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Results of a Follow-up Water Quality Survey of the Eastern Portion of the Gaspereau-Black River Lake Watershed

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Kings County Wildlife Association
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1. Introduction

Increased pressure from recreational boating and fishing, cottage development, forestry operations and other activities in the Gaspereau-Black River Lake watershed has raised concerns as to the impact these activities may be having on water quality within the numerous lakes and streams within this system. To address these concerns, during the fall of 1995 the Acadia Centre for Estuarine Research, at the request of the Kings County Wildlife Association, carried out a preliminary survey of water quality at a number of sites within this watershed. The results of the survey indicated that water quality did not appear to be noticeably degraded as a result of the present levels of development and activity within the watershed. However, there was some concern as to the appropriateness of the time during which the survey was carried out, which was early October, a time when the lakes would have undergone destratification if they do stratify, and were likely to have been recently flushed as a result of fall rains and water drawdown associated with power generation. Because these factors may have made the time of the survey somewhat inappropriate for detection of any water quality problems that may exist, it was recommended that the survey be repeated during late summer when any existing stratification would be at its maximum and a more complete evaluation of water quality would be possible. This recommendation was accepted and a follow-up survey was carried out on 12 and 13 August 1997. This report presents the results of this survey.

The Gaspereau-Black River Lake watershed includes 12 major lakes and headponds and many smaller lakes and streams. The surveys concentrated on the eastern portion of the watershed which includes Gaspereau Lake, Salmontail Lake, Dean Chapter Lake, Murphy Lake, Little River Lake, Methals Lake and Black River Lake. The western portion of the watershed, which includes Lake George, Aylesford Lake, Loon Lake and Hardwood Lake, is currently being evaluated for water quality by the Municipality of Kings County. The primary objective of the surveys was to obtain preliminary baseline data useful in determining if present levels of activity within the watershed are having significant impacts on water quality.

2. Methods

A total of 16 sites were surveyed during the 1995 survey. The sites were chosen to represent the major basins of each lake (7 sites) and the major inlet and outlet streams from each lake (9 sites). Most of these same sites were surveyed during the 1997 study, with the addition of three more sites: one located at the canal between Little River Lake and Methals Lake (Station 10.5); one located within the main basin of Lumsdens Pond (Station 15.5); and one located in the canal immediately upstream of the White Rock Generating Station (Station 17). However, because of a lack of water, three sites surveyed during 1995 were not surveyed during 1997 (Stations 3,11 and 13 of the 1995 survey corresponding to the outlet of Gaspreau Lake into the Canal at Little River Lake, the outlet of Little River Lake into Little River and the outlet of Methals Lake into Black River Lake). This resulted in a total of 16 sites sampled in the 1997 survey. Table 1 lists the date and time each site was sampled together with its location. The location of each sample site is also shown in Figure 1.

The same parameters were measured during each survey (Table 2). These include those parameters most commonly analyzed for determination of water quality. Water samples collected from shallow sites within the inlet and outlet streams were obtained by immersing and filling the sample containers with as little disturbance of bottom sediments as possible. Lake samples were collected using a Van Dorn water sampler. Water column stratification was determined using a YSI-SCT meter. If there was any indication of water column stratification within the lakes, samples were collected both from just beneath the surface and from within the mid-depth of the lower water layer. If there was no evidence of water column stratification, samples were collected only from just beneath the surface.

Sample analysis procedures were those commonly employed in limnological investigations. Apparent and true color were determined by visual observation of water samples before and after filtration. Particulate matter concentrations were measured by oven drying and weighing samples that were filtered onto pre-weighed and pre-combusted Whatman GF/C filters. Particulate organic matter concentrations were determined by reweighing after combustion at 500 °C. Total phosphorous was determined by the ammonium molybdate method after oxidation by persulfate. Nitrate concentrations were determined by the cadmium reduction method using the Hach (1992) procedure. Fecal coliform determinations were carried out by the Valley Health Services laboratory of the Valley Regional Hospital, Kentville, N.S.

Table 1. Location and time of each sampling station.

SITE No.	DATE	TIME	LOCATION
1b	12/08/97	19:36	Main Basin of Gaspreau Lake
2	13/08/97	09:50	Outlet of Gaspereau Lake (into Gaspereau River)
4	13/08/97	12:35	Main Basin of Salmontail Lake
5	13/08/97	12:30	Outlet of Salmontail Lake
6	13/08/97	13:55	Main Basin of Dean Chapter Lake
7	13/08/97	13.40	Outlet of Dean Chapter Lake
8	13/08/97	10:30	Main Basin of Murphy Lake
9	13/08/97	11:00	Outlet of Murphy Lake
10	12/08/97	10:54	Main Basin of Little River Lake
10-5	12/08/97	11:50	Canal between Little River Lake and Methals Lake
12	12/08/97	12:50	Main Basin of Methals Lake
14	12/08/97	14:21	Main Basin of Black River Lake
15	12/08/97	13:27	Outlet of Black River Lake into Canal to Lumsdens Pond
15-5	12/08/97	15:19	Main Basin of Lumsdens Pond
16	13/08/97	09:12	Outlet of Gaspereau River into Whiterock Headpond
17	13/08/97	08:48	Canal just upstream of White Rock Generating Station

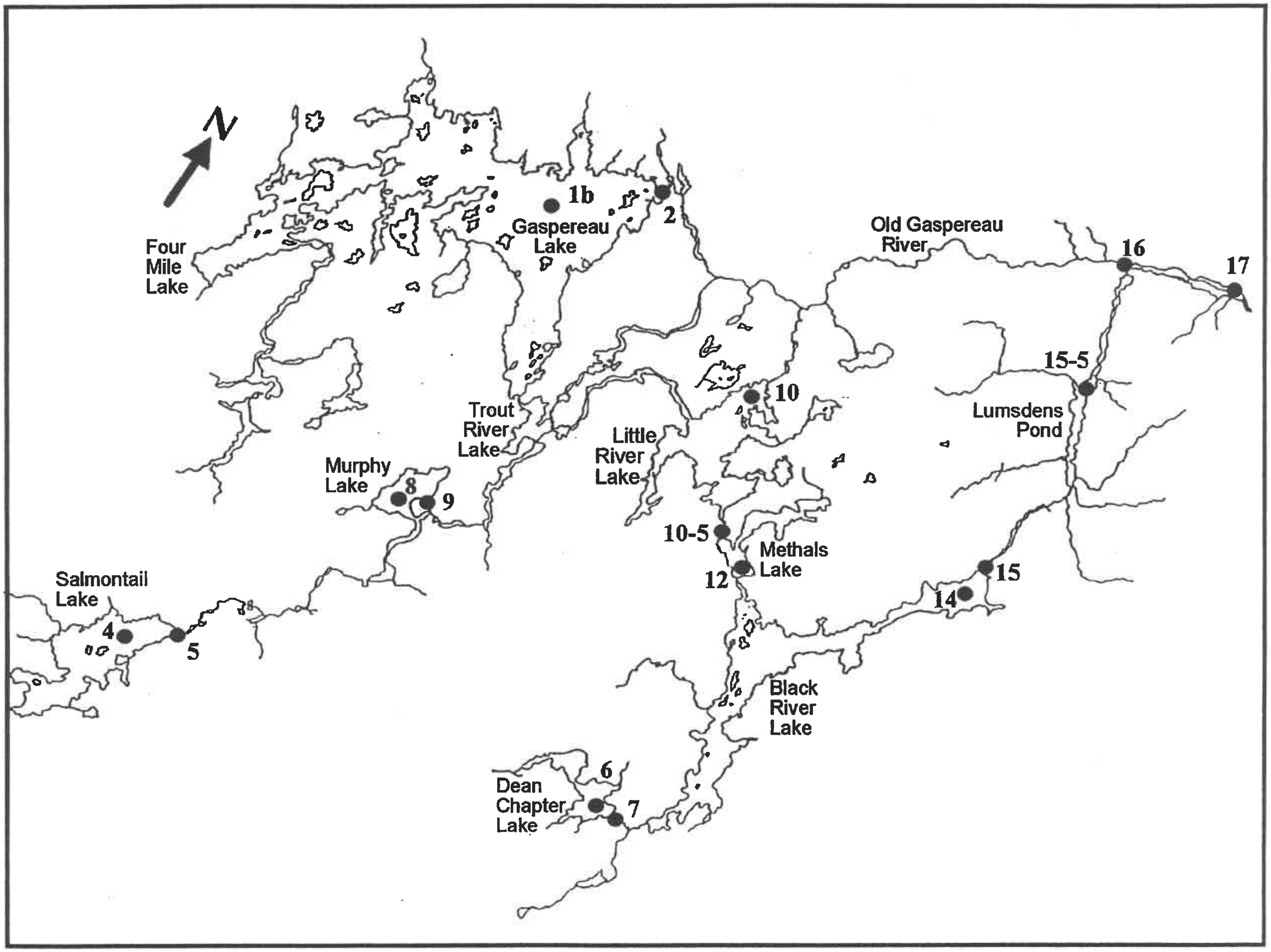

Figure 1. Map showing locations sampled during this survey

Table 2. Water quality parameters measured at each site.

