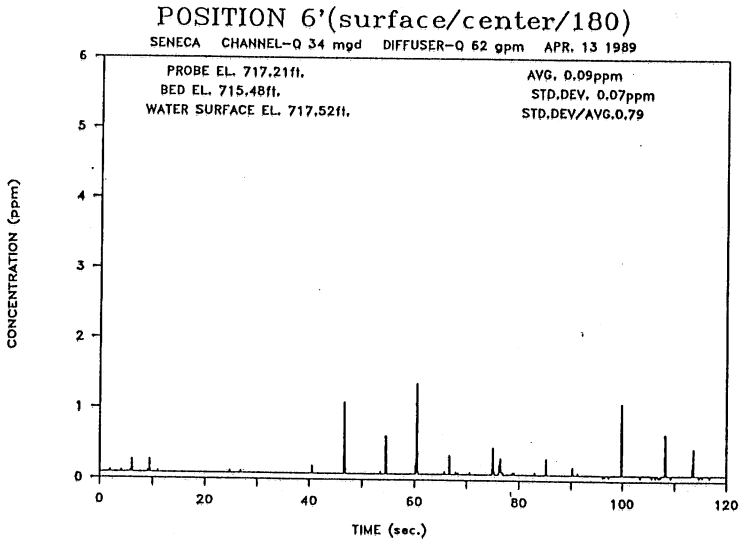
POSITION 6'(bottom/center/90)

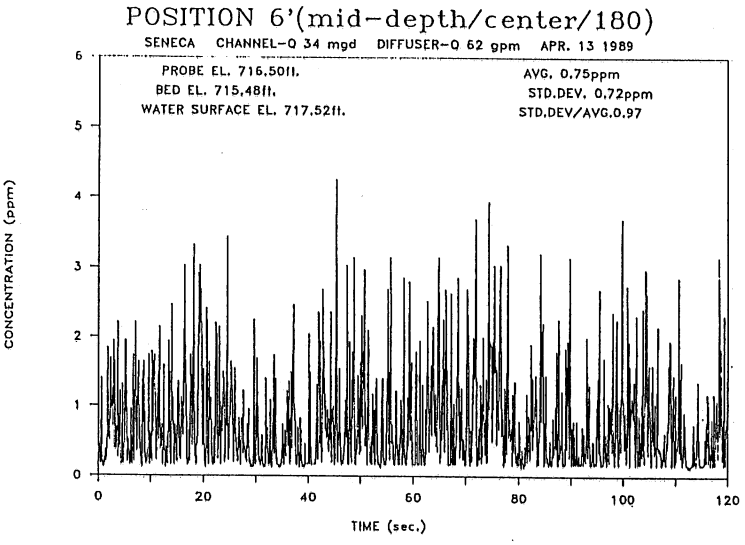


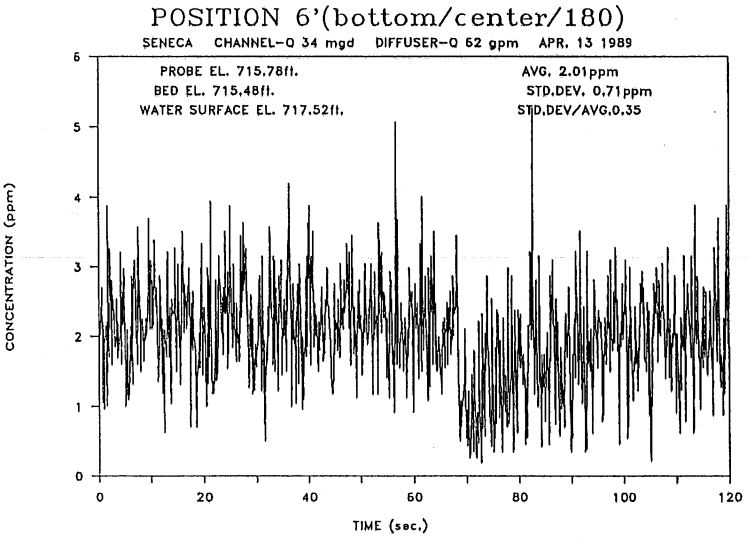

POSITION 6'(surface/side/180)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 717.21ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.52ft.
AVG. 1.84ppm
STD.DEV. 0.61ppm
STD.DEV/AVG.0.33
CONCENTRATION (ppm)
TIME (sec.)

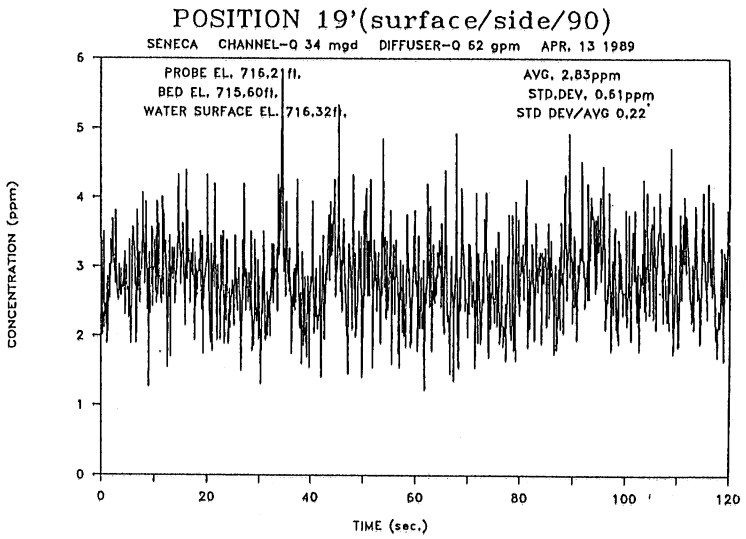

POSITION 6'(mid-depth/side/180)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 716.50ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.52ft.
AVG. 1.26ppm
STD.DEV. 0.82ppm
STD.DEV/AVG.0.65
CONCENTRATION (ppm)
TIME (sec.)

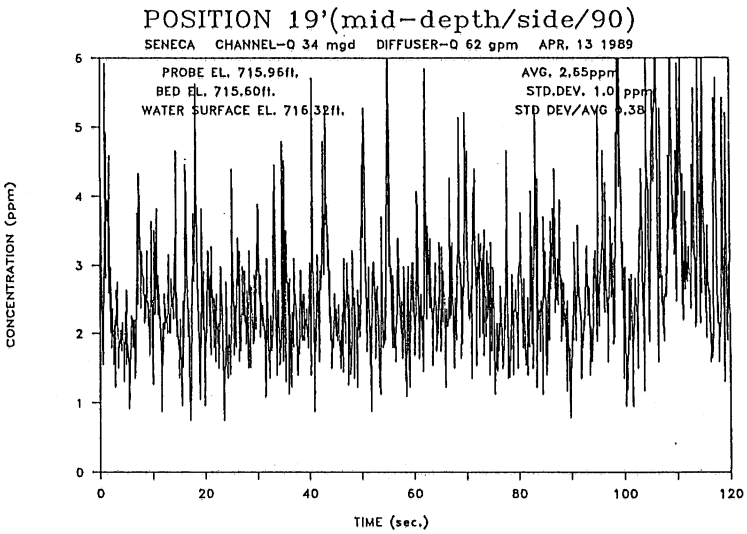

POSITION 6'(bottom/side/180)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 715.78ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.52ft.
AVG. 1.49ppm
STD.DEV. 0.81ppm
STD.DEV/AVG.0.54
CONCENTRATION (ppm)
TIME (sec.)

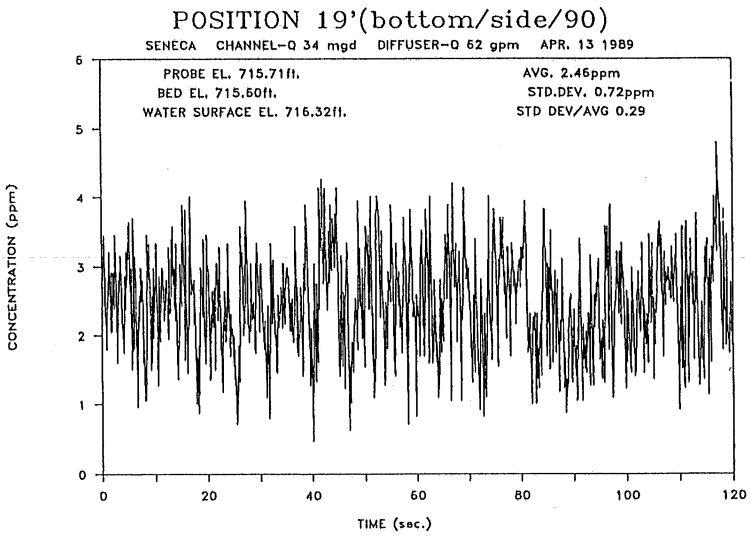

POSITION 6'(surface/center/180)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 717.21ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.52ft.
AVG. 0.09ppm
STD.DEV. 0.07ppm
STD.DEV/AVG.0.79
CONCENTRATION (ppm)
TIME (sec.)

