Kings Agricultural Wetland and Biodiversity Conservation Initiative
Greencover Project

Results of Water Quality Monitoring
2006-2009

Prepared By

Michael Brylinsky
Acadia Centre for Estuarine Research
Acadia University
Wolfville, Nova Scotia

For

Greencover Canada Regional Technical Assistance Programme
of the
Kings Agricultural Wetland and Biodiversity
Conservation Initiative

May 2009

Publication No. 92 of the Acadia Centre for Estuarine Research

SUMMARY

As part of the Kings Agricultural Wetland and Biodiversity Conservation Initiative being carried out by the Nova Scotia Department of Natural Resources under the Greencover Canada Program, a water quality monitoring program was initiated at two agriculture demonstration sites located within the upper reaches of the Cornwallis River watershed.. One of the major objectives of this project is to evaluate the efficacy of Beneficial Management Practices (BMPs) implemented at the demonstration sites to improve water quality within the Cornwallis River. This report describes the approach taken to monitor and evaluate water quality and the results that have been attained over the period between November 2006 and March 2009.

The water quality parameters monitored include nutrient concentrations, fecal coliform bacteria numbers, and turbidity, temperature, conductivity, pH and dissolved oxygen levels. The results obtained to date indicate that water quality at the demonstration sites is severely impacted as exemplified by high levels of nutrients and fecal coliform numbers and, at times, high turbidity and temperature and low dissolved oxygen levels. Results of monitoring in other areas of the River outside of the demonstration sites indicate that this also appears to be generally true of water quality within all of the upper reaches of the Cornwallis River.

Although some of the proposed BMPs have been implemented as early as late 2006, there does not appear to be any obvious improvements in water quality at the demonstration sites thus far. This, however, is not unexpected as it will require considerable time for the remedial processes associated with the implemented BMPs to develop.

Table of Contents

List of Figures

Kings Agricultural Wetland and Biodiversity Conservation Initiative
Greencover Project
Results of Water Quality Monitoring
2006-2008

1. Introduction

During 2006, the Nova Scotia Department of Natural Resources began implementation of the Kings Agricultural Wetland and Biodiversity Conservation Initiative (KAWBCI) as part of the Greencover Canada Plan. The primary objective of the KAWBCI is to determine the effectiveness of a variety of Beneficial Management Practices (BMPs) aimed at reducing the impact of agricultural activities on wetlands and water quality. As part of this initiative, in the late fall of 2006 a water quality monitoring program was established at two demonstration sites, one at a large beef operation and another at a large dairy operation. The primary objective of the water quality program is to obtain baseline data prior to and after implementation of BMPs designed to improve water quality in order to evaluate their improving water quality.

Beginning in 2007, a number of BMPs have been initiated at the demonstration sites. These include (1) fencing livestock out of a buffer strip established along the River's edge to encourage the development of a natural riparian zone; (2) construction of bridges for livestock crossings over, rather than through, the River; (3) provision of alternative livestock watering systems to alleviate the need for livestock watering directly from the River; and (4) construction of an artificial wetland to treat a milkhouse waste stream.

2. Approach

The two demonstration sites chosen for this project are located within the upper reaches of the Cornwallis River watershed on agricultural lands owned by Andrew Van Oostrum and Timothy Lamb. Initially, the intent was to establish two primary water quality monitoring sites, one located where the River entered the uppermost demonstration site and another where the River exited the lowermost demonstration site, the intent being to determine changes in water quality as river water flows through the two demonstration sites. However, it became apparent that there were a number of land use activities within areas of the watershed separating the two demonstration sites that could make it difficult to evaluate water quality changes resulting solely from land use activities occurring at the two demonstration sites. As a result, two primary water quality monitoring stations were established at each demonstration site, one where the River first enters each site and one were the River last exits each site, for a total of four primary monitoring sites (Fig. 2.1). Appendix I contains an aerial photo illustrating the location of each primary monitoring site in relation to the boundaries of the two demonstration sites.

Because of the necessity to increase the number of monitoring stations from two to four, only three of the four primary monitoring sites were equipped with water quality data loggers during 2006-2007. The Upper Van Oostrum site was continuously monitored only for water temperature, water depth, nutrients and coliform bacteria. The remaining three primary sites, Lower Van Oostrum, Upper Lamb and Lower Lamb were monitored for these same parameters, but were also equipped with continuously recording data loggers set to monitor conductivity, pH, dissolved oxygen and turbidity. In 2008, additional water quality data loggers were purchased allowing all of the four primary monitoring sites to be equipped with continuously monitoring data loggers.