Physical:
- Secchi Disk Depth
- Water Temperature Depth Profiles
- Suspended Particulate Matter (Total, Organic and Inorganic)

Chemical:
- Dissolved Oxygen
- Percent Dissolved Oxygen Saturation
- Conductivity
- Hardness (Total, Calcium and Magnesium)
- pH
- Alkalinity
- Total Phosphorous
- Dissolved Nitrate

Biological:
- Chlorophyll *a*
- Fecal Coliform Bacteria

3. Results

The results of the survey are summarized in Table 3. Appendix I contains a summary of sampling locations, times and weather and other conditions at the time of sampling. Appendix II contains some guidelines useful in interpretation of the data.

3.1 Water Column Stratification

In contrast to the earlier 1995 survey, two of the lakes, Methals and Black River, exhibited significant water column stratification (Figure 2). At both lakes surface and bottom water temperatures had a difference of about 10 °C. The mid-depth of the thermocline was located at about seven meters depth. This degree of stratification is relatively strong and has implications for water quality characteristics as will be seen below.

Table 3. Data summary.

Station Number	Secchi Disk Depth (m)	Apparent Colour	True Colour	Total Particulate Matter (mg/l)	Particulate Organic Matter (mg/l)	Particulate Inorganic Matter (mg/l)	Particulate Percent Organics	Total Alkalinity (mg $CaCO_3$/l)	Total Hardness (mg $CaCO_3$/l)	Calcium Hardness (mg $CaCO_3$/l)	Magnesium Hardness (mg $CaCO_3$/l)
1t	2.9	clear	clear	1.63	1.02	0.61	62.5	1.0	5.7	4.3	1.4
1b		v. light brown	v. light brown	4.62	2.56	2.05	55.6	0.5	3.5	2.9	0.6
2		clear	clear	1.46	0.84	0.63	57.1	1.0	4.4	3.2	1.2
4	>1.5	light brown	light brown	10.31	6.56	3.75	63.6	0.5	3.1	2.4	0.7
5		v. light brown	v. light brown	11.56	7.81	3.75	67.6	0.0	4.0	3.6	0.4
6	3.5	clear	clear	1.74	1.74	0.00	100.0	1.5	4.2	3.6	0.6
7		clear	clear	2.81	1.40	1.40	50.0	1.0	4.3	4.2	0.1
8	>3.0	clear	clear	1.78	0.44	1.33	25.0	3.5	7.4	4.5	2.9
9		clear	clear	1.06	0.21	0.85	20.0	2.0	6.7	6.1	0.6
10	2.4	clear	clear	1.47	1.15	0.33	77.8	0.5	4.4	3.2	1.2
10-5		clear	clear	1.51	1.01	0.50	66.7	1.5	4.7	3.8	0.9
12t	2.7	clear	clear	1.44	1.44	0.00	100.0	2.5	3.9	3.3	0.6
12b		light brown	light brown	5.46	2.96	2.50	54.2	0.0	6.2	3.4	2.8
14t	2.9	clear	clear	1.17	0.98	0.19	83.3	1.0	4.6	3.4	1.1
14b		v. light brown	v. light brown	2.63	1.66	0.97	63.2	2.0	10.7	4.6	6.1
15		v. light brown	v. light brown	1.98	1.78	0.20	90.0	1.5	4.2	2.2	2.0
15-5t	3.1	clear	clear	1.11	0.69	0.42	62.5	2.5	3.9	3.4	0.5
15-5b		clear	clear	1.54	0.84	0.70	54.6	2.5	4.4	2.6	1.8
16		clear	clear	1.06	0.43	0.64	40.0	2.5	5.6	2.0	3.6
17		clear	clear	1.89	0.84	1.05	44.4	2.5	8.9	6.7	2.2

Table 3. Data summary (Continued).

Station Number	Sample Depth (m)	Surface Temperature (°C)	Dissolved Oxygen (mg/l)	Dissolved Oxygen % Saturation	Conductivity (usie/cm)	pH	Chlorophyll *a* (ug/l)	Phaeophyton (ug/l)	Nitrate (mg/l)	Total Phosphorus (ug/l)	Fecal Coliforms (#/100 ml)
1t	0	21.9	8.34	95.2	25	5.90	4.37	4.53	<0.1	10.9	0
1b	12.5	20.6	8.32	92.6	28	5.66	2.63	3.62	<0.1	22.7	1
2	0	21.0	7.54	84.6	21	5.85	1.86	3.67	<0.1	17.3	0
4	0	21.0	7.70	86.4	20	5.63	13.65	11.27	<0.1	34.5	4
5	0	19.5	7.54	82.1	20	5.74	14.76	11.84	<0.1	38.0	0
6	0	23.0	7.94	92.6	20	5.73	3.35	2.03	<0.1	13.7	0
7	0	23.0	8.00	93.3	20	5.84	2.98	2.07	<0.1	14.6	2
8	0	21.0	8.02	90.0	50	6.28	1.63	0.42	<0.1	13.3	1
9	0	25.0	6.68	80.9	60	6.05	1.55	0.19	<0.1	20.9	35
10	0	21.2	7.80	87.9	28	5.99	2.71	2.22	<0.1	19.2	0
10-5	0	21.5	6.72	76.1	28	5.98	2.98	1.81	<0.1	14.6	7
12t	0	21.9	7.28	83.1	28	5.93	3.23	1.45	<0.1	4.2	0
12b	12	9.8	0.00	0.00	40	5.84	0.73	5.24	<0.1	91.8	0
14t	0	21.8	7.76	88.4	23	6.00	3.43	2.30	<0.1	7.3	1
14b	11	11.7	3.04	28.0	25	5.62	0.72	2.21	<0.1	16.1	0
15	0	21.9	8.20	93.6	21	6.11	2.87	1.96	<0.1	8.0	2
15-5t	0	22.0	7.10	81.2	29	6.18	0.32	2.24	<0.1	10.4	1
15-5b	15	20.2	5.32	58.7	30	6.17	3.63	3.40	<0.1	12.6	3
16	0	17.0	9.00	93.1	28	6.25	0.82	0.00	<0.1	5.9	33
17	0	20.0	7.68	84.5	29	6.32	3.50	1.87	<0.1	3.7	20