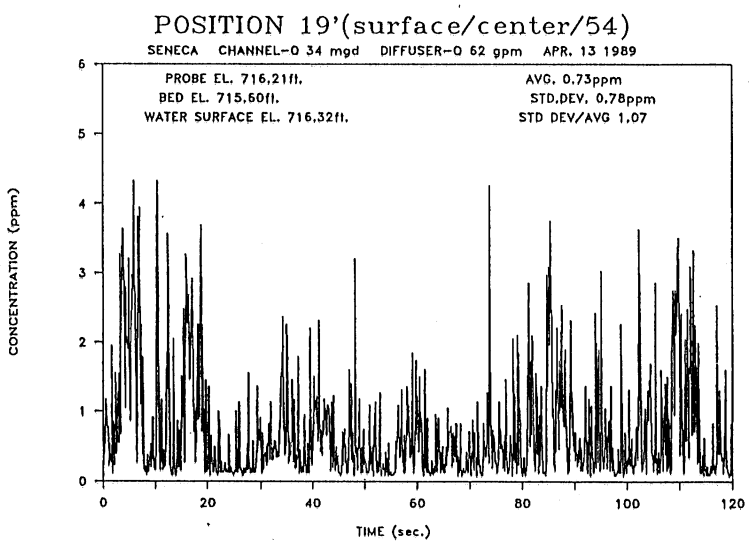

POSITION 6'(mid-depth/center/180)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 716.50ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.52ft.
AVG. 0.75ppm
STD.DEV. 0.72ppm
STD.DEV/AVG.0.97
CONCENTRATION (ppm)
TIME (sec.)

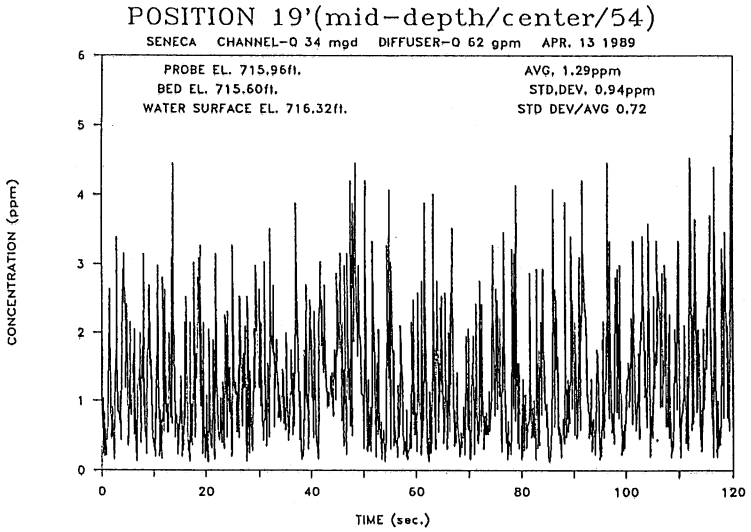

POSITION 6'(bottom/center/180)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 715.78ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.52ft.
AVG. 2.01ppm
STD.DEV. 0.71ppm
STD.DEV/AVG.0.35
CONCENTRATION (ppm)
TIME (sec.)

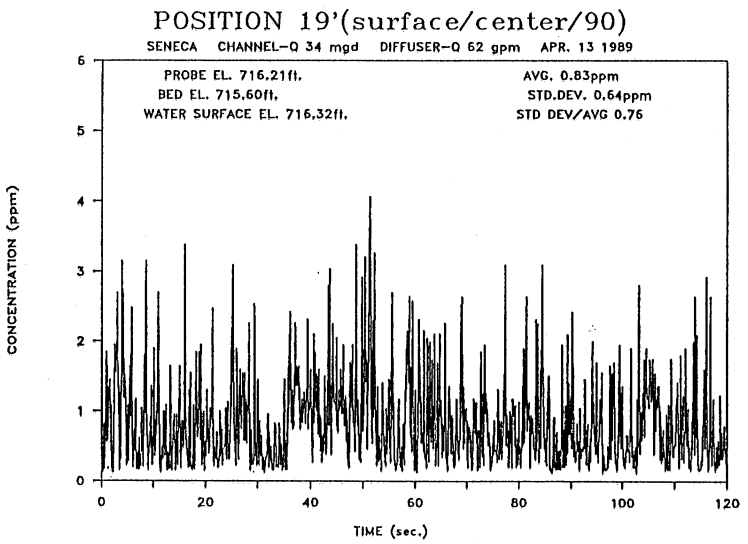

POSITION 19'(surface/side/90)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 716.21ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.32ft.
AVG. 2.83ppm
STD.DEV. 0.61ppm
STD DEV/AVG 0.22
CONCENTRATION (ppm)
TIME (sec.)

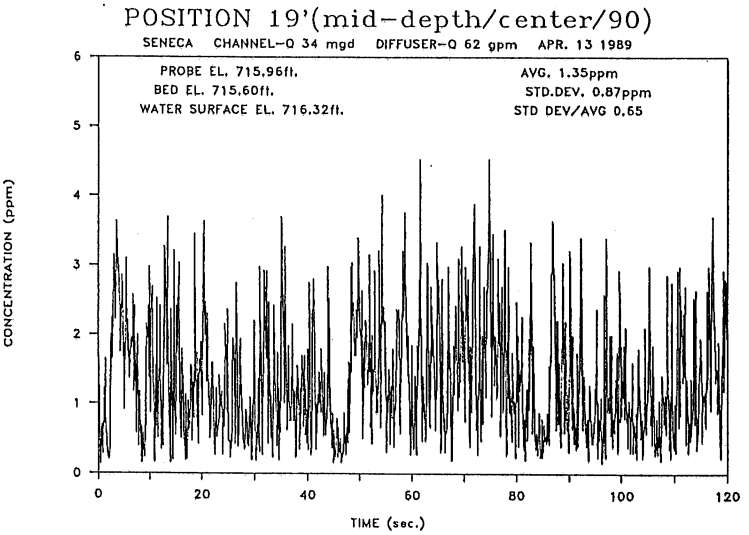

POSITION 19'(mid-depth/side/90)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 715.96ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.32ft.
AVG. 2.65ppm
STD.DEV. 1.0 ppm
STD DEV/AVG 0.38
CONCENTRATION (ppm)
TIME (sec.)

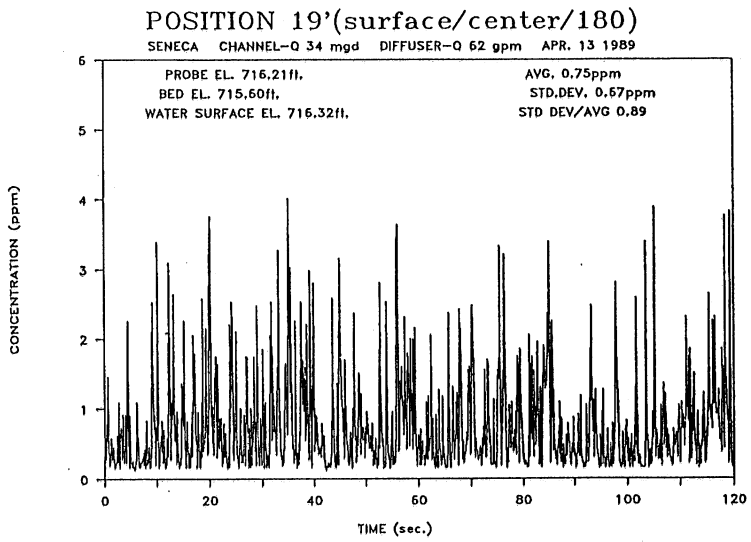

POSITION 19'(bottom/side/90)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 715.71ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.32ft.
AVG. 2.46ppm
STD.DEV. 0.72ppm
STD DEV/AVG 0.29
CONCENTRATION (ppm)
TIME (sec.)

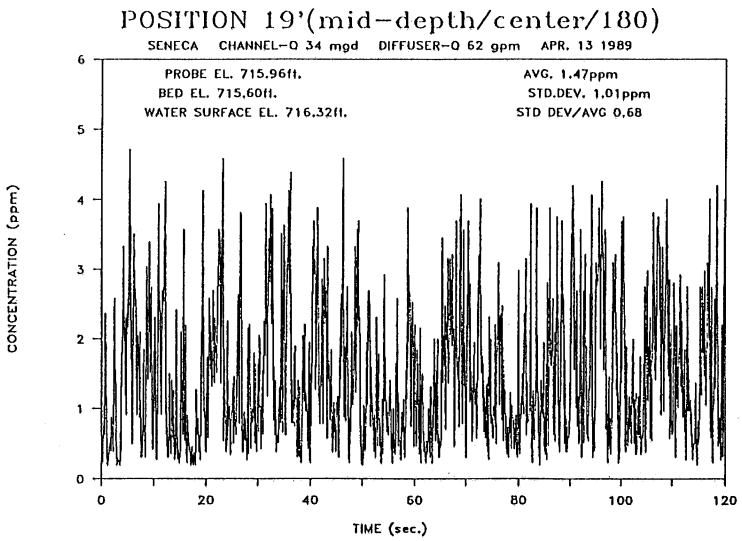

POSITION 19'(surface/center/54)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 716.21ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.32ft.
AVG. 0.73ppm
STD.DEV. 0.78ppm
STD DEV/AVG 1.07
CONCENTRATION (ppm)
TIME (sec.)


POSITION 19'(mid-depth/center/54)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 715.96ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.32ft.
AVG. 1.29ppm
STD.DEV. 0.94ppm
STD DEV/AVG 0.72
CONCENTRATION (ppm)
TIME (sec.)

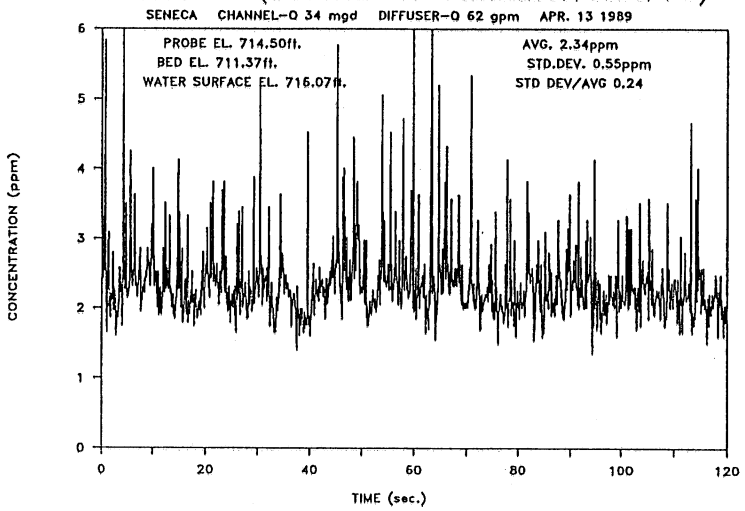

POSITION 19'(surface/center/90)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 716.21ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.32ft.
AVG. 0.83ppm
STD.DEV. 0.64ppm
STD DEV/AVG 0.76
CONCENTRATION (ppm)
TIME (sec.)