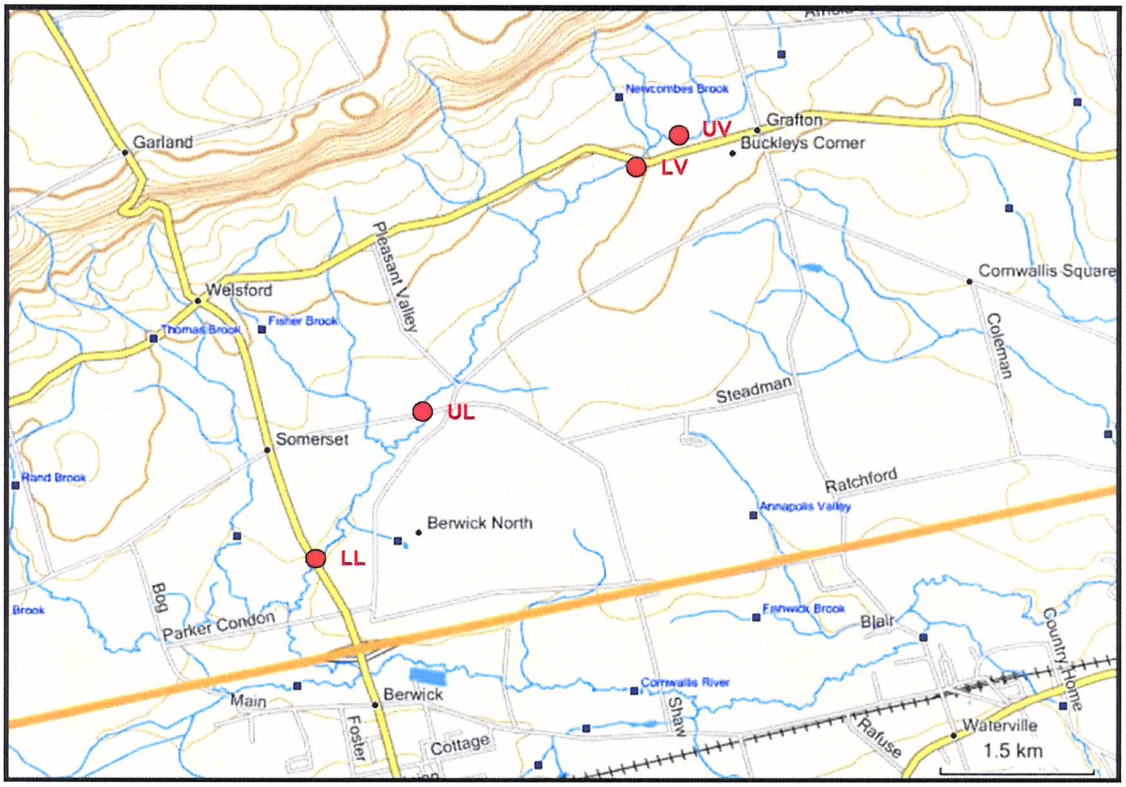


Fig. 2.1 Location of primary water quality monitoring sites (UV – Upper Van Oostrum; LV – Lower Van Oostrum; UL – Upper Lamb; LL – Lower Lamb).

In addition to the primary monitoring sites, nutrient and coliform samples were collected at seven secondary reference monitoring sites, some of which were located in areas outside of the sub-watersheds in which the demonstration sites were located (Fig.2.2). The locations of the secondary monitoring sites were chosen partly to provide information on water quality in areas surrounding, but not affected by land-use activities at the demonstration site, and partly to provide additional information on water quality in areas of the demonstration sites located between the primary monitoring sites. Site R1 represents what is thought to be relatively pristine water originating from an area at the base of the North Mountain. Three of the secondary monitoring sites (WC, MC and EC) are located within the main River at sites upstream, just below and downstream of the demonstration sites. .Fisher Brook, a major tributary flowing through the Lamb demonstration site was monitored at three locations: UFB, located where Fisher Brook first enters the Lamb site; FBT, located at the bottom of a tributary entering Fisher Brook, and; LFB, located within the main River just below where Fisher Brook enters the River. The Upper Fisher Brook site was also continuously monitored for water depth, conductivity and turbidity.