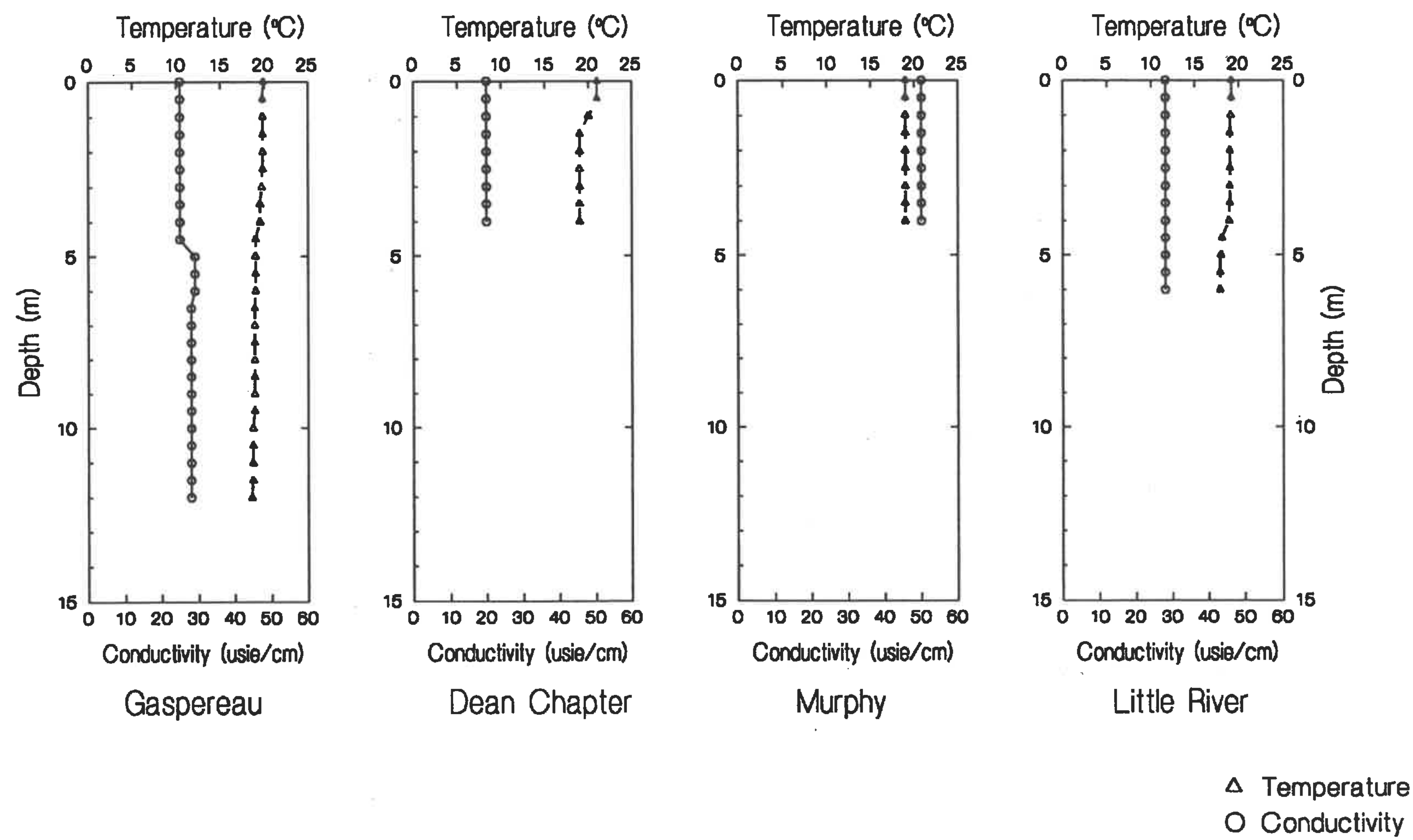

Figure 2. Water column temperature profiles for the main basin of each lake.

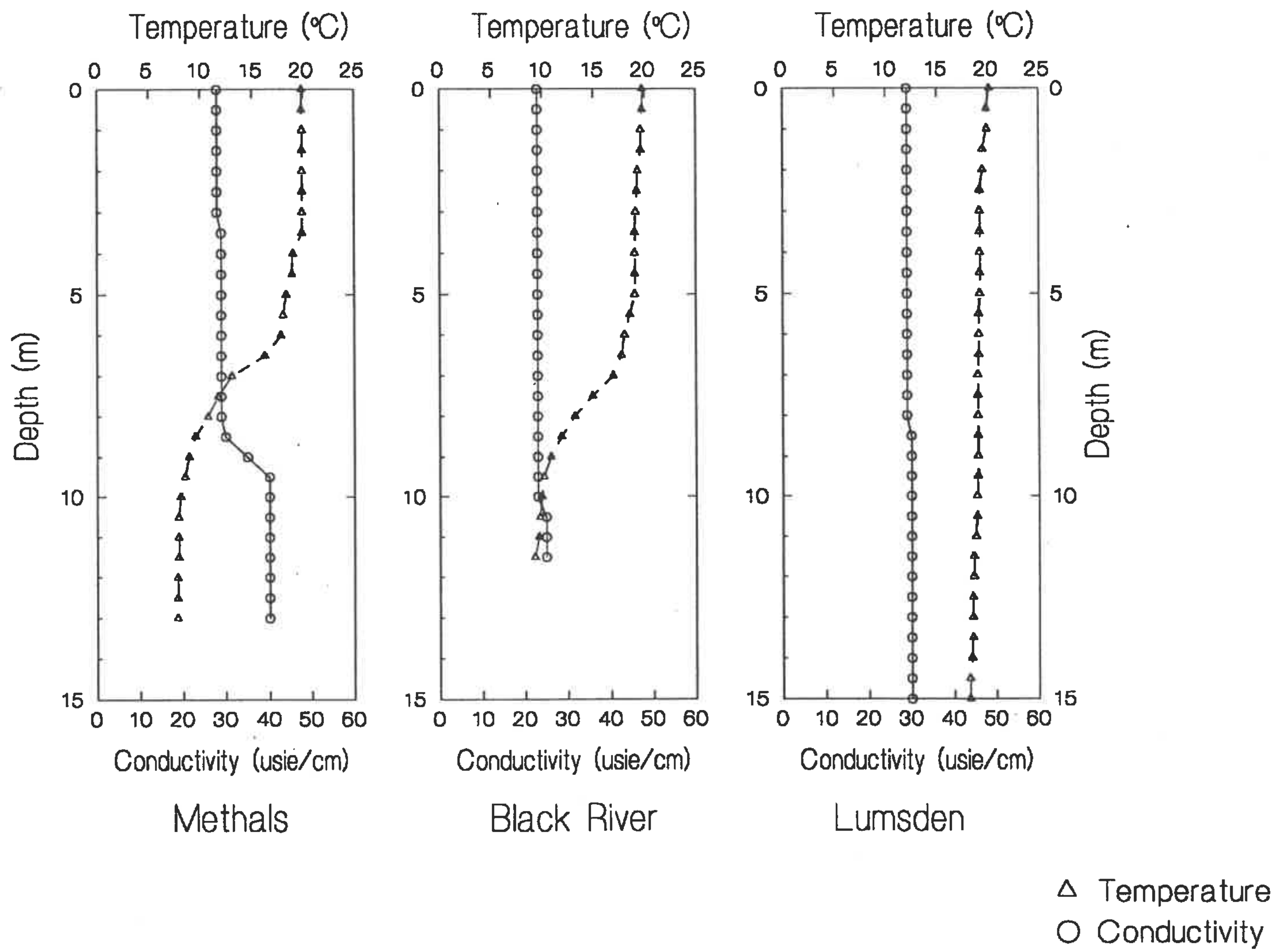

Figure 2. (Continued).

3.2. Water Clarity

Water clarity, as indicated by the Secchi Disk depths (Figure 3) and color observations (Table 3), was quite good at most of the sites surveyed. Secchi Disk depths were generally greater than 2.5 meters and there was little evidence of any color resulting from high algae or suspended sediment concentrations. The values for suspended particulate matter concentration were also very low (Figure 4), usually less than 5 mg/l, and in most cases consisted of about equal amounts of inorganic and organic matter. The latter observation suggests that during the sampling period there was little evidence of significant sediment input as a result of soil erosion. The only sites showing somewhat depressed water clarity and relatively high suspended particulate matter concentrations were the main basin and outlet of Salmontail Lake (sites 4 and 5). Most of this material was organic which suggests its origin is from within the lake itself as opposed to materials being eroded from the drainage basin. The shallowness of this lake makes it susceptable to sediment resuspension from wind driven water circulation and this is the most likely cause of the high suspended particulate matter concentrations observed at these two sites.

Overall, the results of the Secchi Disk observations and the suspended sediment concentration measurements indicate little evidence of erosion being a problem at most sites. It should be noted. however, that there was little precipitation, either prior to or during the survey, which would make serious soil erosion problems difficult to detect.

3.3. Chemistry

All of the lakes and streams surveyed are very dilute in terms of their chemistry. Conductivity values at all sites were less than 60 µsei/cm. Total hardness values were also very low, generally less than 10 mg/l. Most of the hardness is due to calcium as opposed to magnesium. Total alkalinity values are also low but the relatively high pH measured at all sites (generally greater than 5.6) indicates that there is currently sufficient alkalinity in this system to have prevented it from becoming seriously acidified as a result of acid precipitation.