POSITION 19'(mid-depth/center/90)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 715.96ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.32ft.
AVG. 1.35ppm
STD.DEV. 0.87ppm
STD DEV/AVG 0.65
CONCENTRATION (ppm)
TIME (sec.)

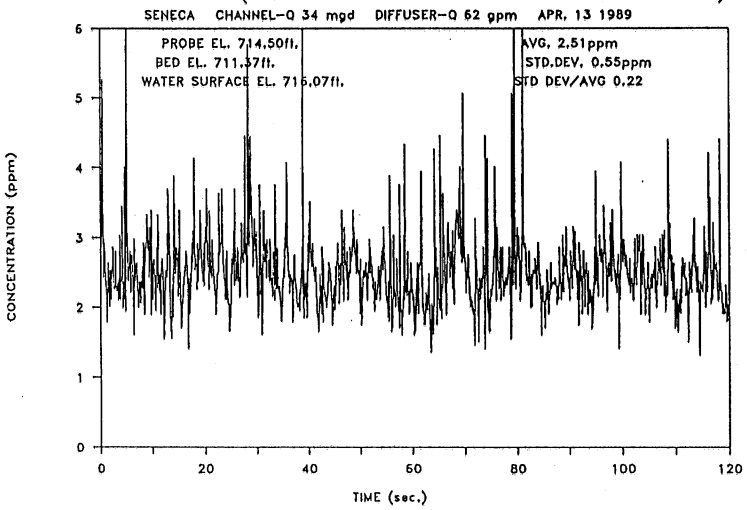

POSITION 19'(surface/center/180)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 716.21ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.32ft.
AVG. 0.75ppm
STD.DEV. 0.67ppm
STD DEV/AVG 0.89
CONCENTRATION (ppm)
TIME (sec.)


POSITION 19'(mid-depth/center/180)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
PROBE EL. 715.96ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.32ft.
AVG. 1.47ppm
STD.DEV. 1.01ppm
STD DEV/AVG 0.68
CONCENTRATION (ppm)
TIME (sec.)

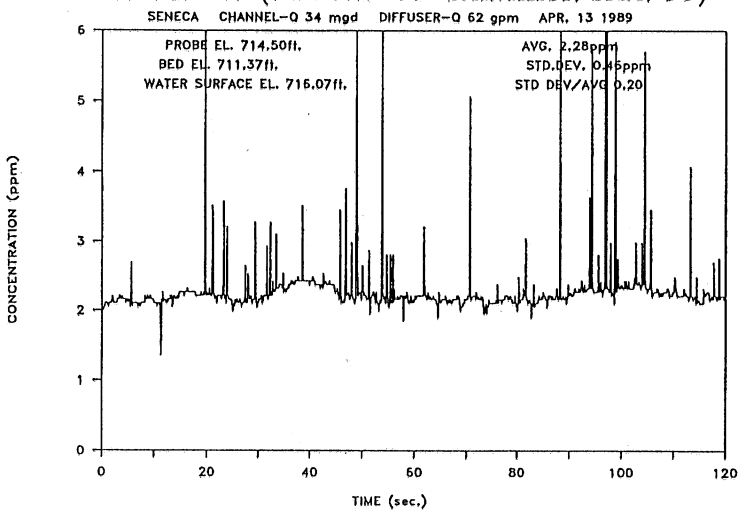
POSITION 27'(bottom-of-skimmer/side/90)



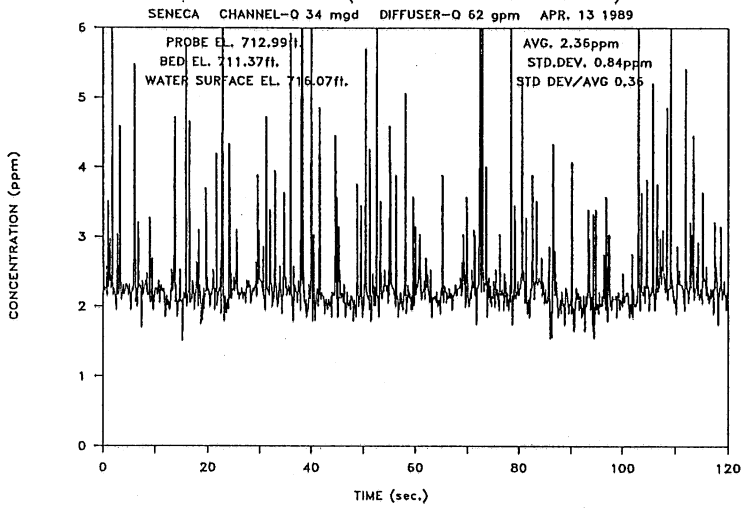
POSITION 27'(bottom-of-skimmer/center/90)



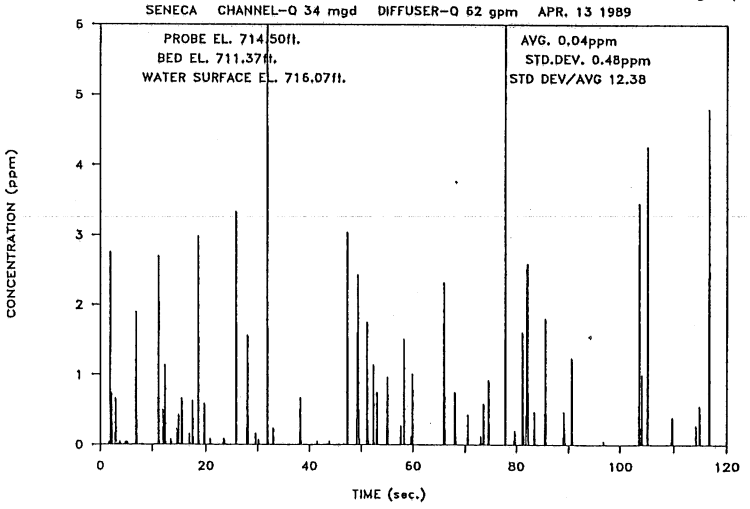
POSITION 29'(bottom-of-skimmer/side/90)

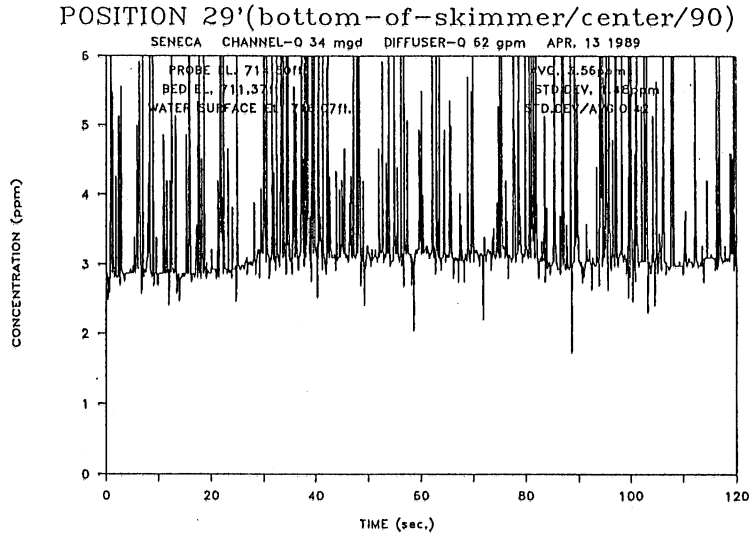


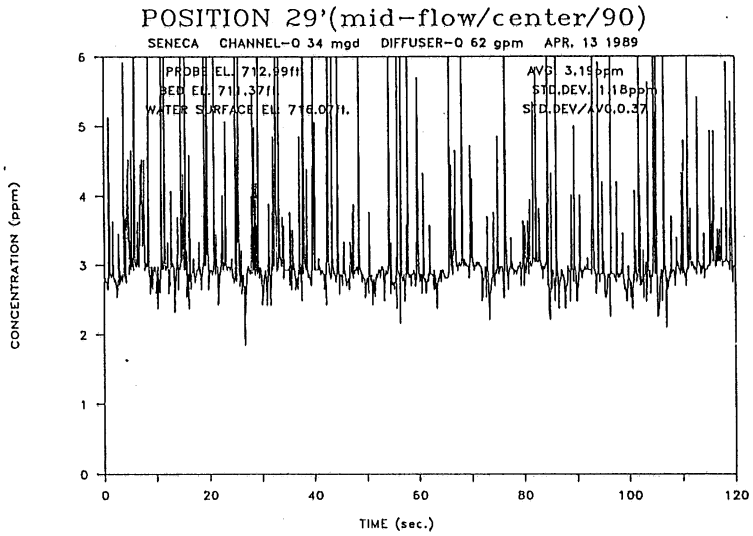
POSITION 29'(mid-flow/side/90)



