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NIAGARA RIVER AND LITTLE NIAGARA RIVER FLOW MEASUREMENT SUMMARY

102nd Street Landfill Site

Niagara Falls, New York

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MARCH 1990

REF. NO. 1431 (58)

CONESTOGA-ROVERS & ASSOCIATES

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1.0 INTRODUCTION

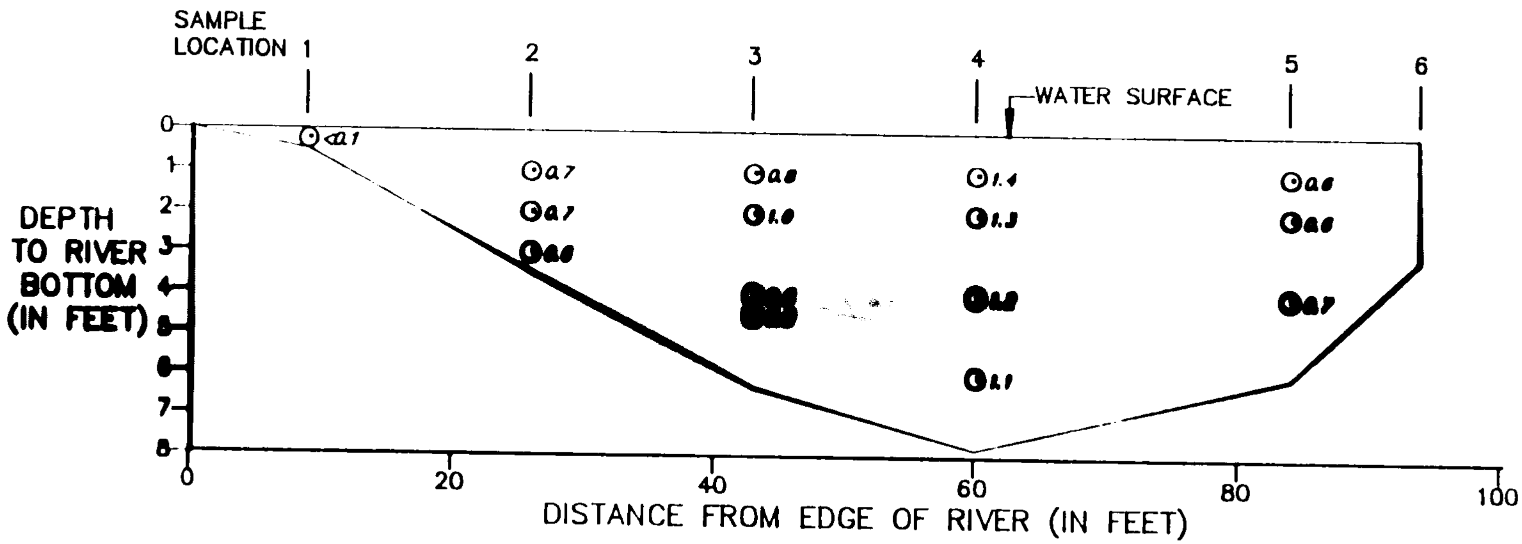
On February 28, 1990, March 2, 1990 and March 15, 1990 flow measurements were taken in the Little Niagara River and in the embayment area adjacent to the 102nd Street Landfill Site. The purpose of the measurements was to measure the flow velocity and direction of the water off shore of the 102nd Street Landfill. These data are to be used in the assessment of risks associated with chemical migration from the Site.

At each measurement location, the total depth of water (including ice, when present) [illegible] and velocity measurements were collected at various depths. Velocity measurements were taken with a "Marsh McBirney Model 201" current meter attached to a graduated extension pole. The results of the measurements taken are briefly described in the following subsections. The locations where measurements were taken are presented on Plan 1.