Dissolved oxygen concentrations and percent oxygen saturation values (Figures 5 and 6) were well within acceptable levels for all samples collected in surface waters of all lakes as well as within the inlets and outlets sampled. The were, however, low dissolved oxygen levels in samples collected from the bottom waters of Methals and Black River Lake, the two stratified lakes, as well as Lumsdens Pond. The latter is surprising since there was little evidence of stratification at this

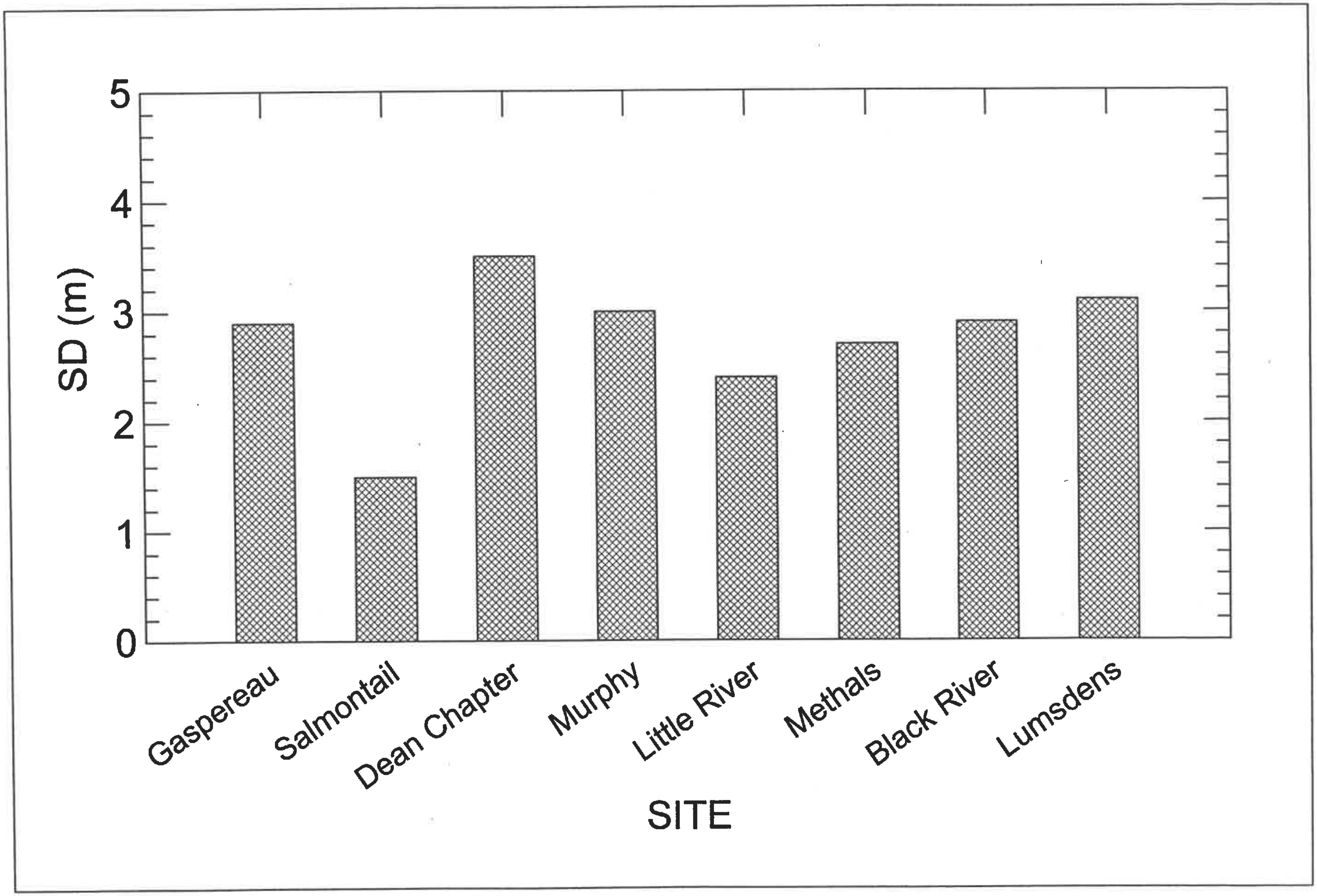

Figure 3. Secchi Disk depths for the main basin of each lake.

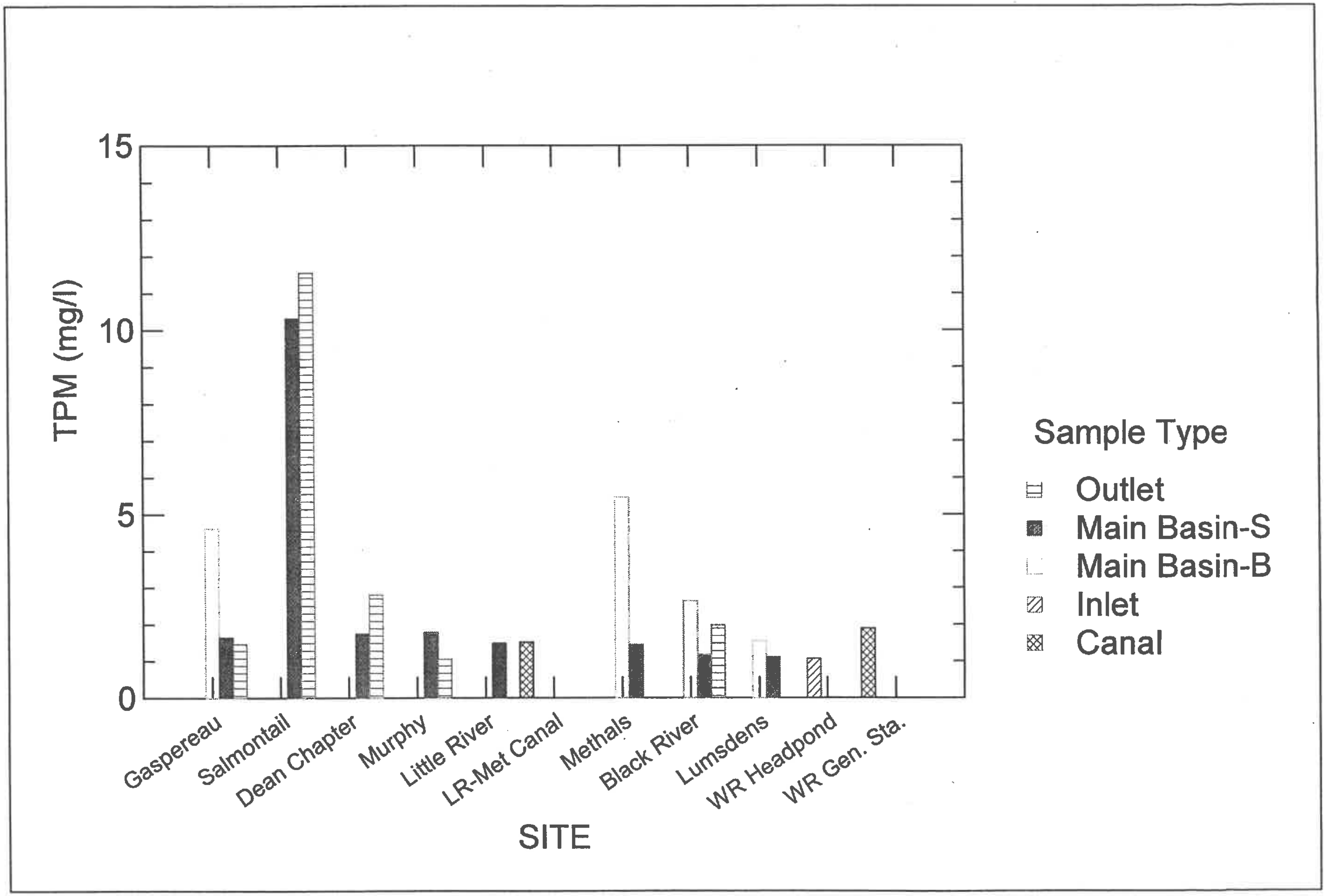

Figure 4. Total particulate matter concentration at each site.