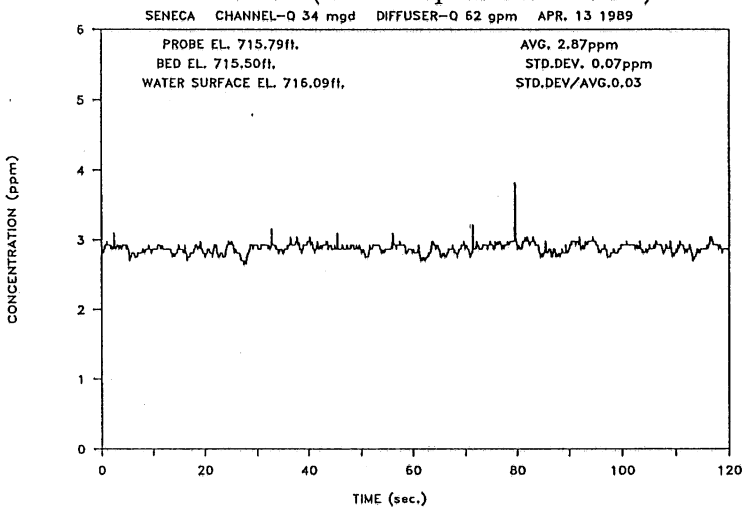
POSITION 29'(bottom-of-skimmer/side/no dye)



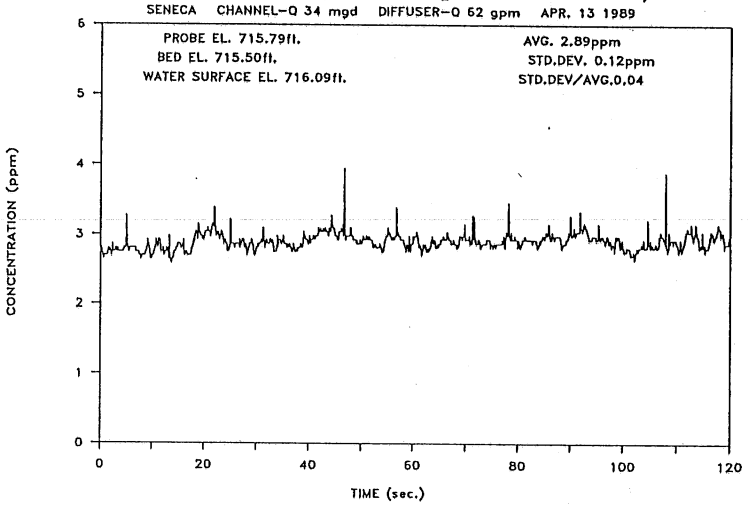

POSITION 29'(bottom-of-skimmer/center/90)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
CONCENTRATION (ppm)
TIME (sec.)


POSITION 29'(mid-flow/center/90)
SENECA CHANNEL-Q 34 mgd DIFFUSER-Q 62 gpm APR. 13 1989
CONCENTRATION (ppm)
TIME (sec.)

POSITION 36'(mid-depth/center/90)



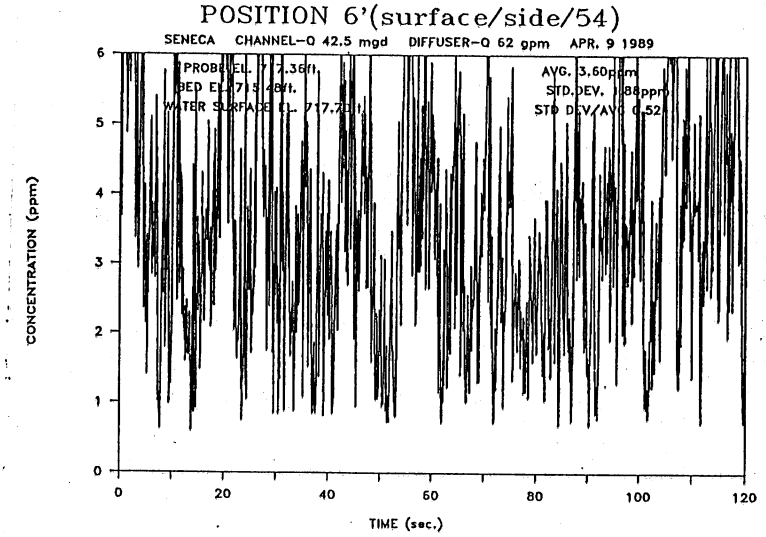
POSITION 36'(mid-depth/r side/90)

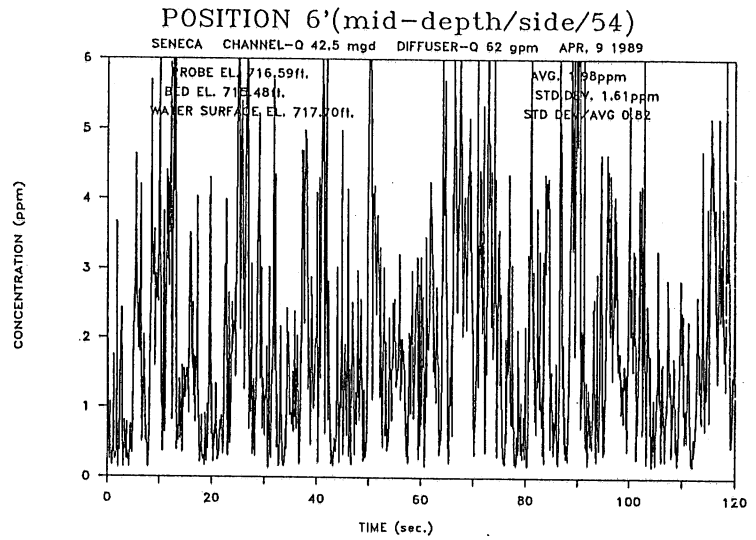


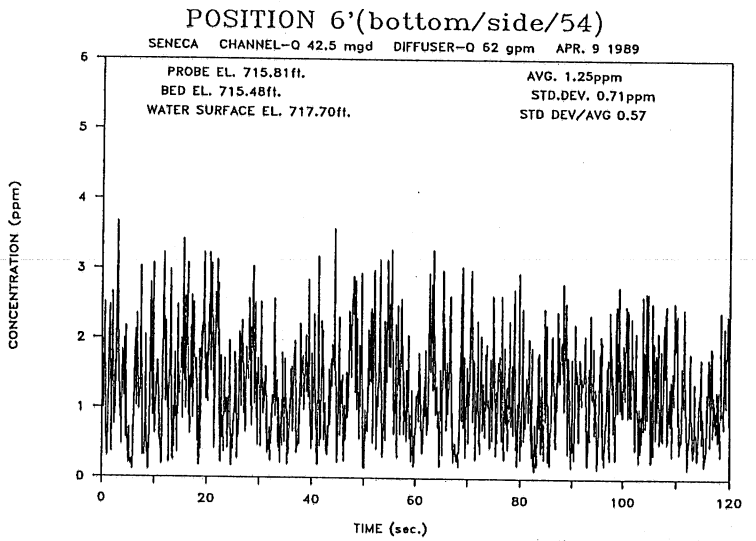
CONCENTRATION RECORDS

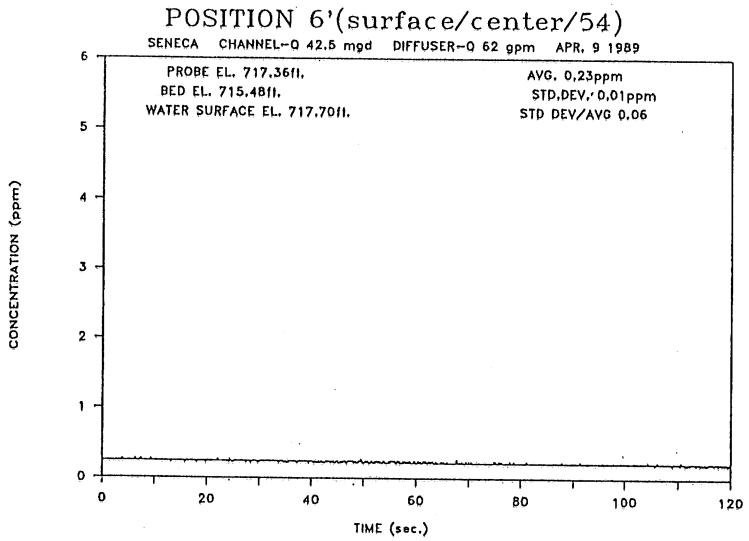
FOR

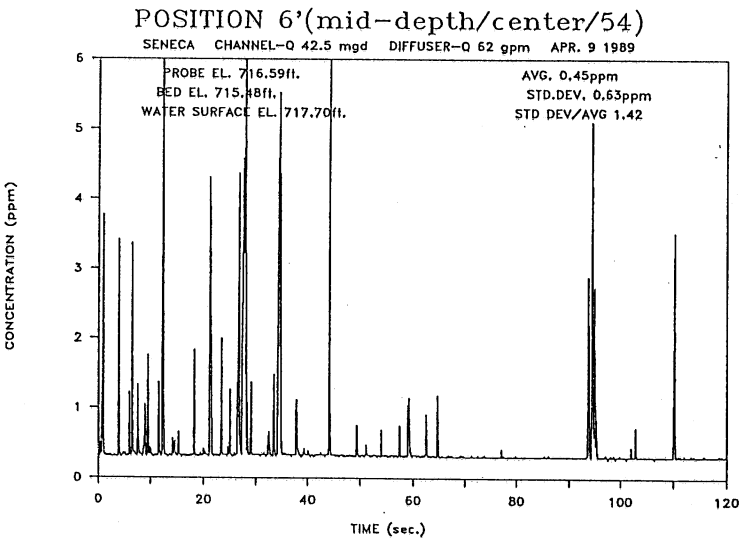
Q_w = 42.5 mgd

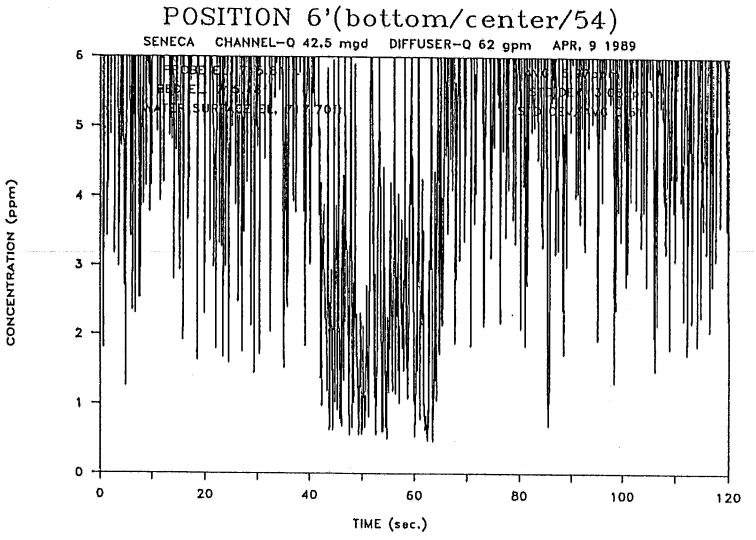

POSITION 6'(surface/side/54)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 717.36ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.70ft.
AVG. 3.60ppm
STD.DEV. 1.88ppm
STD DEV/AVG 0.52
CONCENTRATION (ppm)
TIME (sec.)