2.0. LITTLE NIAGARA RIVER

On February 28, 1990, Conestoga-Rovers & Associates (CRA) personnel collected flow velocity data and bathymetric information on the Little Niagara River for the purpose of determining the volume of water flowing through the Little Niagara River. Two cross-section locations were established across the open water and ice fringe at the locations shown on Figure 1. At each cross-section, depth of flow and velocity at various depths were measured. Figures 1 and 2 present the area in the two cross-sections and the various velocity measurements noted. A calculation of flow was completed for each cross-section using the average velocity at each cross-section point in the river and multiplying this velocity by the width of river assigned to each sectional area. The resultant sectional flows were totaled to determine the average flow across the entire cross-section. Table 1 summarizes the flow measurements taken. Vector A was calculated to have 390 cubic feet of water per second passing through it and Vector B was calculated to have 351 cubic feet of water per second. The average flow is calculated to be 371 cubic feet per second.

The wind on February 28, 1990 was out of the west at an average speed of 12 miles per hour as measured at the Buffalo Weather Station. This is consistent with the Site conditions observed by CRA personnel.



LEGEND:

⊙ VELOCITY MEASUREMENT SAMPLE LOCATION

1.15 VELOCITY (ft./sec.)

figure 1

VECTOR A CROSS-SECTION
LITTLE NIAGARA RIVER
102ND STREET LANDFILL
OxyChem/Olin

CRA

1431-21/03/90-58-0 (X-41)

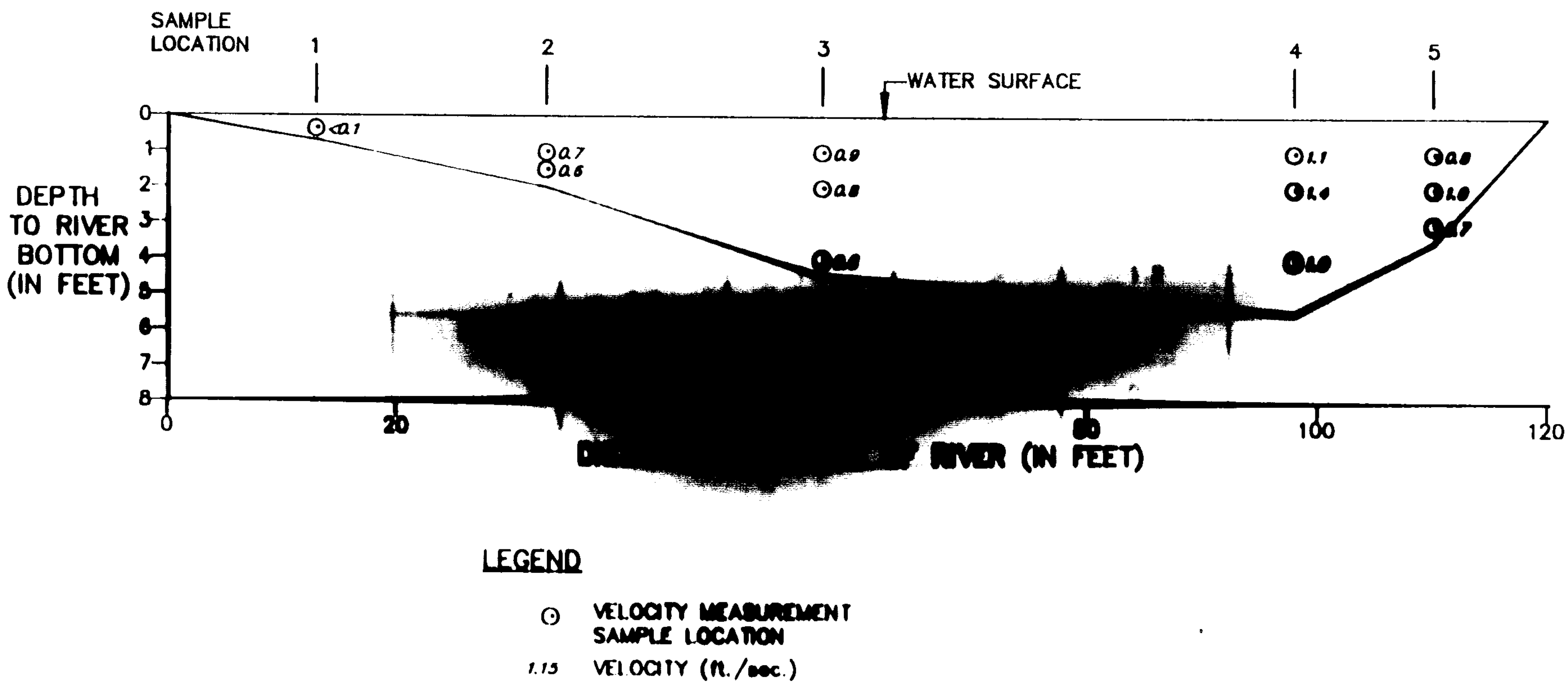


figure 2

VECTOR B CROSS-SECTION
LITTLE NIAGARA RIVER
102ND STREET LANDFILL
OxyChem/Olin

CRA

1431-21/03/90-58-0 (X-42)