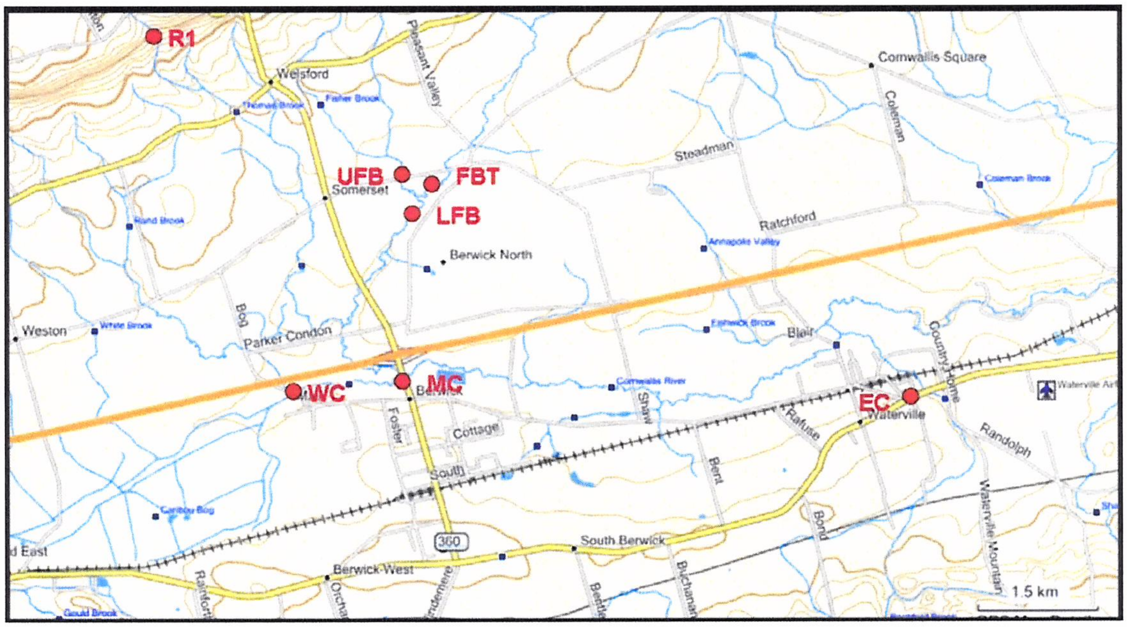


Fig. 2.2 Location of secondary water quality monitoring sites (R1 - Reference Site 1; UFB – Upper Fisher Brook; FBT – Fisher Brook Tributary; LFB – Lower Fisher Brook; WC - West Cornwallis; MC - Middle Cornwallis; EC - East Cornwallis).

Two additional monitoring sites (not shown) were added in 2008 to monitor nutrients and coliform bacteria at the inlet and outlet of a constructed wetland designed to treat a milkhouse waste stream at the Lamb demonstration site

3. Methodology

3.1 Continuously Monitored Water Quality Parameters

A number of water quality parameters were monitored continuously using Yellow Spring Instruments (YSI) 6000 series Sondes. These included: water temperature, water depth, conductivity, pH, dissolved oxygen and turbidity. Each sonde was encased within PVC tubing having open ends that allowed water to flow freely over the probes (Figure 3.1). The probe end was deployed in the downstream direction and was elevated approximately 15 cm above the river bottom by two metal bars on the downstream end of the PVC tubing[1].

All data loggers were programmed to log each parameter at 15 minute intervals and were retrieved, downloaded, recalibrated and re-deployed at approximately one month intervals. At these times one litre water samples were also collected for analysis of suspended particulate matter (SPM) concentration and this information was used to determine the relationship between turbidity (measured as Nephelometric Turbidly Units (NTUs) by the dataloggers) and SPM.

Figure 3.1 YSI Sonde and PVC tubing used for placement on River bottom.

SPM measurements for calibration of the turbidity sensors were made by filtering 1 litre water samples through pre-weighed Watman GF/C glass fiber filters and oven drying the filters at 60-70 °C to a constant dry weight. SPM was determined as the difference between the pre-weight and final weight. The relationship between NTUs and SPM concentrations is illustrated in Appendix II.

[1] Initially, the probes were oriented upstream, but this often resulted in heavy accumulations of sediments on the surface of the probes during events of high sediment load which influenced the ability of the probes to respond properly, especially in the case of dissolved oxygen measurements.

3.2 Water Depth, Current Velocity and River Discharge

Although the YSI sondes recorded water depth, they lack the sensitivity required to measure the small changes in depth necessary to obtain accurate data for determining discharge rates at each site. As a result, HOBOware PRO depth loggers were deployed at each primary monitoring and the Upper Fisher Brook secondary site. These were also encased in PVC tubing and placed directly on the River bottom within the centre of the River channel. Logged depth measurements were corrected for variations in barometric pressure by atmospheric pressure measurements collected by a base reference logger located at ground level under a small building nearby the Upper Van Oostrum monitoring site during 2007 and nearby the Upper Fisher Brook site during 2008.

Measurements of current velocity and water depth collected during 2008 using a GLOBAL Model FP101 flow probe were used to construct current velocity-depth rating curves for each monitoring site (Appendix III)). The rating curves were in turn used to calculate a stage-discharge relationship (Appendix IV) for each monitoring site using the relationship between surface area and depth at site, and this relationship was used to calculate daily water discharge, daily sediment loads and monthly nutrient loads during the 2007 and 2008 monitoring period.

3.3 Nutrients

Nutrients (total nitrogen, nitrate, ammonia, total phosphorous and phosphate) were monitored at biweekly intervals between May and November, and at monthly intervals between December and April. Water samples for nutrient analyses were collected from just below the surface in pre-acid washed polyethylene bottles and stored frozen until analysis. All nutrient analyses were carried out at the water quality laboratory of the K.C. Irving Environmental Centre at Acadia University using a Technitron automated nutrient analyzer.

3.4 Fecal Coliform Bacteria

Samples for fecal coliform bacteria were collected at the same locations and time intervals as nutrient samples. The water samples were collected in pre-sterilized containers and kept refrigerated until processing which was carried out within 24 hours of collection. All samples were processed at the Microbiological Laboratory of the Biology Department at Acadia University using the membrane filtration technique and 24 hour incubations at 44.5 °C on mSC media.

4. Results

The initial stages of the monitoring program proved to be problematic. Cold weather during late December 2006 resulted in ice formation on the surface of the River and it was not possible to retrieve the loggers until mid March 2007. In some cases, especially at the shallower sites, the River froze completely to the bottom and the loggers became entirely encased in ice. Although the loggers continued to collect data during this period, it is unlikely that any of this data is useful as it does not represent conditions during winter thaw episodes when some periods of free flowing water over the ice layer occur. As a result of the problems associated with ice formation and the potential for damage to the loggers, the YSI loggers were removed in mid-November 2007 and not redeployed until early April 2008 after all of the winter ice had melted. They remained deployed until late December 2008 before winter conditions resulted in ice formation.