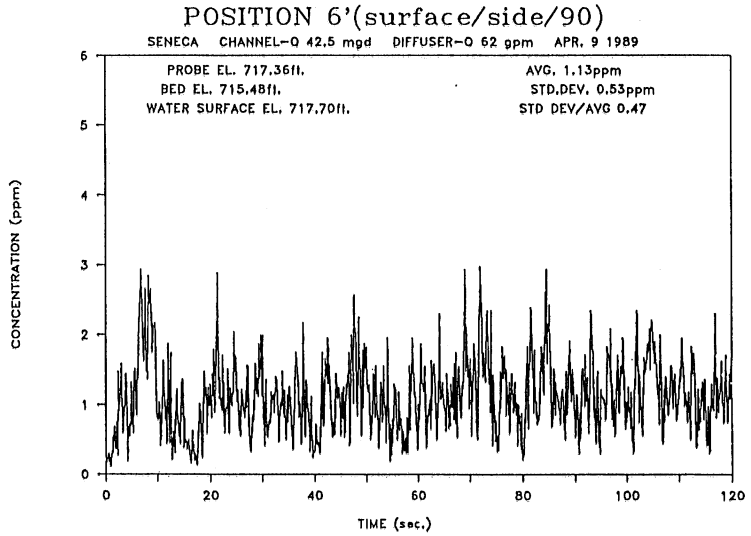

POSITION 6'(mid-depth/side/54)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.59ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.70ft.
AVG. 1.98ppm
STD.DEV. 1.61ppm
STD DEV/AVG 0.82
CONCENTRATION (ppm)
TIME (sec.)

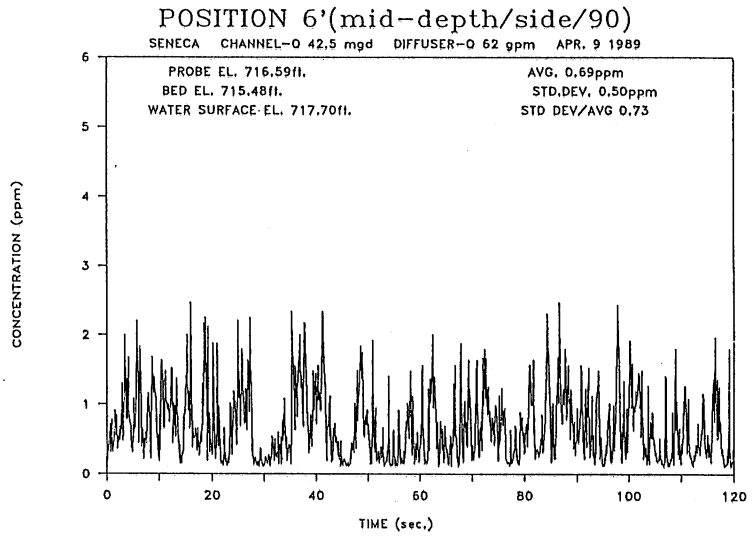

POSITION 6'(bottom/side/54)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 715.81ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.70ft.
AVG. 1.25ppm
STD.DEV. 0.71ppm
STD DEV/AVG 0.57
CONCENTRATION (ppm)
TIME (sec.)

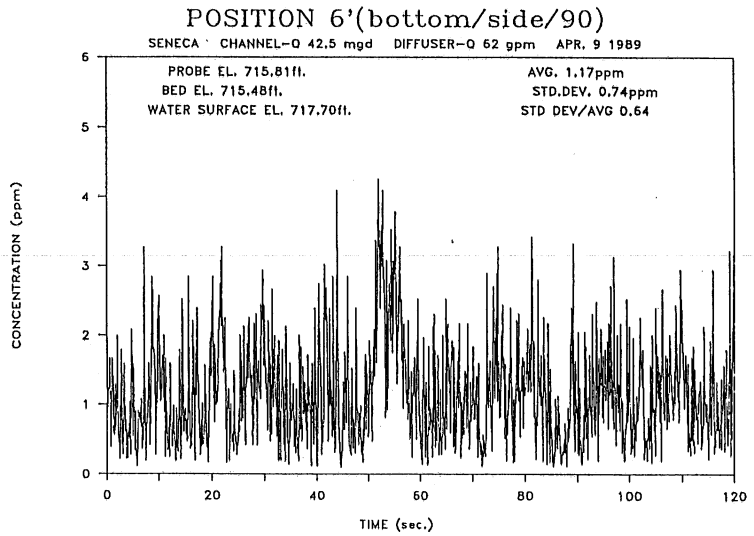

POSITION 6'(surface/center/54)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 717.36ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.70ft.
AVG. 0.23ppm
STD.DEV. 0.01ppm
STD DEV/AVG 0.06
CONCENTRATION (ppm)
TIME (sec.)

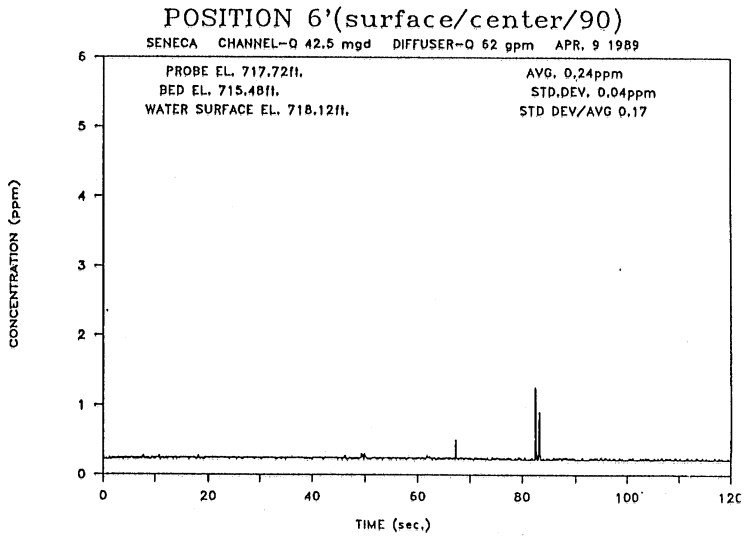

POSITION 6'(mid-depth/center/54)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.59ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.70ft.
AVG. 0.45ppm
STD.DEV. 0.63ppm
STD DEV/AVG 1.42
CONCENTRATION (ppm)
TIME (sec.)

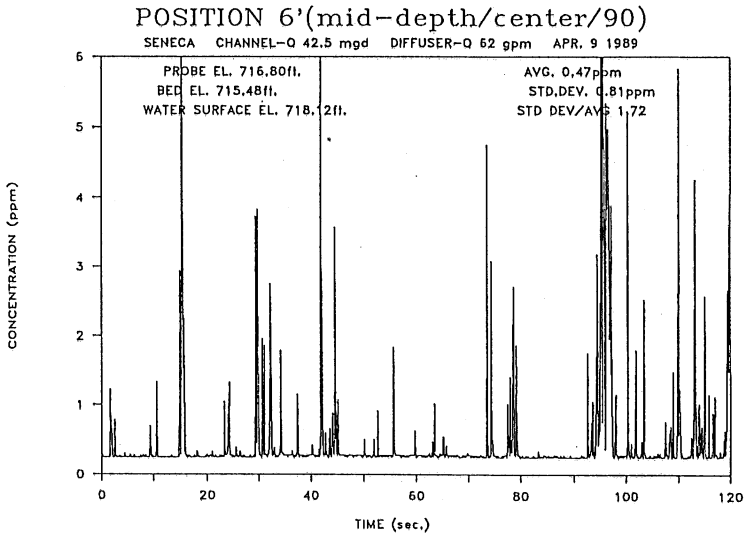

POSITION 6'(bottom/center/54)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
CONCENTRATION (ppm)
TIME (sec.)

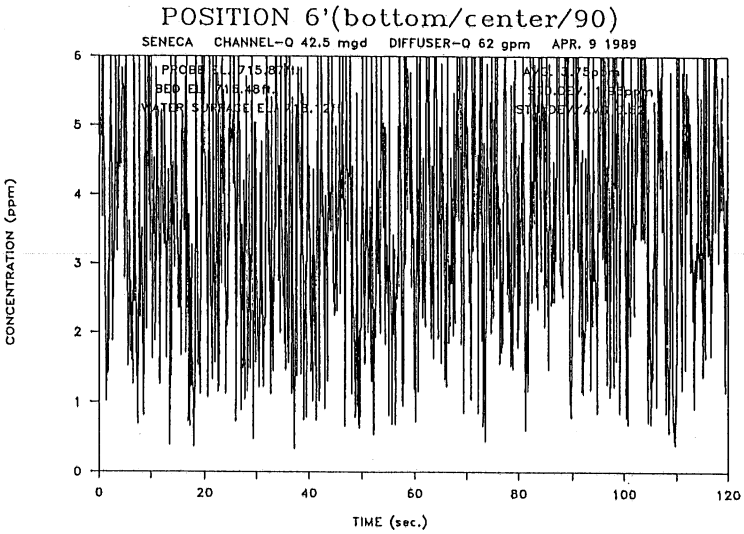

POSITION 6'(surface/side/90)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 717.36ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.70ft.
AVG. 1.13ppm
STD.DEV. 0.53ppm
STD DEV/AVG 0.47
CONCENTRATION (ppm)
TIME (sec.)