Table 1
FLOW MEASUREMENT IN LITTLE NIAGARA RIVER
February 28,1990

	Vector Location	Water Depth (in)	Water Flow (ft/s) At Depth Below Water Surface						
			6"	12"	24"	36"	48"	52"	72"
A	1	10	<0.1						
	2	42		0.7	0.7	0.6			
	3	76		0.8	1		0.5	0.8	
	4	94		1.4	1.8		1.2		1.1
	5	72		0.6	0.6		0.7		
B	1	8	ICE						
	2	24		0.7	0.6				
	3	54		0.9	0.8		0.6		
	4	66		1.1	1.4		1		
	5	42		0.8	1	0.7			

3.0. EMBAYMENT AREA

Due to the adverse weather, measurement of flow in the embayment area could not be completed on February 28. On March 2, 1990, the river conditions (flowing ice) had improved but some solid ice was present in the embayment [illegible] shown on Plan 1. It was decided to proceed with the flow measurements by making holes through the ice sheet and measuring the velocity below[illegible] offered an opportunity to measure the flow conditions in shallow [illegible] eliminated the ripple interference due to the wave action on the [illegible] on March 2 was stronger, averaging 23 miles per hour [illegible]thwest and thus some minor wave action was present.

All of the [illegible] taken in the embayment area (Plan 1 - locations 1-1[illegible] through the ice surface after a 6-inch diameter auger [illegible]. No measurements were taken in open water areas. Velocity [illegible] were taken at various depths where the depth was suffici[illegible]odate the measurements. Table 2 summarizes the total depth of [illegible]erved and the velocity measurements taken.

In almost every case, the measured flow was on the order of 0.1 feet per second which is the lower limit of accurate flow measurement for the instrument. At five of the measurement locations, the flow was less than 0.1 feet per second but flow was still noted.

Table 2
Flow Measurement in Embayment Area
March 2,1990

Vector Location	*Water Depth (in.)*	**Velocity (ft/s)**	*Measurement Depth (in.)*	*Direction of dye movement*
1-1	12	<0.1	6	Northerly, very slow
1-2	14	<0.1	8	Northwest
1-3	20	0.1	14	Northwest
		0.1	8	
2-1	15	0.1	9	Westerly
2-2	19	0.1	13	Westerly
2-3	20	ice	14	solid ice
3-1	15	0.1	9	Westerly
3-2	21	<0.1	15	Westerly
3-3	20	0.1	14	Westerly
		<0.1	9	
		0.1	8	
4-1	14	0.1	8	Westerly
4-2	18	0.15	12	Westerly
4-3	14	0.15	8	Westerly
		0.20	6	
5-1	20	0.20	8	Westerly
6-1	22	0.1	10	Westerly
		0.18	16	
7-1	20	0.1	14	Westerly
		<0.1	8	

NOTE: Dye visible through ice or extra holes were bored for visible identification of movement from test hole.

As a secondary confirmation that there was flow in this area, a tracer dye was added to each measurement point to allow flow to be tracked. The dye was observed to flow beneath the ice sheet and could be seen through the ice. On occasion, it was necessary to bore a few extra holes to confirm the direction of the dye flow because the ice was more opaque in certain areas. The observed directions of dye movement are also presented on Table 2. As can be seen from the data, flow through the ice covered area of the embayment is westerly. [illegible]