In addition, for a number of reasons related to problems encountered during the 2006-2007 deployments when the dataloggers often became completely covered with sediments, the Upper Van and Upper Fisher Brook monitoring sites were relocated a short distance downstream from the 2006-2007 sites to locations where new culverts had been installed during 2007. This alleviated the sediment problem resulting in an improved data set.

4.1 Water Temperature

Water temperature (Fig.4.1) showed little variation between sites. There was a distinct seasonal trend with maximum temperatures of about 23°C occurring during late July and early August.

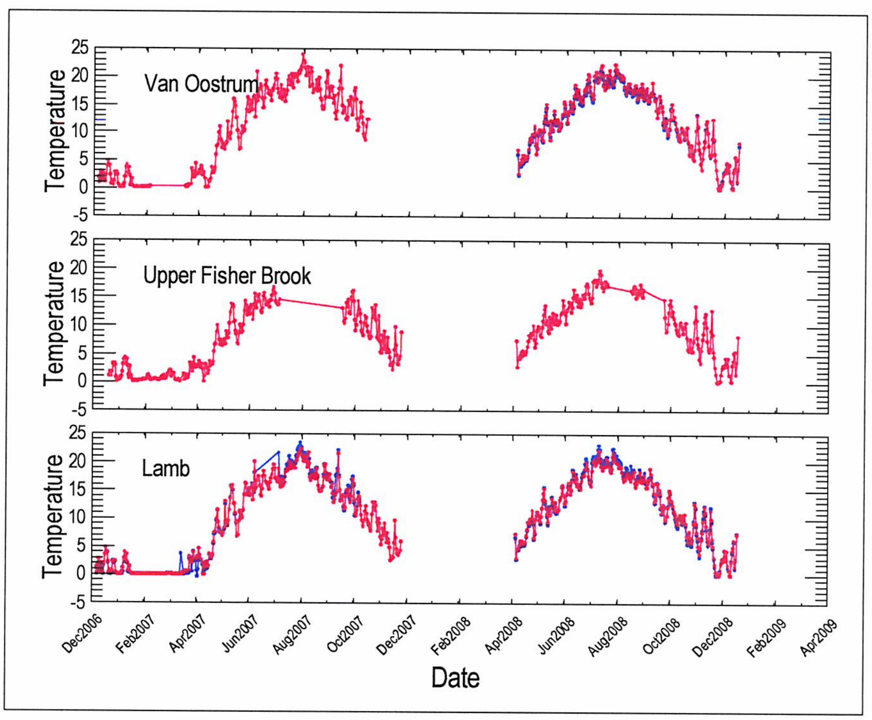


Fig. 4.1 Seasonal variation in water temperature at each site (blue lines represent the Upper monitoring site and red lines represent the Lower monitoring site).

The Upper Fisher Brook site was slightly cooler than all other sites with maximum temperatures of about 15°C and 20°C during 2007 and 2008, respectively, which suggests that a significant portion of its inflow originates from groundwater sources.

4.2 Conductivity and pH

Conductivity (an indirect measure of dissolved salt content) was generally quite high and showed considerable seasonal variation with relatively low values during the cooler months and very high values during the summer months (Fig. 4.2). It exhibits a strong inverse relationship to water depth which is most likely a result of a greater proportion of groundwater inputs (which typically contain much higher salt contents than surface waters) during periods of low water. Fisher Brook has slightly higher conductivities than the other sites. At the Van Oostrum site the conductivity of inflowing water was slightly higher than that of the outflowing water. Conductivity values at the Upper Fisher Brook site are slightly higher than at the other sites which, like water temperature, are likely a result of groundwater inputs. The Lamb site exhibited significantly higher conductivity levels at the outflow which may be due, in part, to the influence of Fisher Brook.