POSITION 6'(mid-depth/side/90)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.59ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.70ft.
AVG. 0.69ppm
STD.DEV. 0.50ppm
STD DEV/AVG 0.73
CONCENTRATION (ppm)
TIME (sec.)

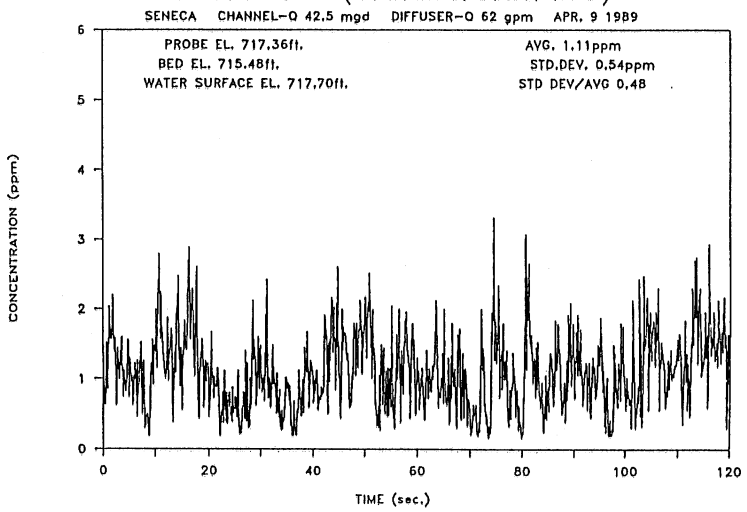

POSITION 6'(bottom/side/90)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 715.81ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.70ft.
AVG. 1.17ppm
STD.DEV. 0.74ppm
STD DEV/AVG 0.64
CONCENTRATION (ppm)
TIME (sec.)


POSITION 6'(surface/center/90)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 717.72ft.
BED EL. 715.48ft.
WATER SURFACE EL. 718.12ft.
AVG. 0.24ppm
STD.DEV. 0.04ppm
STD DEV/AVG 0.17
CONCENTRATION (ppm)
TIME (sec.)

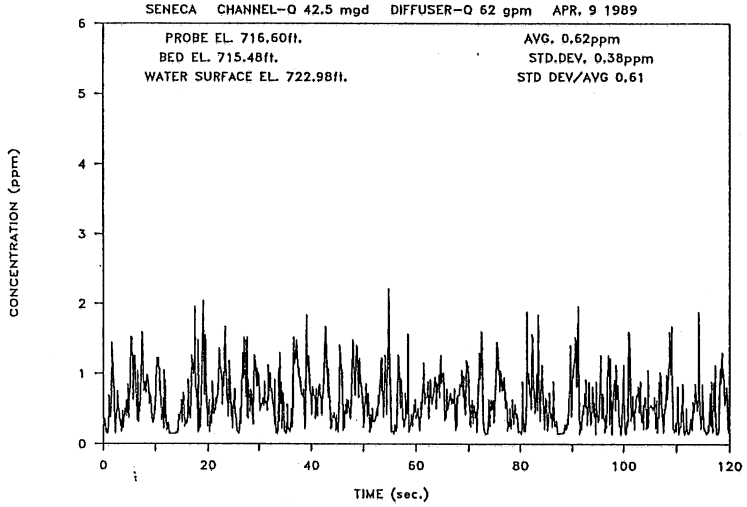

POSITION 6'(mid-depth/center/90)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.80ft.
BED EL. 715.48ft.
WATER SURFACE EL. 718.12ft.
AVG. 0.47ppm
STD.DEV. 0.81ppm
STD DEV/AVG 1.72
CONCENTRATION (ppm)
TIME (sec.)


POSITION 6'(bottom/center/90)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
CONCENTRATION (ppm)
TIME (sec.)

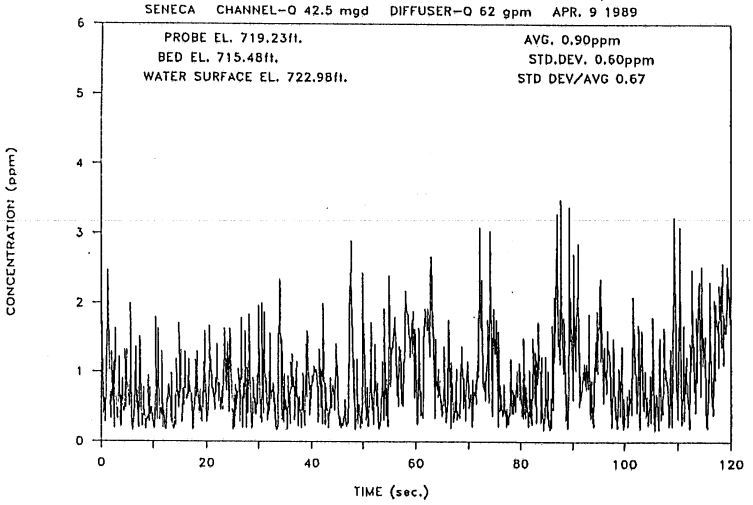
POSITION 6'(surface/side/180)

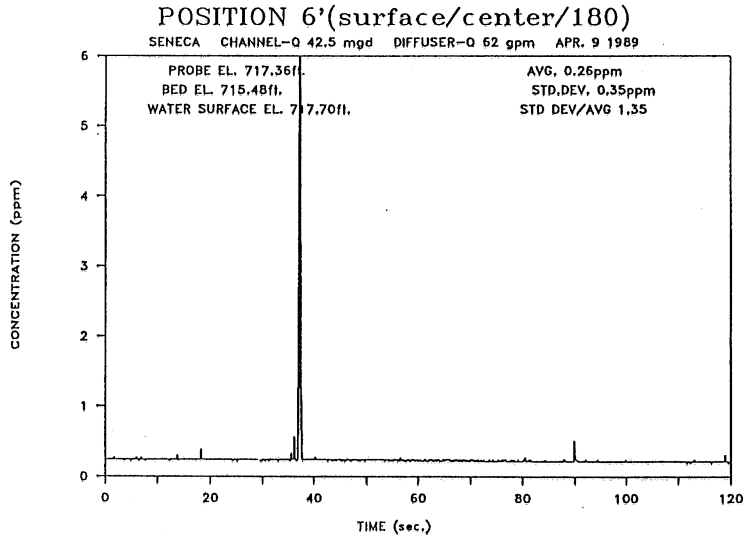


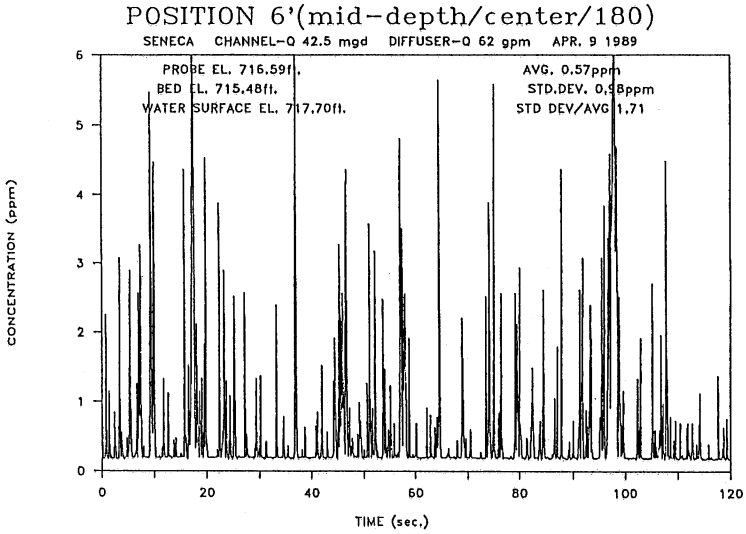
POSITION 6'(mid-depth/side/180)

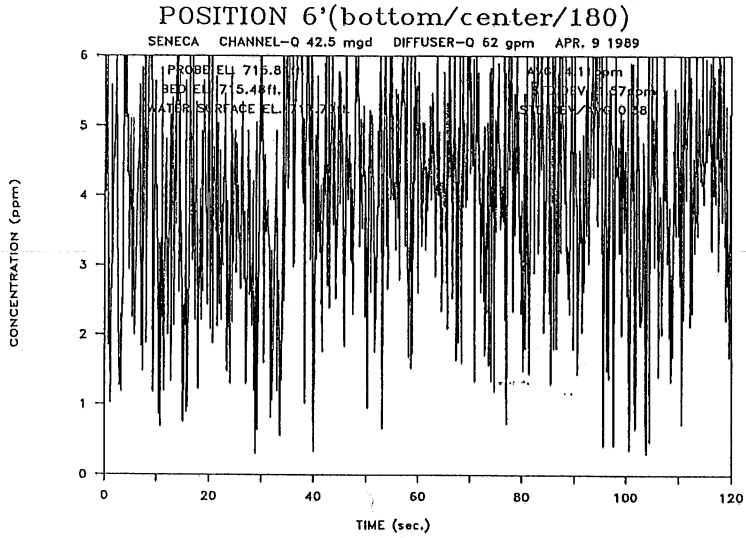


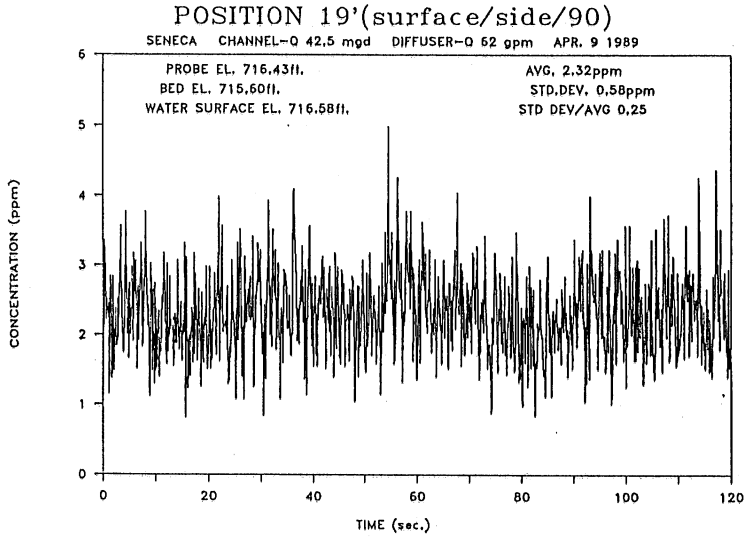
POSITION 6'(bottom/side/180)