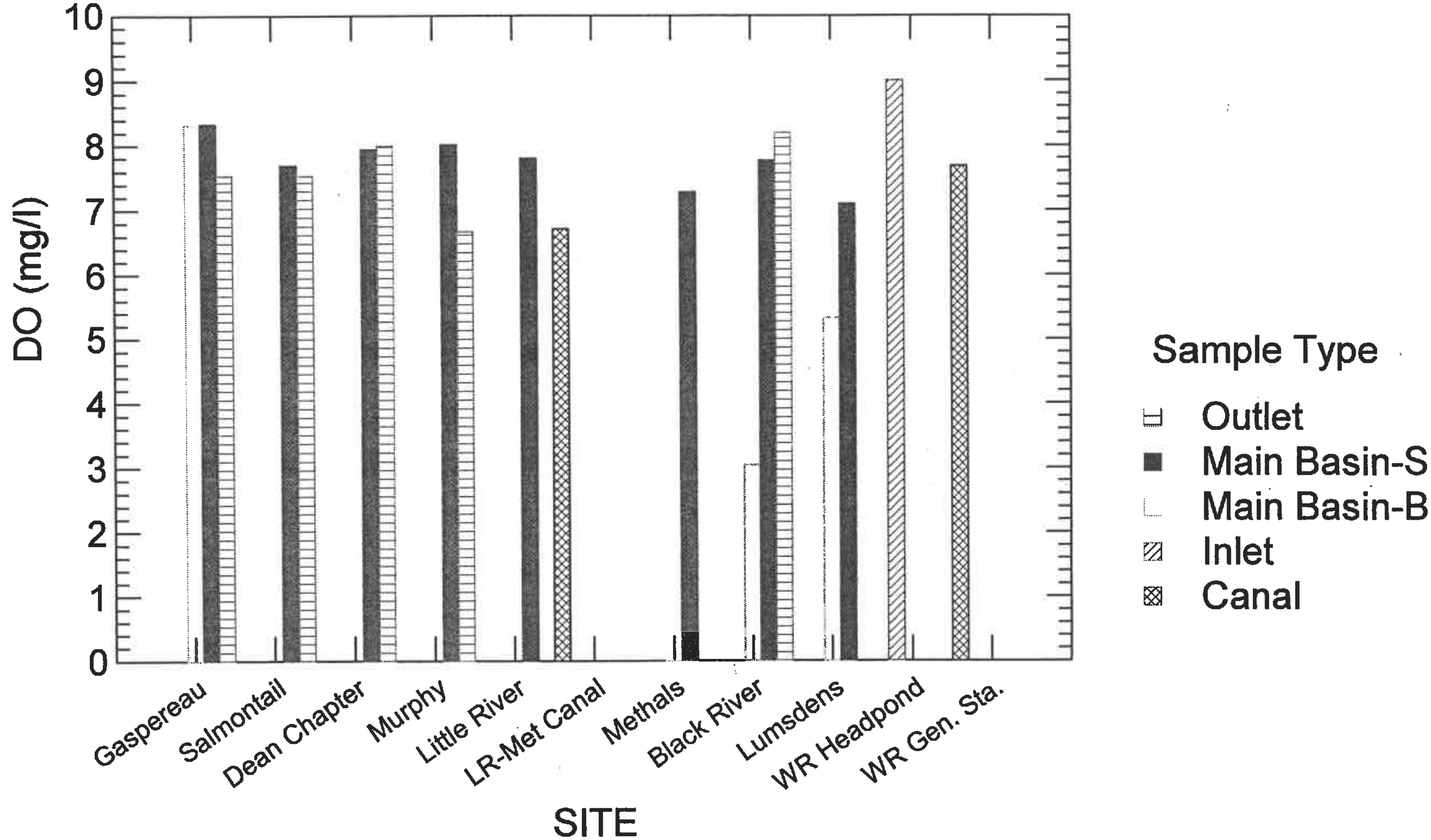

Figure 5. Dissolved oxygen concentration at each site.

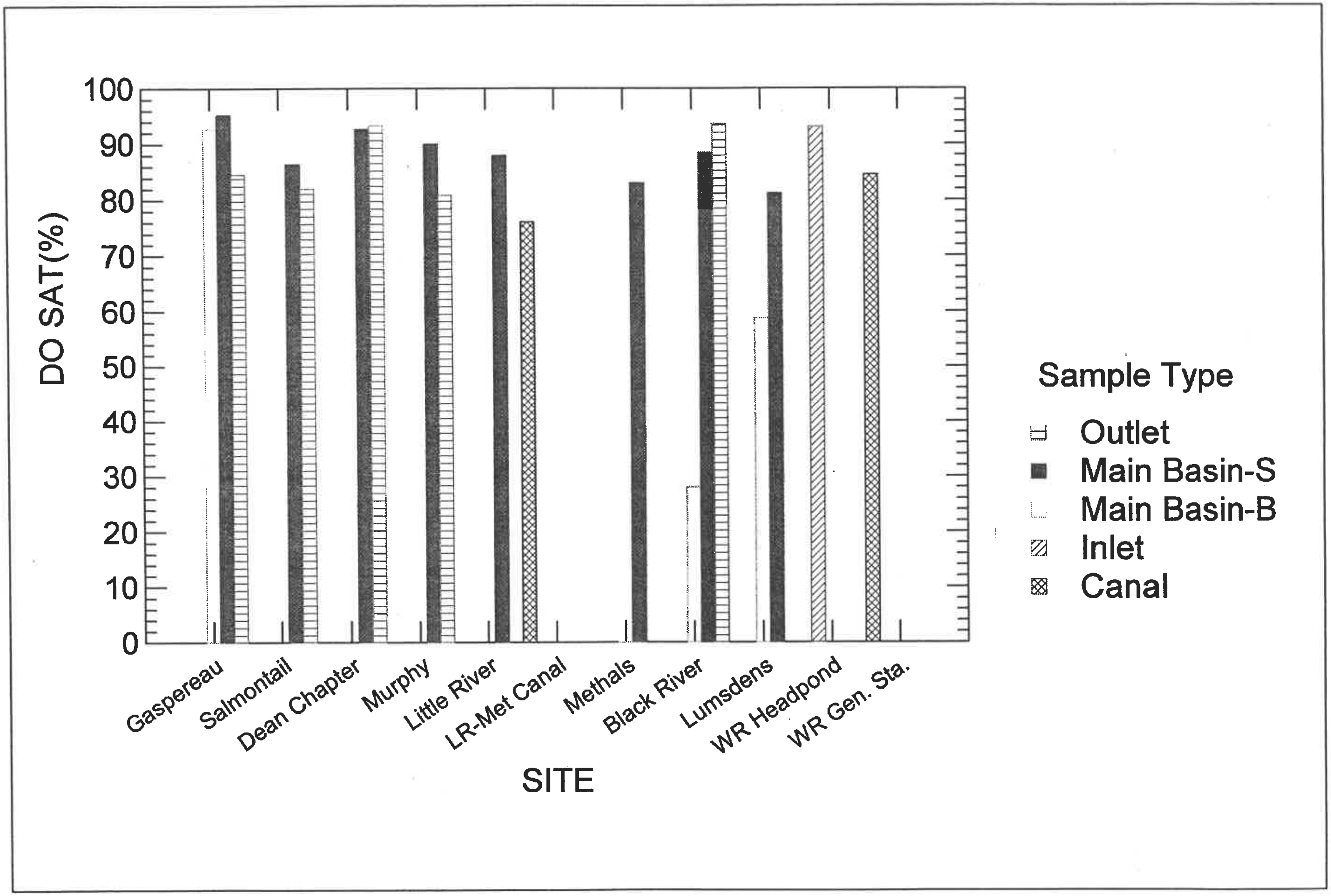

Figure 6. Percent dissolved oxygen saturation at each site.

lake. The lowest dissolved oxygen concentration was observed in the bottom waters of Methals Lake which was had no detectable dissolved oxygen. Black River Lake and Lumsdens Pond had percent saturation values of 28.0 and 58.7 respectively. The latter is just above what is considered to be the critical value (generally 50 percent saturation) for most aquatic organisms.

Nitrate levels were in all cases very low and below the limit of detection of the measurement procedure used.

Total phosphorus values (Figure 7) at most sites were considerably greater than those measured during the 1995 survey. Values ranged from a low of 4.2 to a high of 91.8 µg/l. In contrast, a range of 0.0 to 24.1 µg/l was observed in the 1995 survey. Because of the large difference between the two surveys, there was some concern that there may have been technical problems associated with our measurements of total phosphorous. To determine if this was the case, duplicate water samples were sent for processing to the Environmental Laboratory of the Queen Elizabeth II Health Sciences Centre in Halifax. Their results confirmed ours (see Table 4 for a comparison of results) indicating that the high concentrations of total phosphorous observed are valid.

In most cases, the reasons for the high total phosphorous concentrations are obvious. The highest value, 91.8 µg/l, was observed for the bottom water of Methals Lake. As indicated earlier, this lake was stratified at the time of the survey and the bottom water was anaerobic (no dissolved oxygen present). Under these conditions, phosphorous undergoes a chemical change from an insoluble to a soluble form and diffuses into the water column. The origin of this phosphorous is probably the sediment within the lake, which most likely contains relatively high concentrations of organic matter and nutrients since it is basically a flooded woodland. The fact that the surface waters contained very low concentrations of total phosphorous further supports the suggestion that the source of the phosphorous is the sediments. These same factors may also explain the higher total phosphorous concentration observed for bottom water, compared to surface water, for Black River Lake, which was also stratified at the time of the survey.