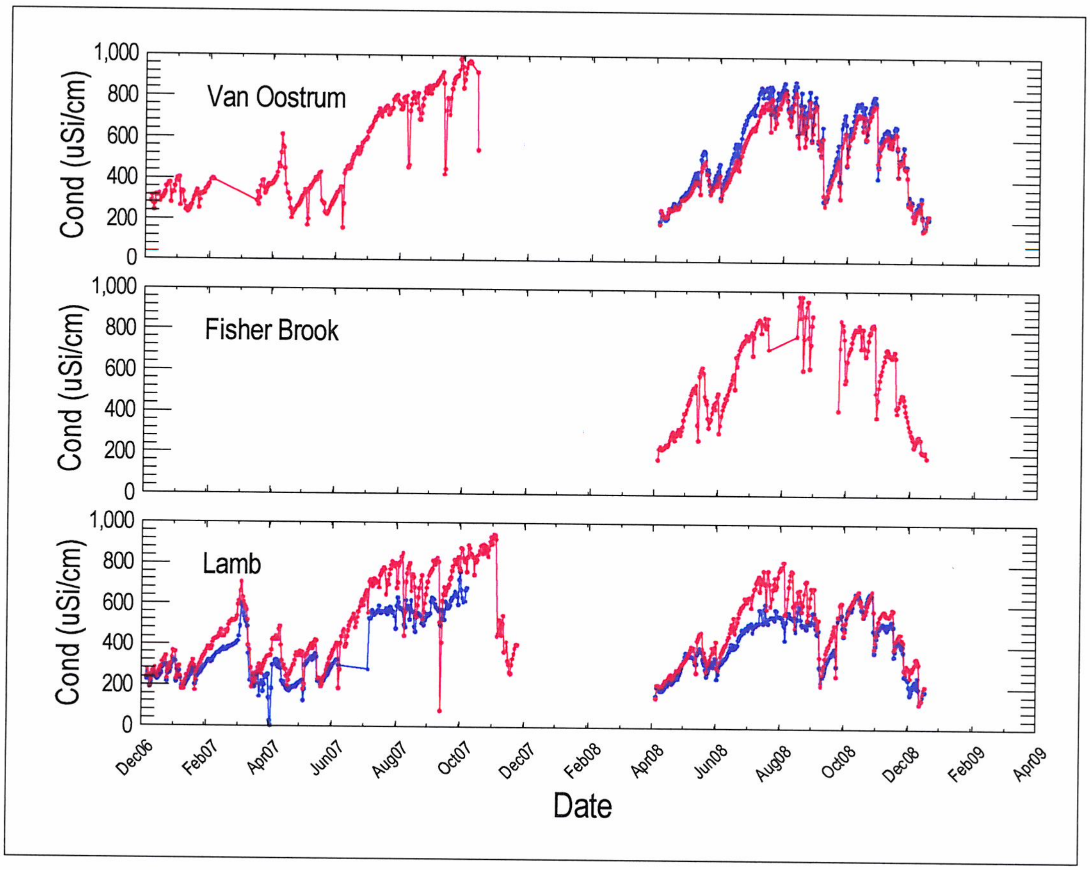


Fig. 4.2 Seasonal variation in water conductivity at each site (blue lines represent the Upper monitoring sites and red lines represent the Lower monitoring sites).

The values for pH at all sites were also quite high ranging between about 7 and 8 (Fig. 4.3). The high and relatively stable pH values indicate that the high conductivity levels of the River are most likely due to salts of carbonates, the main buffering component of natural fresh waters.

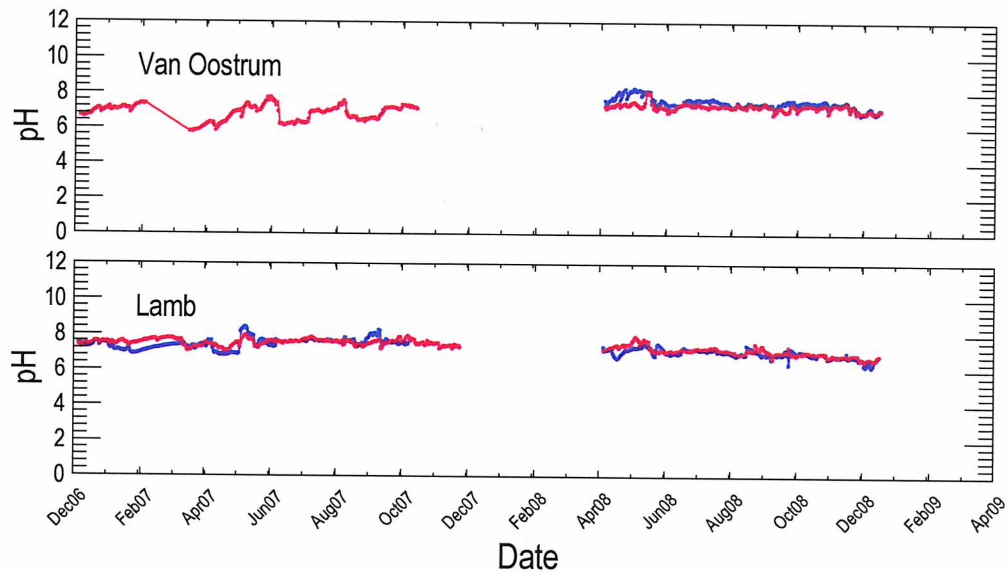


Fig. 4.3 Seasonal variation in pH at each site (blue lines represent the Upper monitoring sites and red lines represent the Lower monitoring sites).

4.3 Dissolved Oxygen Concentration and Percent Saturation

Continuous monitoring of dissolved oxygen concentration was not entirely successful. In many instances, particularly during periods when suspended sediment concentrations were high, the dissolved oxygen probe failed to operate properly. Fig. 4.4 illustrates the variation in dissolved oxygen at each site at which YSI Sondes were deployed (only those values of dissolved oxygen recorded when the probe was determined to be operating properly are shown[2].).

Dissolved oxygen levels ranged from highs reaching to nearly 20 mg/L to lows of 0 mg/L. There was considerable seasonal variation, the highest values occurring during early spring and the lowest values occurring during the late summer. There were also times when there were significant differences between water entering and leaving the sites in which case water leaving had much lower dissolved oxygen values than water

[2] The YSI Sonde records a parameter (dissolved oxygen charge) that provides an indication of whether or not the dissolved oxygen probe is working properly.

entering. This was most pronounced at the Lamb site and occurred during the late summer when water depths were low and water temperatures were high. At the Van Oostrum site it occurred in the late fall of 2008.