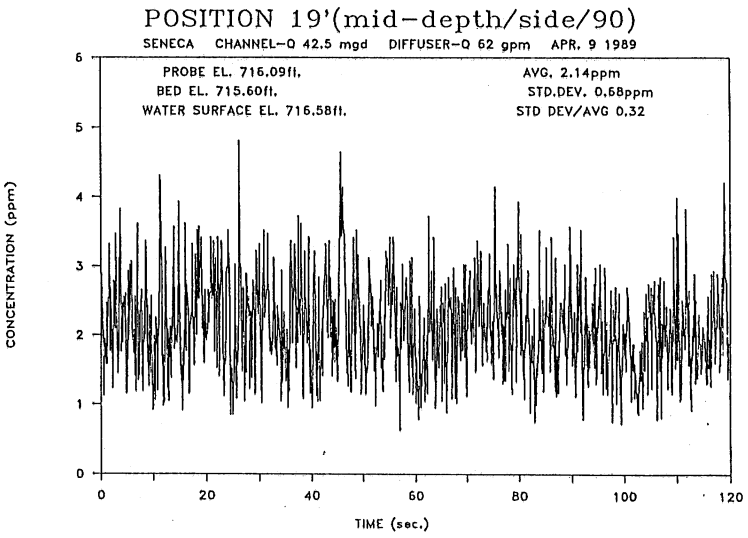


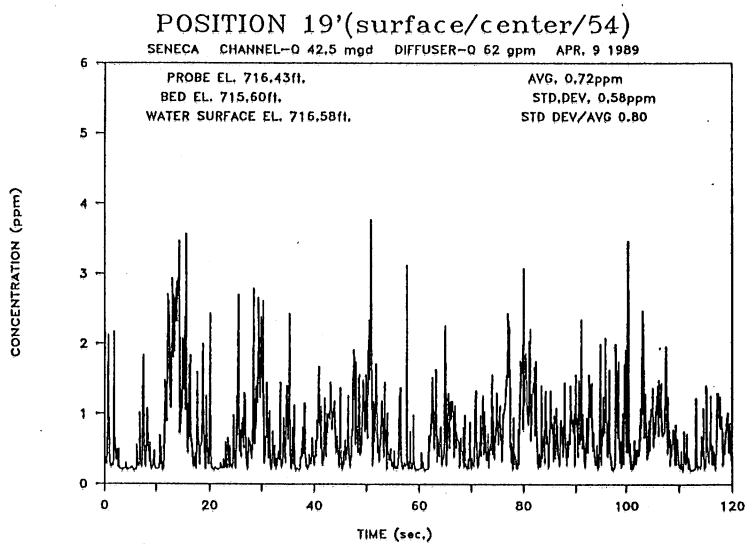

POSITION 6'(surface/center/180)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 717.36ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.70ft.
AVG. 0.26ppm
STD.DEV. 0.35ppm
STD DEV/AVG 1.35
CONCENTRATION (ppm)
TIME (sec.)

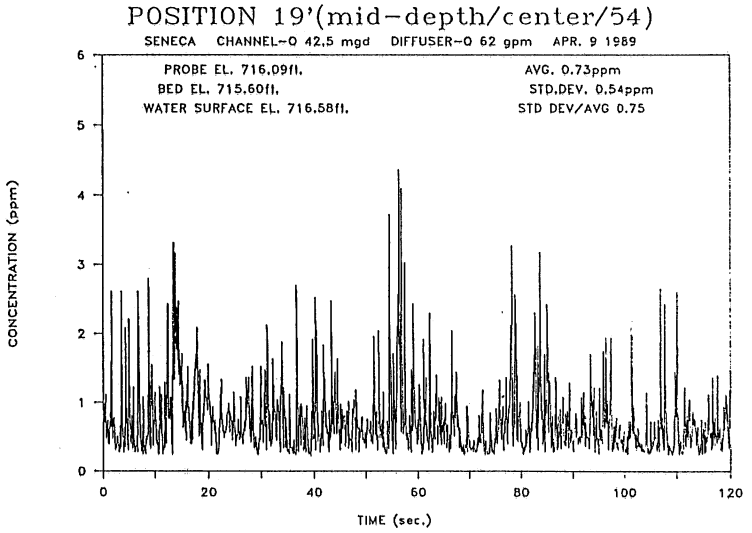

POSITION 6'(mid-depth/center/180)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.59ft.
BED EL. 715.48ft.
WATER SURFACE EL. 717.70ft.
AVG. 0.57ppm
STD.DEV. 0.98ppm
STD DEV/AVG 1.71
CONCENTRATION (ppm)
TIME (sec.)

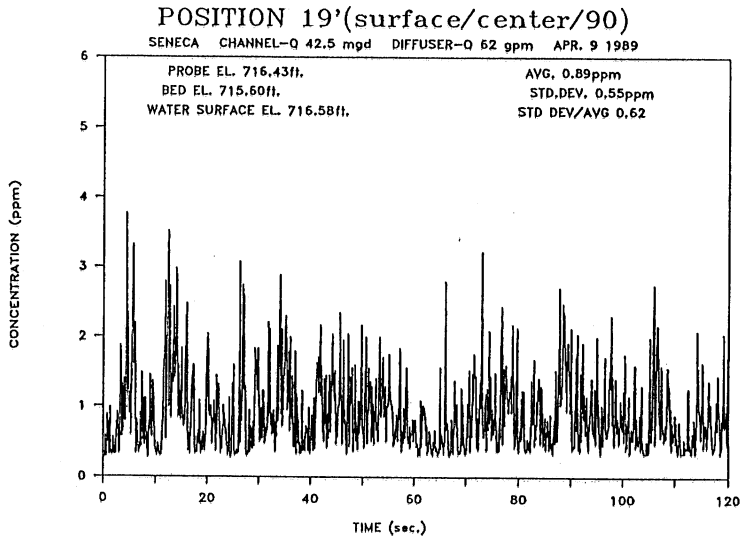

POSITION 6'(bottom/center/180)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 715.8
BED EL. 715.48ft.
CONCENTRATION (ppm)
TIME (sec.)

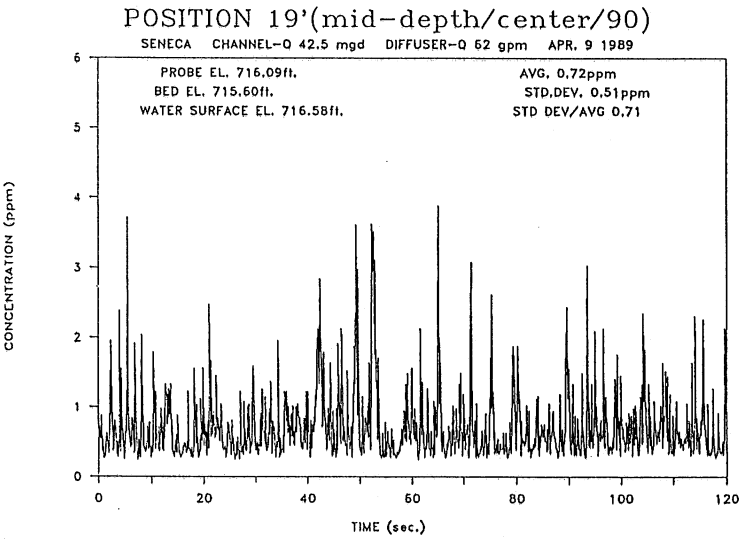

POSITION 19'(surface/side/90)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.43ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.58ft.
AVG. 2.32ppm
STD.DEV. 0.58ppm
STD DEV/AVG 0.25
CONCENTRATION (ppm)
TIME (sec.)

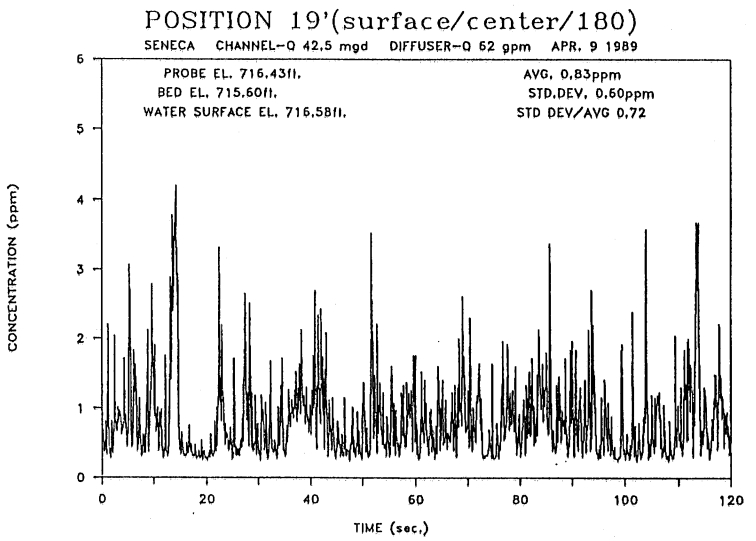

POSITION 19'(mid-depth/side/90)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.09ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.58ft.
AVG. 2.14ppm
STD.DEV. 0.68ppm
STD DEV/AVG 0.32
CONCENTRATION (ppm)
TIME (sec.)