The high values of total phosphorous observed for both the main basin and outlet of Salmontail Lake are probably related to the shallowness of this lake and the resuspension of sediments by wind mixing. This lake also had high total phosphorous concentrations during the 1995 survey. The relatively high concentrations of total phosphorous at the other sites, particularly Gaspereau and Murphy Lakes, are more difficult to explain since they were not stratified at the time of the survey. However, they are both relatively shallow and may also be subject to wind induced resuspension of sediments. Both had slightly elevated particulate matter concentrations suggesting that this could be the source of the high total phosphorous concentrations. It is also possible that phosphorous could be entering Murphy Lake from the outlet of Salmontail Lake.

3.4 Biological Factors

Fecal coliform numbers (Figure 8) were very low (less than 10/100 ml) at all sites except for the outlet of Murphy Lake (site 9) which had a value of 35 (and which also had the highest value in the 1995 survey), the outlet of the Gaspreau River into the Whiterock Headpond (site 16) and within the Canal just above the White Rock Generating Station. These higher values suggest the possibility of some sewage inputs into these sites.

Chlorophyll *a* values (Figure 9) for the main basin of each lake were generally less than 5 μg/l which suggests that most of the lakes have low productivity and are not characterized by high algal concentrations. An exception to this was the main basin and outlet of Salmontail Lake (site 4) which had chlorophyll *a* concentrations greater than 10 μg/l. This is consistent with the observations of high total phosphorous concentrations also observed at this site.

4. Discussion

The general results of this survey indicate that none of the sites surveyed presently have serious water quality problems. There is little evidence that development within the watersheds of these systems has resulted in any serious eutrophication problems, particularly since chlorophyll *a* concentrations, the most obvious indication of eutrophication, are quite low. The relatively high chlorophyll *a* concentrations observed in Salmontail Lake are probably indicative of a naturally productive system, especially since this system appears to be little influenced by any development activities within its drainage basin.

The low oxygen concentrations observed in the bottom waters of Methals Lake and Black River Lake are probably natural events that would normally occur during summer months, particularly if these systems were not subject to drawdowns for power generation and there were extended periods of calm weather.

The high total phosphorous concentrations observed at Gaspereau Lake and Murphy Lake, however, do raise some concern. This is particularly true for the latter since it is one of the more highly developed sites and also had the highest coliform numbers. These sites should be considered for further monitoring. The source of the high coliform numbers in the White Rock area is also something that should be investigated and monitored. It is recommended that a monitoring program similar to that presented here be carried out periodically, preferably during late summer, in order to provide a continual data base to detect changes that may occur in water quality as a result of increased development activities within the watershed.

5. Acknowledgements

This study was made possible through funding provided to the Kings County Wildlife Association by Nova Scotia Power Incorporated. Scott Cook provided valuable assistance in the field.

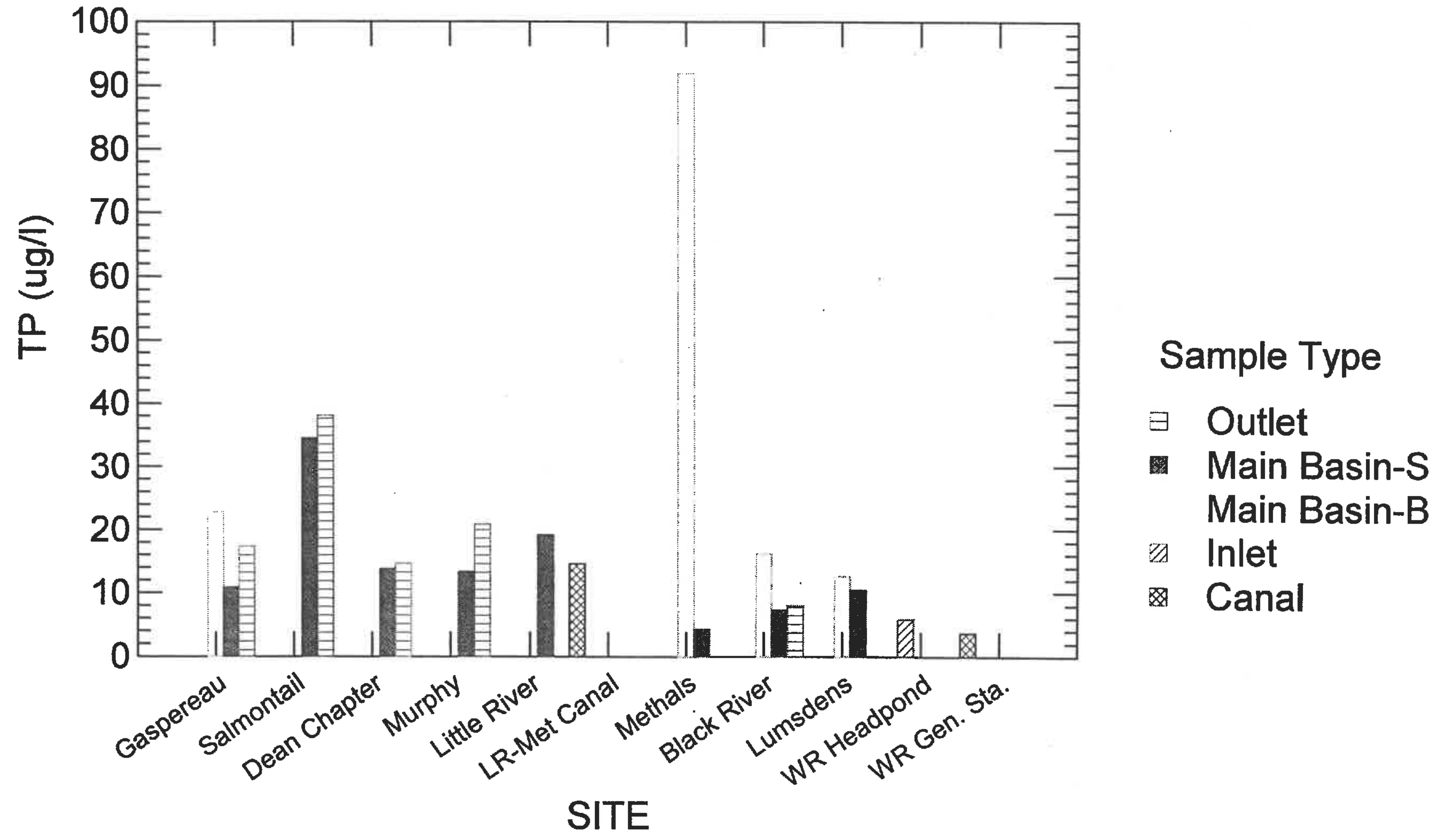

Figure 7. Total phosphorous concentration at each site.

Table 4. Comparison of ACER and VG Health Laboratory total phosphorous determinations (values are in μg/l).

Site No.	ACER	VG Health
SC-10	19.1	13
SC-10.5	14.6	13
SC-12b	91.8	90
SC-12t	4.2	10
SC-14b	16.1	17
SC-14t	7.3	9
SC-15	8.0	9
SC-15.5b	12.6	11
SC-15.5t	10.4	9
SC-16	5.9	11
SC-17	3.7	13
SC-1b	22.7	9
SC-1t	10.9	10
SC-2	17.3	14
SC-4	34.5	24
SC-5	38.0	36
SC-6	13.7	15
SC-7	14.6	13
SC-8	13.3	17
SC-9	20.9	12