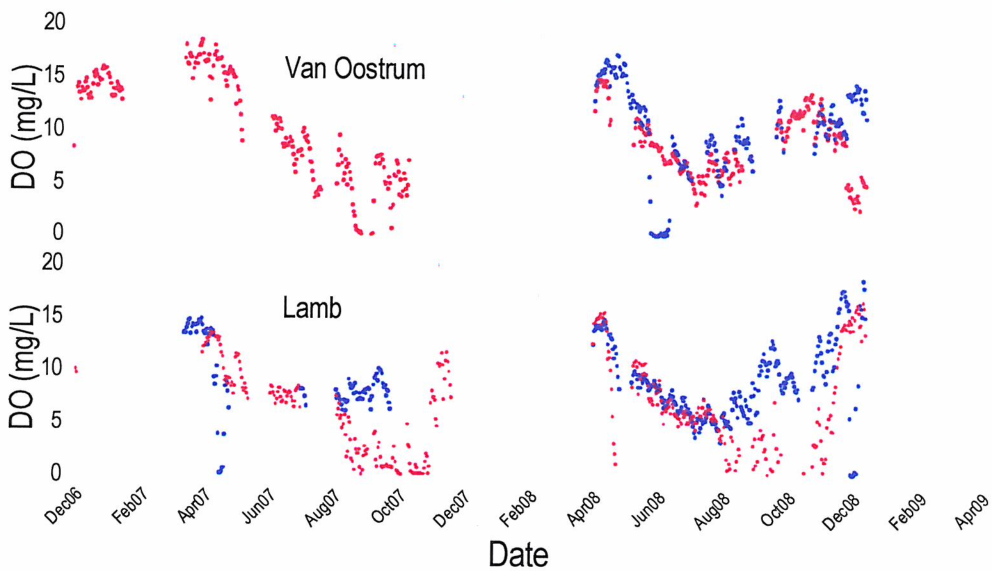


Fig. 4.4 Seasonal variation in dissolved oxygen concentration at each site (blue dots represent the Upper monitoring sites and red dots represent the Lower monitoring sites).

Percent dissolved oxygen levels also varied greatly. In some instances percent saturation values exceeded 100 percent (Fig 4.5), particularly in the early spring during high water flows associated with snow melts, and during low water levels in the summer when a greater proportion of the River originates from cold groundwater flows that gradually become heated resulting in a decrease in the dissolved oxygen level required for saturation to occur.

At times, percent saturation fell below 50%, the value which is typically considered to be stressful for aquatic organisms, especially cold water fish species such as brook trout. This typically occurred during August and lasted until early November at both the Lower Van Oostrum and Lower Lamb site, but was more extensive at the latter.

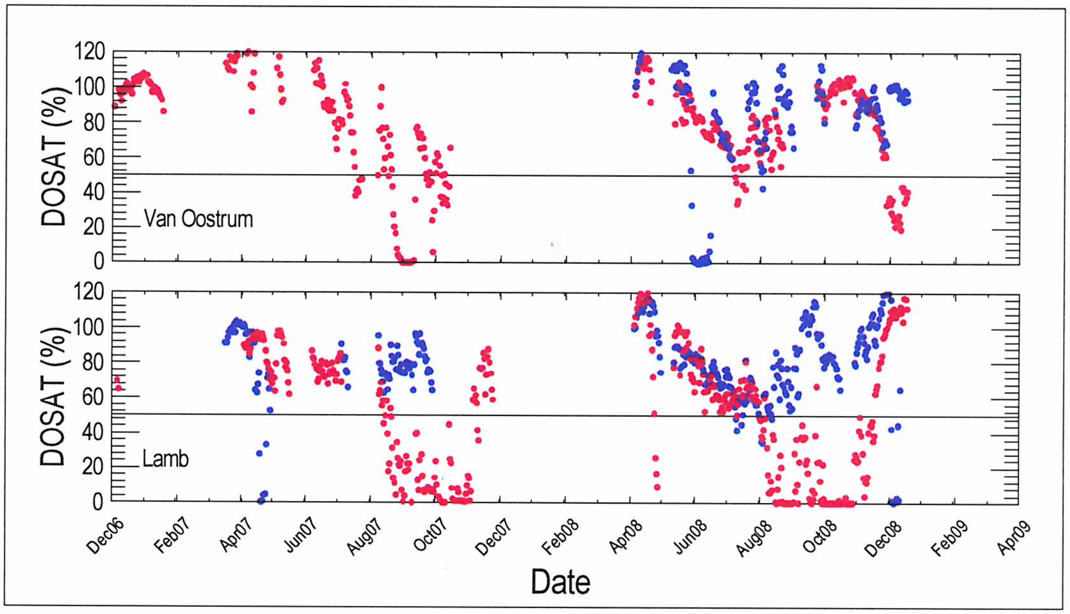


Fig. 4.5 Seasonal variation in percent dissolved oxygen saturation at each site (blue dots represent the Upper monitoring sites and red dots represent the Lower monitoring sites; solid lines indicate the critical 50% saturation level).

At times, percent saturation fell below 50%, the value which is typically considered to be stressful for aquatic organisms, especially cold water fish species such as brook trout. This typically occurred during August and lasted until early November at both the Lower Van Oostrum and Lower Lamb site, but was more extensive at the latter

4.4 Turbidity

Turbidity, a measure of suspended particulate matter, exhibited considerable variation and often attained values of nearly 1000 NTUs (Fig.4.6). Although there were generally high values associated with periods of high precipitation there does not appear to be a strong direct relationship between precipitation events and turbidity. There was considerable difference between sites in the times at which high turbidity events occurred which suggest that these events may be partly related to site specific land use activities occurring within each site.