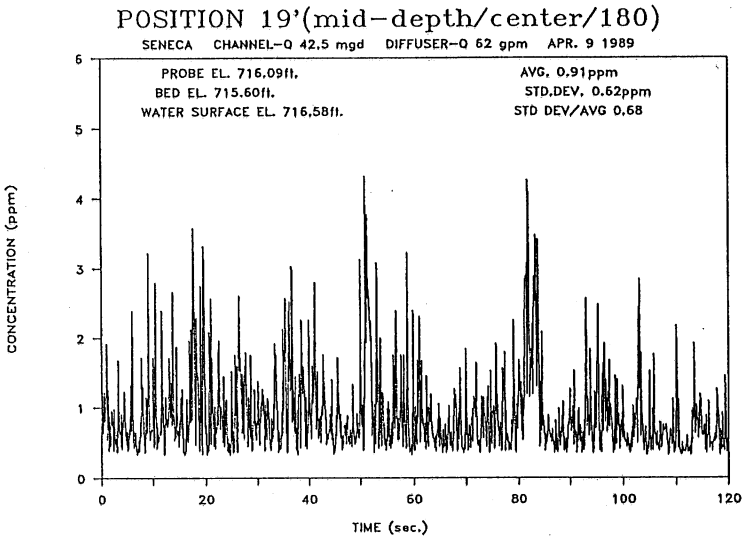

POSITION 19'(surface/center/54)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.43ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.58ft.
AVG. 0.72ppm
STD.DEV. 0.58ppm
STD DEV/AVG 0.80
CONCENTRATION (ppm)
TIME (sec.)

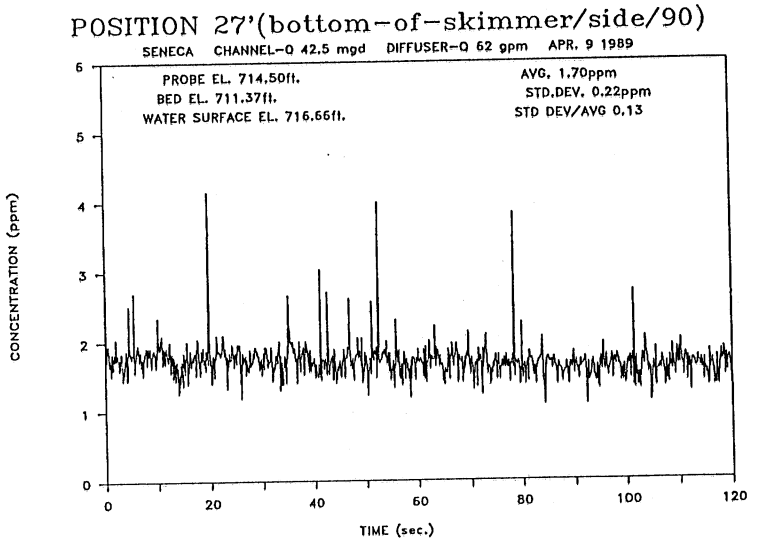

POSITION 19'(mid-depth/center/54)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.09ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.58ft.
AVG. 0.73ppm
STD.DEV. 0.54ppm
STD DEV/AVG 0.75
CONCENTRATION (ppm)
TIME (sec.)


POSITION 19'(surface/center/90)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.43ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.58ft.
AVG, 0.89ppm
STD.DEV. 0.55ppm
STD DEV/AVG 0.62
CONCENTRATION (ppm)
TIME (sec.)

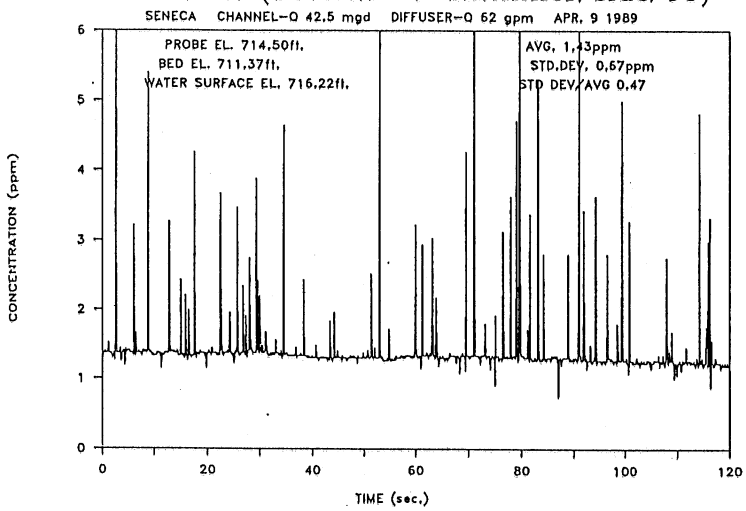

POSITION 19'(mid-depth/center/90)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.09ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.58ft.
AVG, 0.72ppm
STD.DEV. 0.51ppm
STD DEV/AVG 0.71
CONCENTRATION (ppm)
TIME (sec.)


POSITION 19'(surface/center/180)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.43ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.58ft.
AVG. 0.83ppm
STD.DEV. 0.60ppm
STD DEV/AVG 0.72
CONCENTRATION (ppm)
TIME (sec.)

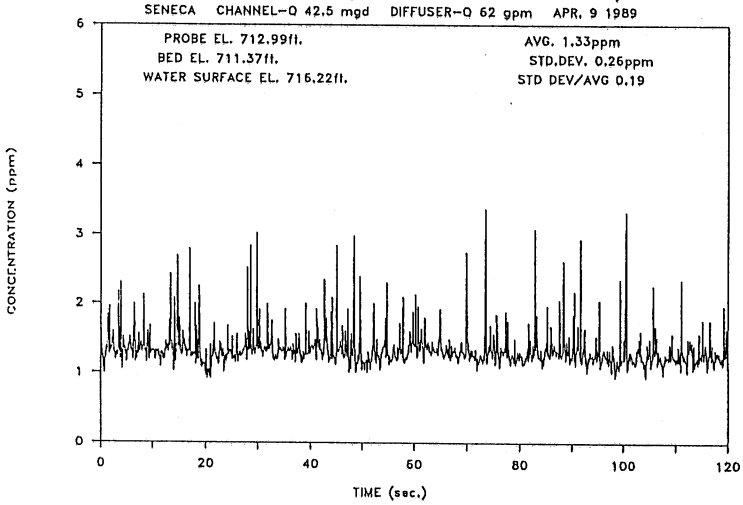

POSITION 19'(mid-depth/center/180)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.09ft.
BED EL. 715.60ft.
WATER SURFACE EL. 716.58ft.
AVG. 0.91ppm
STD.DEV. 0.62ppm
STD DEV/AVG 0.68
CONCENTRATION (ppm)
TIME (sec.)

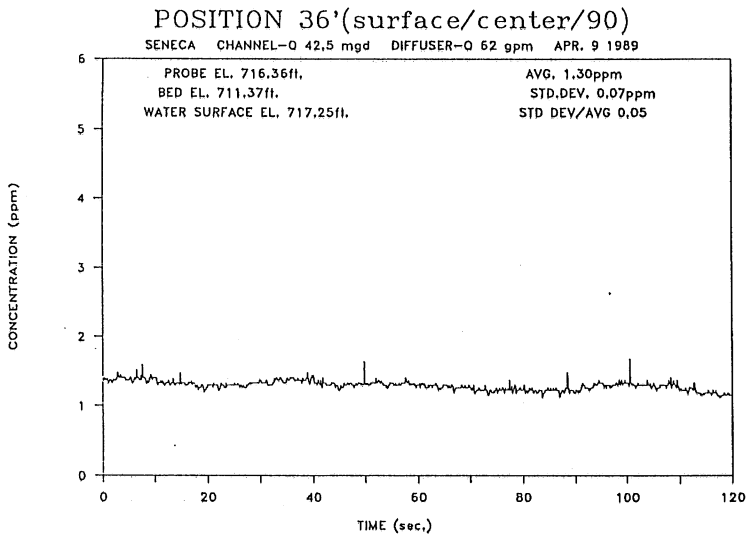

POSITION 27'(bottom-of-skimmer/side/90)
SENECA CHANNEL-Q 42.5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 714.50ft.
BED EL. 711.37ft.
WATER SURFACE EL. 716.66ft.
AVG. 1.70ppm
STD.DEV. 0.22ppm
STD DEV/AVG 0.13
CONCENTRATION (ppm)
TIME (sec.)
0
1
2
3
4
5
6
0
20
40
60
80
100
120

POSITION 29'(bottom-of-skimmer/side/90)



POSITION 29'(mid-flow/side/90)




POSITION 36'(surface/center/90)
SENECA CHANNEL-Q 42,5 mgd DIFFUSER-Q 62 gpm APR. 9 1989
PROBE EL. 716.36ft.
BED EL. 711.37ft.
WATER SURFACE EL. 717.25ft.
AVG. 1.30ppm
STD.DEV. 0.07ppm
STD DEV/AVG 0.05
CONCENTRATION (ppm)
0
1
2
3
4
5
6
0
20
40
60
80
100
120
TIME (sec.)