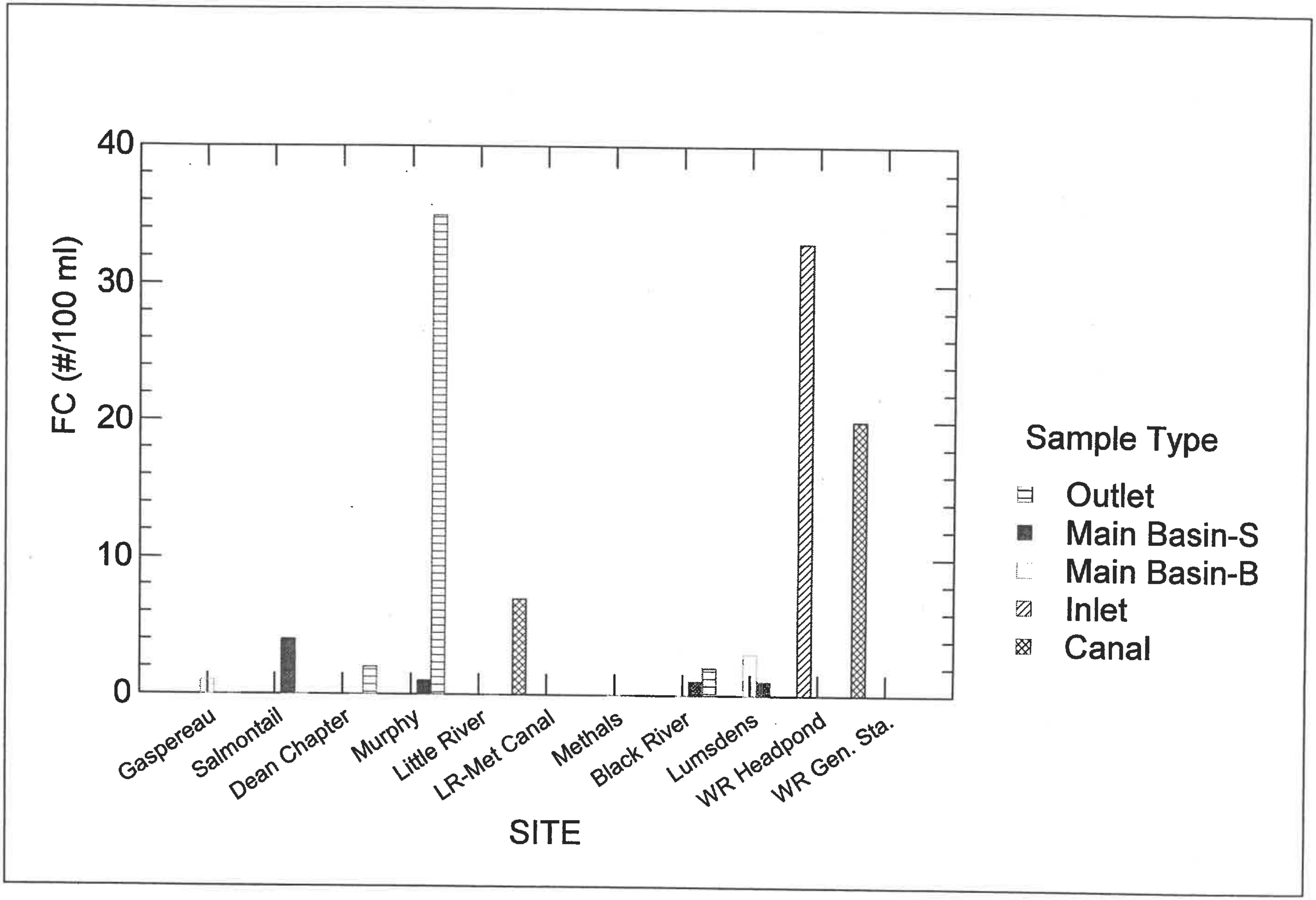

Figure 8. Fecal coliform number at each site.

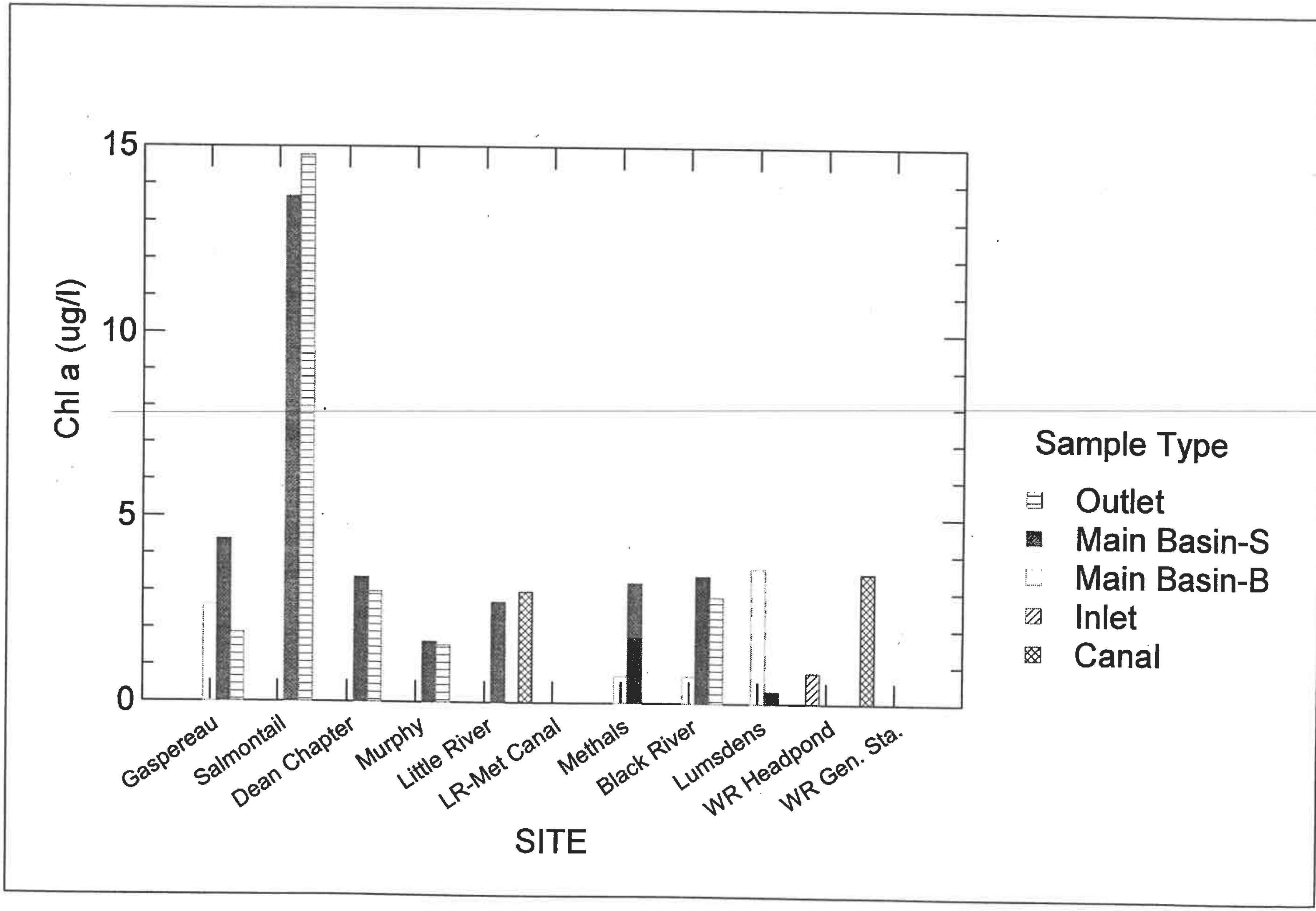

Figure 9. Chlorophyll a concentrations at each site.

APPENDIX I

Summary of sampling locations, times, weather and other conditions at time of sampling.

APPENDIX I

Summary of sampling locations, times, weather and other conditions at time of sampling.

Site 1. Main Basin of Gaspereau Lake.
Date: 10 October 1995
Time: 1525
Weather: 14 °C with 100% cloud cover; no wind.
Samples collected from the lake by boat.
Water level in the lake was low (621.5 ft. on the water level gauge on the dam above the canal).

Site 2. Outlet of Gaspereau Lake into Gaspereau River.
Date: 10 October 1995
Time: 1130
Weather: 14 °C with 100% cloud cover; no wind.
Samples collected from shore just above the Lane Mills Fish Ladder.

Site 3. Outlet of Gaspereau Lake into the canal to Little River Lake.
Date: 10 October 1995
Time: 1200
Weather: 13 °C with 100% cloud cover; no wind.
Samples collected from shore just below the Highway 12 bridge; little or no flow from Gaspereau Lake into the canal.

Site 4. Main Basin of Salmontail Lake.
Date: 11 October 1995
Time; 1445
Weather: 14 °C with 100% cloud cover; strong wind.
Samples collected from the lake by boat.
Water level in the lake was low (estimated as 749 ft. on the water level gauge on the dam - the bottom of the gauge reads 752 ft.); maximum depth observed in the lake was less than 2 m.

Site 5. Outlet of Salmontail Lake.
Date: 10 October 1995
Time: 1230
Weather: 12 °C with 100% cloud cover; no wind.
Samples collected from shore just below the dam by the lake.

Site 6. Main Basin of Dean Chapter Lake.
Date: 11 October 1995
Time; 1115
Weather: 14 °C with 100% cloud cover; strong wind.
Samples collected from the lake by boat.
Water level in the lake was low (603.5 ft. on the water level gauge on the dam).

Site 7. Outlet of Dean Chapter Lake.
Date: 11 October 1995
Time: 1030
Weather: 14 °C with 90% cloud cover; strong breeze.
Samples collected from shore just below the dam by the lake.
Very low flow through the outlet.

Site 8. Main Basin Of Murphy Lake.
Date: 11 October 1995
Time; 1330
Weather: 14 °C with 100% cloud cover; strong wind.
Samples collected from the lake by boat.
Water level in the lake appeared normal.