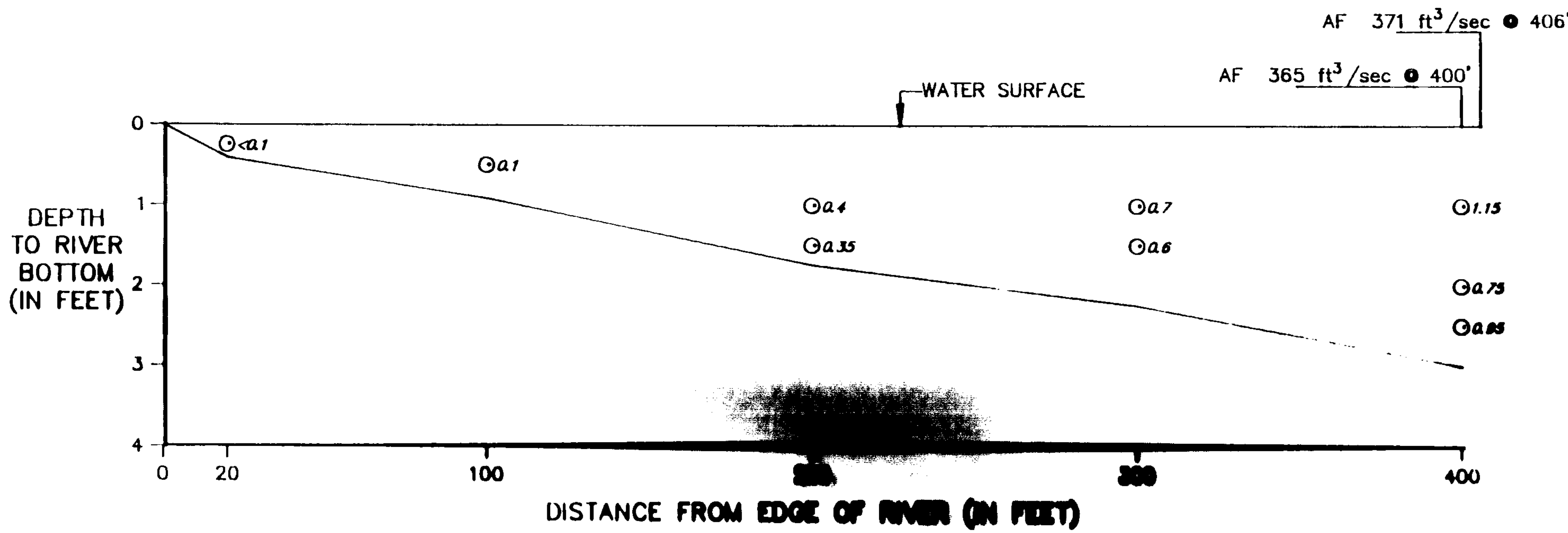
The data [illegible] that measurable flow is occurring in the area monitored. This [illegible] is closest to shore and is protected by its recessed [illegible] river flow. Therefore, river influence on flow in this [illegible] is likely to be lowest and flow velocity is likely to be [illegible]

On March [illegible] ice was present in the River near the Site. CRA personnel [illegible] Site and collected additional flow measurement data within the [illegible] area of the 102nd Street Landfill. On this date, wind was out of the south at up to 11 mph (average 6 mph). Five (5) transect lines were established in a north-south alignment as shown on Plan 1. Measurement points were marked from a shoreline reference point at distances of 20 feet, 100 feet, 200 feet, 300 feet and 400 feet using a surveyors transit and measuring tape for accurate alignment and distances. At lines 3 and 5, flow measurements were also collected 500 feet from shore. At each measuring point, the total water depth was measured and velocity measurements were obtained at various depths. The direction of water flow was determined at each location using a strip of flagging material affixed to a stationary pole.

The results of the March 15 flow measurements are presented in Table 3. Figures 3 through 7 present cross-sections of transects 1 through 5 respectively and the various velocity measurements observed. A calculation of total average flow was completed for each river cross-section by multiplying the average velocity by the end area of each section. The resultant sectional flows were totaled to determine the average flow across the entire cross-section as indicated on each figure. In addition to the total average flow calculation shown, each cross-sectional area was evaluated to determine the distance from shore where a flow volume equivalent to the Little Niagara River flow volume occurred. As previously determined, the average flow volume of the Little Niagara River was 371 ft^3/sec. (February 28, 1990).