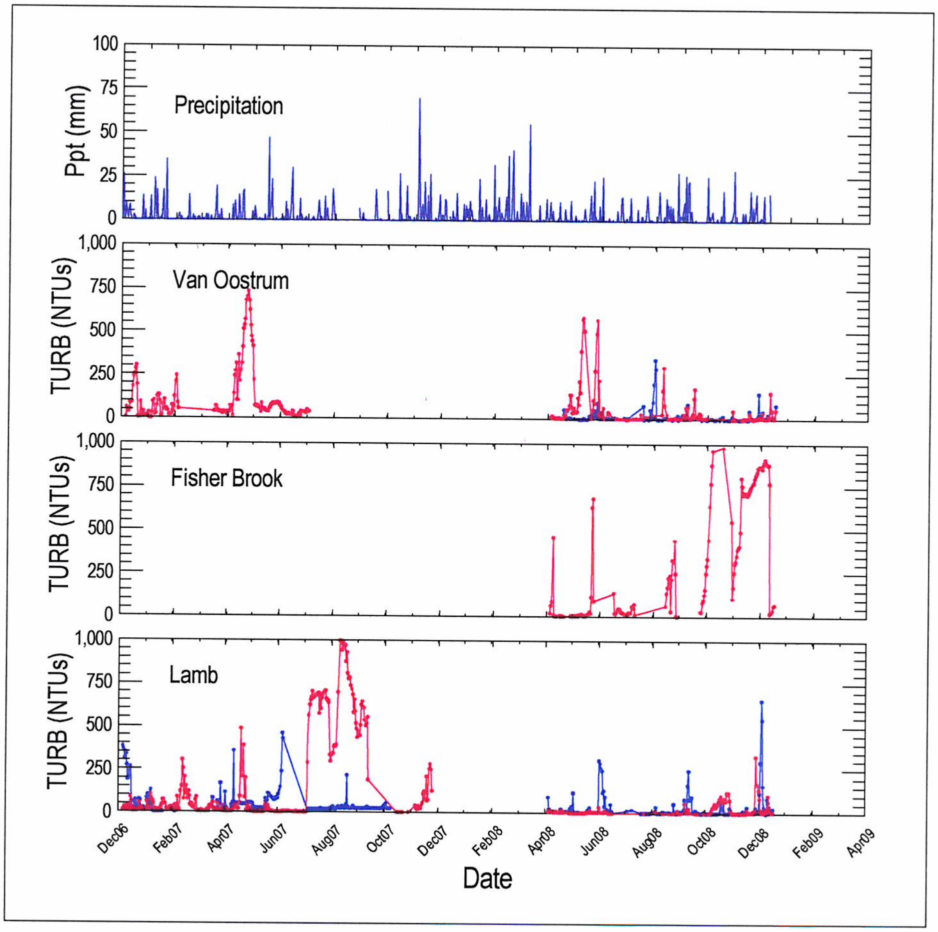


Fig. 4.6 Seasonal variation in total precipitation as recorded at the Kentville Research Agricultural Research Station (upper panel) and turbidity at each monitoring site (blue lines represent the Upper monitoring sites and red lines represent the Lower monitoring sites).

4.5 Nutrients

4.5.1 Nitrogen

Nitrogen levels varied greatly among the primary monitoring sites (Fig. 4.7). They were particularly high at the Lower Lamb site during the summer of 2007. In contrast, the highest values at the Van Oostrum sites occurred during the winter periods. At both sites, most of the total nitrogen is in the nitrate form which showed the same spatial and seasonal trends as total nitrogen. At the Lamb sites during the summer of 2007 they were very near the CCME guideline of 2.9 mg/L nitrate-N for the protection of aquatic life (CCME 2002). Ammonia levels were very low at most times.