Site 9. Outlet of Murphy Lake.
Date: 11 October 1995
Time; 1400
Weather: 14 °C with 100% cloud cover; strong wind.
Samples collected just above the bridge.
Very low (<1 L/sec) flow through outlet.

Site 10. Main Basin of Little River Lake.
Date: 12 October 1995
Time; 1240
Weather: 14 °C with 100% cloud cover and intermittent showers; strong breeze.
Samples collected from the lake by boat.
Water level appeared normal.

Site 11. Outlet of Little River Lake into Little River.
Date: 12 October 1995
Time; 1220
Weather: 14 °C with 100% cloud cover and intermittent showers; strong breeze.
Samples collected from shore just below the dam.
Flows were abnormally high at the time of sampling as water was being let down this passage to fill the White Rock Headpond.

Site 12. Main Basin of Methals Lake.
Date: 12 October 1995
Time; 1130
Weather: 14 °C with 100% cloud cover and intermittent showers; strong breeze.
Samples collected from the lake by boat.
Water level appeared normal.

Site 13. Outlet of Methals Lake into Black River Lake.
Date: 12 October 1995
Time; 1110
Weather: 12 °C with 100% cloud cover and intermittent showers; strong breeze.
Samples collected from walkway on the downstream side of power station; there was no flow through this passage at the time of sampling.

Site 14. Main Basin of Black River Lake.
Date: 12 October 1995
Time; 1015
Weather: 12 °C with 100% cloud cover and intermittent showers; strong breeze.
Samples collected from the lake by boat.
Water level appeared normal.

Site 15. Outlet of Black River Lake into canal towards Lumsden Pond.
Date: 12 October 1995
Time; 1050
Weather: 12 °C with 100% cloud cover and intermittent showers; strong breeze.
Samples collected from shore just below the power station.
Water level very low; little or no flow through the canal at the time of sampling.

Site 16. Outlet of Gaspereau River into White Rock headpond.
Date: 12 October 1995
Time: 1030
Weather: 14 °C and sunny; no wind.
Samples collected from the Highway bridge.

APPENDIX II

Guidelines for Data Interpretation

APPENDIX II

Guidelines for Data Interpretation

Secchi Disk Depth - A Secchi Disk is a small white and black disk that is lowered into the water until it can no longer be seen. The depth at which the disk disappears provides information on water clarity which depends on the kind and amount of dissolved and particulate material in the water body. Extremely turbid waters may have Secchi depths less than 1 meter while very clear waters have Secchi depths greater than 10 meters. Readings between 2 and 5 m are typical of Nova Scotia lakes.

Apparent Color and True Color - The color of a water body depends primarily on two factors; the kinds of particulate substances suspended in the water and the kinds of substances dissolved in the water. The color that results from suspended materials is called apparent color and the color caused by dissolved substances is called true color. Apparent color is caused by such things as microscopic algae and clay and silt particles. True color is usually caused by various substances leached from the soil within the watershed, especially decomposition products of plants, which are then carried into the stream or lake as runoff.

Conductivity - Conductivity is a measure of the amount of dissolved salts present in a water body. It is measured with a meter that determines the water's ability to conduct electricity - the higher the salt content the greater the conductivity. Conductivity values less than 100 μsei/cm generally indicate soft water, values between 100-300 moderately hard water, and values greater than 300 hard water.

Hardness - Hardness is related to conductivity but is a more direct measure of the amount of dissolved calcium and magnesium, the major salts that cause hardness, present in a water body. Total hardness values are expressed as mg/l of calcium carbonate equivalents and can range from as low as near 0 mg/l for very soft water to greater than 5000 mg/l for very hard waters. Generally, values less than 50 mg/l indicate soft water, values between 50 and 100 moderately hard water and values greater than 100 hard water.

pH - pH is a measure of the acidity of a liquid. Values of pH can range between 0 and 14. pH values less than 7 indicate acidic conditions and values greater than 7 indicate basic conditions. pH values below 5 indicate potentially harmful acidic conditions and are a cause for concern.

Alkalinity - Alkalinity is a measure of the buffering capacity (ability to resist change in pH) of a water body. Water bodies having a low alkalinity have little ability to neutralize acids and are very susceptible to acidic inputs such as acid precipitation. Water bodies having alkalinity values less than 10 mg/l have little buffering capacity, those having values between 10 and 100 moderate buffering capacity and those above 100 good buffering capacity.

Dissolved Oxygen and Percent Oxygen Saturation - The amount of dissolved oxygen present provides important information on the suitability of a water body to support aquatic organisms. It is one of the most sensitive indicators of water quality. Equally important is the percent oxygen saturation which depends on water temperature as well as the amount of dissolved oxygen present. Generally, dissolved oxygen concentrations below 3-4 mg/l are lethal for most fish and many other aquatic organisms. Percent saturation values above 80 generally indicate healthy conditions. Values less than 50 percent saturation are cause for concern.

Suspended Particulate Matter - Measurement of suspended particulate matter provides information on the amount of particulate material in a water body. Particulate materials are diverse in origin and may consist of soils that have washed into the water through land erosion (inorganic particulate matter), materials resuspended from the bottom of a stream or lake, as well as microscopic organisms such as algae and bacteria (organic particulate matter). Particulate matter levels than 10 mg/l are about normal for clear waters. Levels between 10-25 mg/l indicate moderate suspended particulate matter concentrations and levels above 50 mg/l indicate particularly high concentrations.

Chlorophyll *a* - Chlorophyll *a* is the pigment that gives plants their green color. Measurement of the amount of chlorophyll a in a water body provides an estimate of the quantity of plant material present which is closely related to the level of productivity of the water body. Very often, when water quality deteriorates as a result of high nutrient inputs, the productivity of the system increases leading to heavy blooms of algae (microscopic plants). In some cases this can lead to depletion of oxygen if the plants die and sink into the bottom waters. In severe instances this depletion of oxygen can result in the build up of toxic substances such as hydrogen sulfide and ammonia. Chlorophyll *a* values generally range from less than 1 to as high as 30 μg/l. Values less than 3 μg/l generally indicate relatively unproductive waters, values between 3 and 10 μg/l moderately productive waters, and values above 10 μg/l very productive waters.

Total Phosphorous - Phosphorous is a major micronutrient required for the growth of plants. In aquatic ecosystems it is often the nutrient that limits the growth of algae. Excessive inputs of phosphate often leads to blooms of algae and results in deterioration of water quality. Common sources of excess phosphate include run off from human sewage, animal manures and farm and lawn fertilizers. The amount of phosphorous that can be assimilated by a water body before water quality is severely impacted depends on a number of factors, particularly the degree of water column stratification and flushing rate of the water body. However, rough guidelines often used to determine the concentrations that may result in impacts on water quality are:

less than 10 μg/l - little impact; between 10 and 20 μg/l - moderate impact; greater than 20 μg/l - high impact.

Nitrate - Nitrate is also a major plant micronutrient that can limit the growth of algae and result in rapid plant growth when supplied to a water body in excessive amounts. Potential sources of this nutrient are the same as for phosphorous, but it is particularly abundant in sewage and manures and is sometimes used as an indicator of contamination from these sources. Rough guidelines used to determine the concentrations that may impact water quality are: less than 0.5 mg/l - little impact; between 0.5 and 2 mg/l - moderate impact; values greater than 2 mg/l - high impact.

Fecal Coliform Bacteria - Coliform bacteria are bacteria that are common in the intestines of warm-blooded animals. Although they are not toxic in themselves, they are an indicator of the presence of fecal material that may contain organisms potentially harmful to humans. In aquatic ecosystems coliforms often originate from poorly treated human sewage. They may also originate, however, from run-off from farm feedlots and pastures, and even from wild waterfowl such as ducks. Acceptable fecal coliform numbers depends on the proposed use of the water. Limits for various uses as proposed in the Canadian Water Quality Guidelines are: drinking water for humans - 0 per 100 ml; drinking water for livestock - 20 to 50 per 100 ml; irrigation of produce for human consumption - 100 per 100 ml; recreation (e.g. swimming, board sailing) - 200 per ml.

Figure 2. Water column temperature profiles for the main basin of each lake.

Figure 3. Secchi Disk depths for the main basin of each lake.

Figure 4. Total particulate matter concentrations at each site.

Figure 5. Dissolved oxygen concentrations at each site.

Figure 6. Percent dissolved oxygen saturation at each site.

Figure 7. Total phosphorous concentration at each site.

Figure 8. Fecal coliform numbers at each site.

Figure 9. Chlorophyll *a* concentrations at each site.