Table 3
102nd Street Flow Measurement Study
March 15, 1990

Transect	Measurement Point Distance From Shoreline (ft.)	Measured Water Depth (in.)	Observed Flow Direction	Water Flow (ft./sec.) At Depth Below Water Surface 3"	6"	12"	18"	24"	30"
1	20	5	NNE	<0.1					
	100	11	N		0.1				
	200	21	NNW			0.4	0.35		
	300	27	NNW			0.7	0.6		
	400	36	NW			1.15		0.75	0.95
2	20	12	W		0.35				
	100	16	NW		0.2	0.3			
	200	20	NW			0.5	0.2		
	300	30	NW			0.7		0.65	
	400	36	WNW			0.9		0.95	1
3	20	8	W		0.35				
	100	16	WNW		0.4	0.3			
	200	22	NW			0.45	0.35		
	300	22	NW			0.5	0.5		
	400	32	WNW			0.8		0.7	0.6
	500	37	WNW			1		0.95	0.85
4	20	14	W		0.55	0.4			
	100	20	WNW			0.55	0.5		
	200	20	WNW			0.6	0.4		
	300	30	WNW			0.8		0.5	
	400	38	WNW			1.15		0.95	0.8
5	20	9	W		0.35				
	100	22	WNW			0.5	0.6		
	200	18	WNW		0.65	0.65			
	300	20	NW			0.6	0.4		
	400	27	WNW			0.7	0.8		
	500	36	WNW			0.9		0.75	0.7



LEGEND:

⊙ VELOCITY MEASUREMENT SAMPLE LOCATION

1.15 VELOCITY (ft./sec.)

AF = AVERAGE FLOW

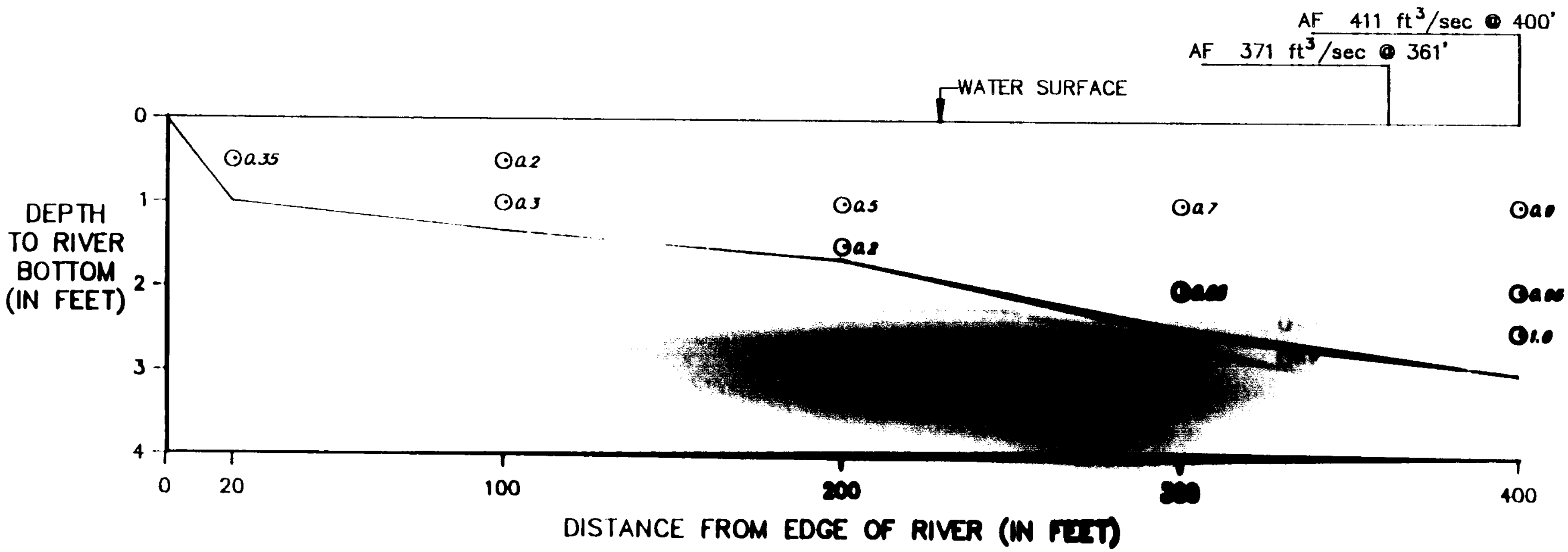
figure 3

TRANSECT LINE 1 CROSS-SECTION OF THE NIAGARA RIVER EMBAYMENT AREA 102ND STREET LANDFILL

OxyChem/Olin

CRA

1431-21/03/90-58-0 (X-36)



LEGEND:

⊙ VELOCITY MEASUREMENT SAMPLE LOCATION

1.15 VELOCITY (ft./sec.)

AF = AVERAGE FLOW

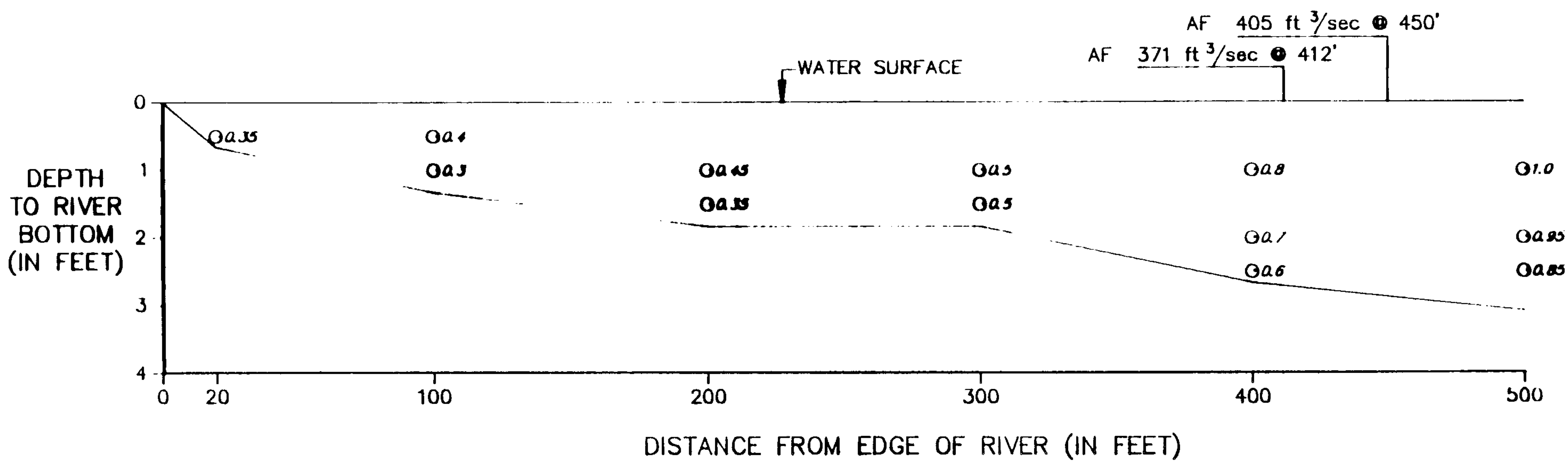
figure 4

TRANSECT LINE 2 CROSS-SECTION OF THE NIAGARA RIVER EMBAYMENT AREA 102ND STREET LANDFILL

OxyChem/Olin

CRA

1431-21/03/90-58-0 (X-37)



LEGEND:

⊙ VELOCITY MEASUREMENT SAMPLE LOCATION

1.15 VELOCITY (ft./sec.)

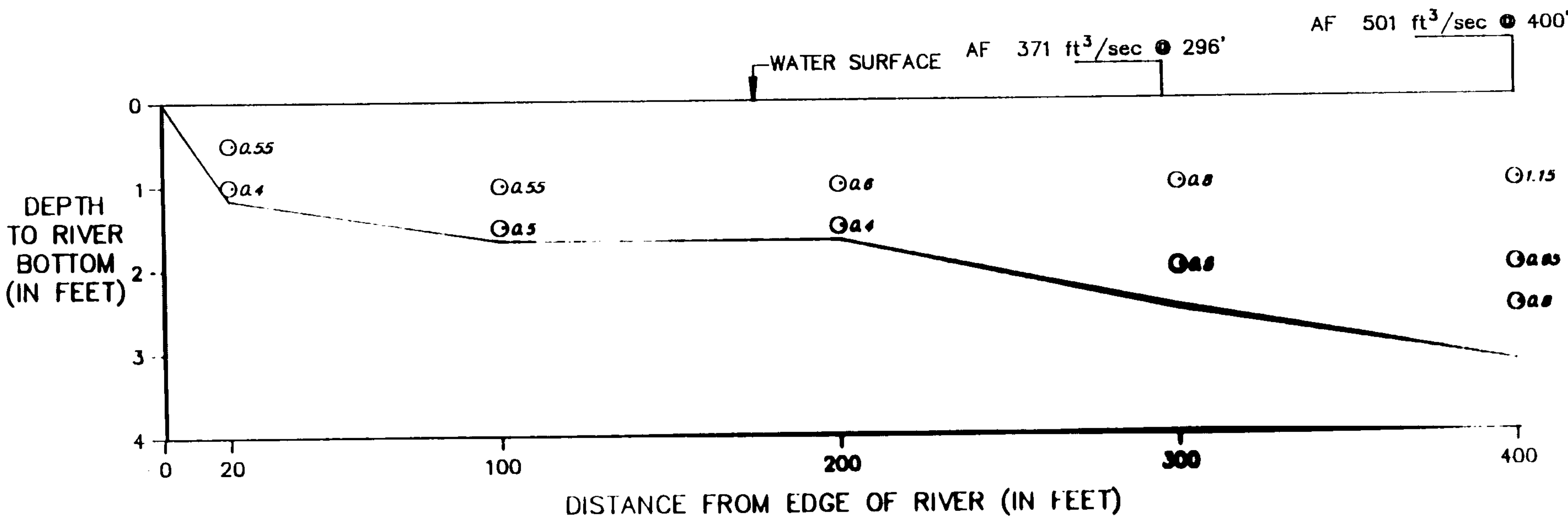
AF = AVERAGE FLOW

figure 5

TRANSECT LINE 3 CROSS–SECTION OF THE NIAGARA RIVER EMBAYMENT AREA
102ND STREET LANDFILL
OxyChem/Olin

CRA

1431-21/03/90-58-0 (X-38)



LEGEND:

⊙ VELOCITY MEASUREMENT SAMPLE LOCATION

1.15 VELOCITY (ft./sec.)

AF = AVERAGE FLOW

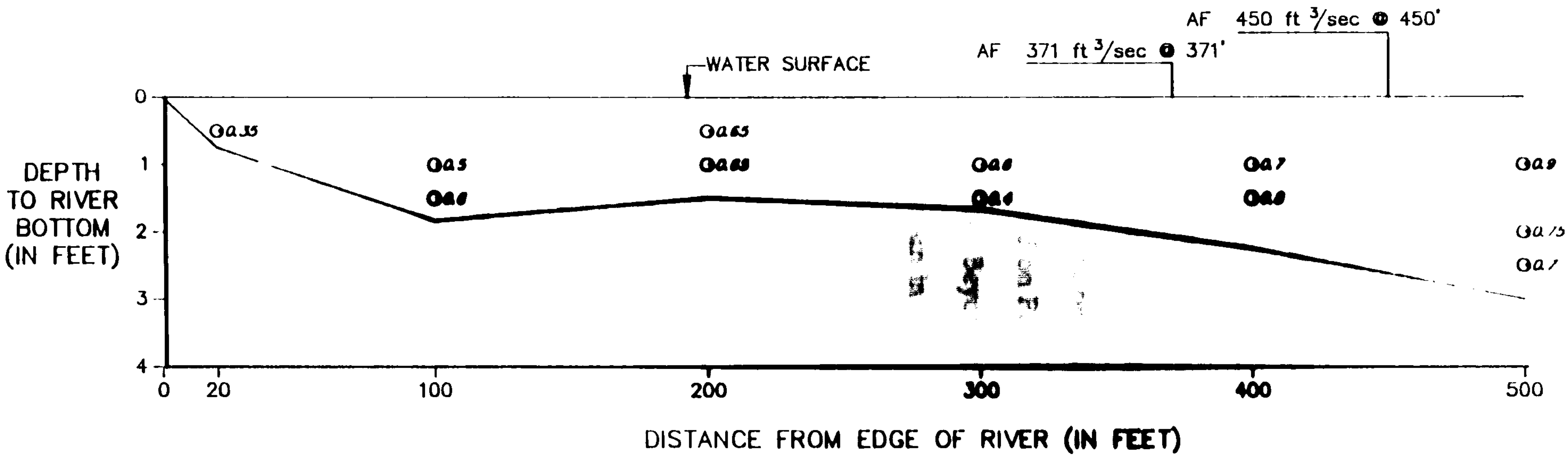
figure 6

TRANSECT LINE 4 CROSS–SECTION OF THE NIAGARA RIVER EMBAYMENT AREA 102ND STREET LANDFILL

OxyChem/Olin

CRA

1431–21/03/90–58–0 (X–39)



LEGEND:

- ⊙ VELOCITY MEASUREMENT SAMPLE LOCATION
- *1.15* VELOCITY (ft./sec.)
- AF = AVERAGE FLOW

figure 7

TRANSECT LINE 5 CROSS–SECTION OF THE NIAGARA RIVER EMBAYMENT AREA 102ND STREET LANDFILL

OxyChem/Olin

CRA

1431–21/03/90–58–0 (X–40)

4.0 SUMMARY

As can be seen from the data presented on Plan 1, the entire embayment area is actively flowing. The general flow direction is northwesterly which indicates that the majority of flow through the embayment area would enter the Little Niagara River. If one were to assume that the river flow through the embayment area closest to the shoreline is the most likely water to enter the Little Niagara River, then the flow representing 371 ft^3/sec. of water closest to shore represents that flow. A line defining the 371 ft^3/sec. flow line is presented on Plan 1. This generally includes flow out as far as 300-400 feet from shore. Beyond this distance from shore, it is expected that the flow will remain in the main stream flow of the Niagara River.

Based upon the data collected on February 28 and March 15, the velocity is generally higher closer to the water surface and reduces with depth in the water column. However, there are a few exceptions to this.

The velocity through the embayment area is consistent with expected conditions. Closer to shore in the shallow water, the flow is the slowest. Further from shore, the velocity increases. The average velocities measured on March 15 are as follows:

Distance from Shore (feet)	*Average Velocity (ft/sec)*
20'	0.32
100'	0.36
200'	0.46
300'	0.60
400'	0.86
500'	0.86

It was observed that the velocity closest to shore in the area closest to the eastern property line is the lowest (0.1 ft/sec±) since this is the most protected area of the embayment. Further to the west, the velocity close to shore (20') approaches 0.35 ft/sec indicating better water circulation. At the 400 and 500 foot distance from shore, the velocity is on the order of 0.9 ft/sec. Using the two extremes of measured flow (minimum 0.1 ft/sec to 0.35 ft/sec at 20 feet from shore and maximum 0.9 ft/sec at 400 feet from shore) the time required for water to pass through the entire embayment area ranges from 2.7 to 0.4 hours (Based on 700' @ 0.1 ft/sec plus 900' @ 0.35 ft/sec for minimum flow and 1400' @ 0.9 ft/sec for maximum flow). This means that the water within the embayment area turns over between 9 and 55 times a day depending upon the distance from shore.

These turnover rates do not take into account the additional turnover that would occur due to other factors such as:

- increased flow due to wind effects and wave action
- surface water flow entering the embayment from the Site during storm events

- water entering the embayment from the 100th Street storm sewer during storm events
- cycling effect of the river due to flow manipulation by the Power Authorities.

On the days that measurements were taken, the effect of the wind was the only factor impacting the measured veolocities. It is recognized that the measurements taken were based on single day events and some variability of the flow system would be expected. However, since the flow in the Niagara River is so consistent, the variability would be considered minor compared to that which would be expected in other river flow systems.

Assuming, as Gradient Corporation did in their risk assessment, that the embayment area extends approximately 525 feet from shore, a calculation of the flow through the embayment can be made. Using the five transects of March 15, 1990 and extrapolating the data out to the 525 foot distance from shore the average flow along the transects within the embayment, would be on the order of 750 cfs. This is based on calculated flows of:

Transect 1	- 780 cfs
Transect 2	- 800 cfs
Transect 3	- 620 cfs
Transect 4	- 950 cfs
Transect 5	- 620 cfs