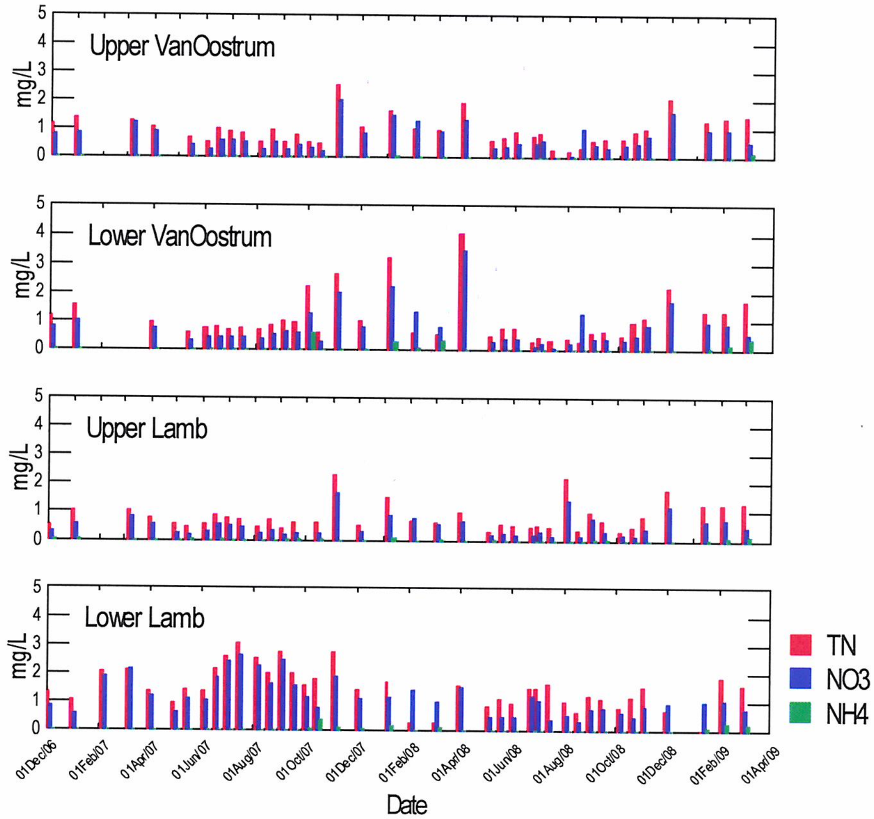


Fig. 4.7 Total nitrogen, nitrate and ammonia nitrogen concentrations at each primary monitoring site.

At the Van Oostrum site, total nitrogen levels were generally similar at both the Upper and Lower monitoring sites except for a number of times during the late fall and winter of 2007 when the Lower site had much higher values than the Upper site (Fig. 4.8). .In contrast, the Lamb site typically had much higher values at the Lower site which often approached levels greater than 2 mg/L This may indicate land use activities located within the watershed between the Upper and Lower monitoring sites that result in significant nitrogen loading to the River.

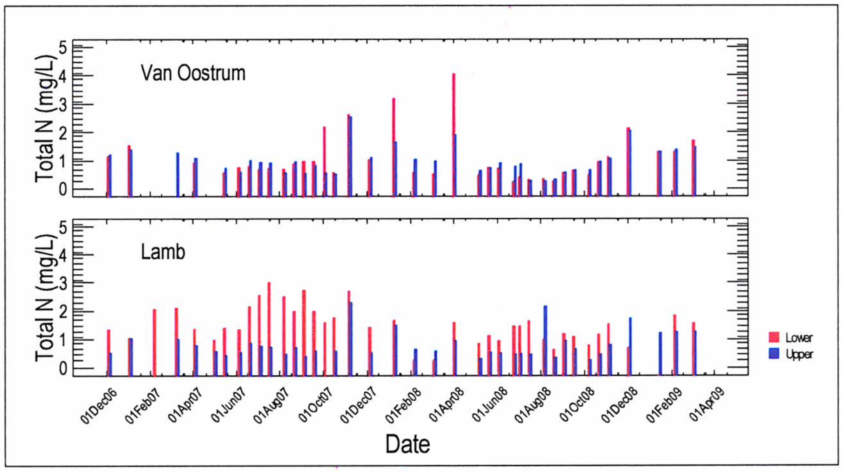


Fig. 4.8 Total nitrogen levels at the primary monitoring sites.

The highest values of nitrogen were observed at the secondary monitoring sites associated with the Fisher Brook tributary (Fig. 4.9). They were especially high at the tributary flowing into Fisher Brook where they often exceeded concentrations of 4 mg/L. Most of this was in the nitrate form, except during the summer when high levels of ammonia were observed.

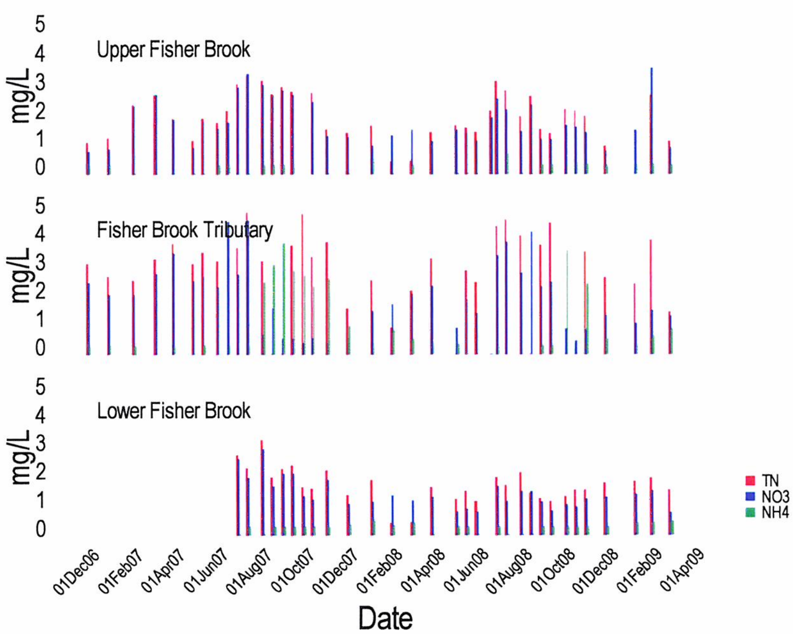


Fig. 4.9 Nitrogen levels at the monitoring sites associated with Fisher Brook.

Total nitrogen levels were also high at those secondary monitoring sites located within the main River (Fig.4.10). In some cases they exceeded 3 mg/L. At site R1, however, they seldom exceeded 1 mg/L.

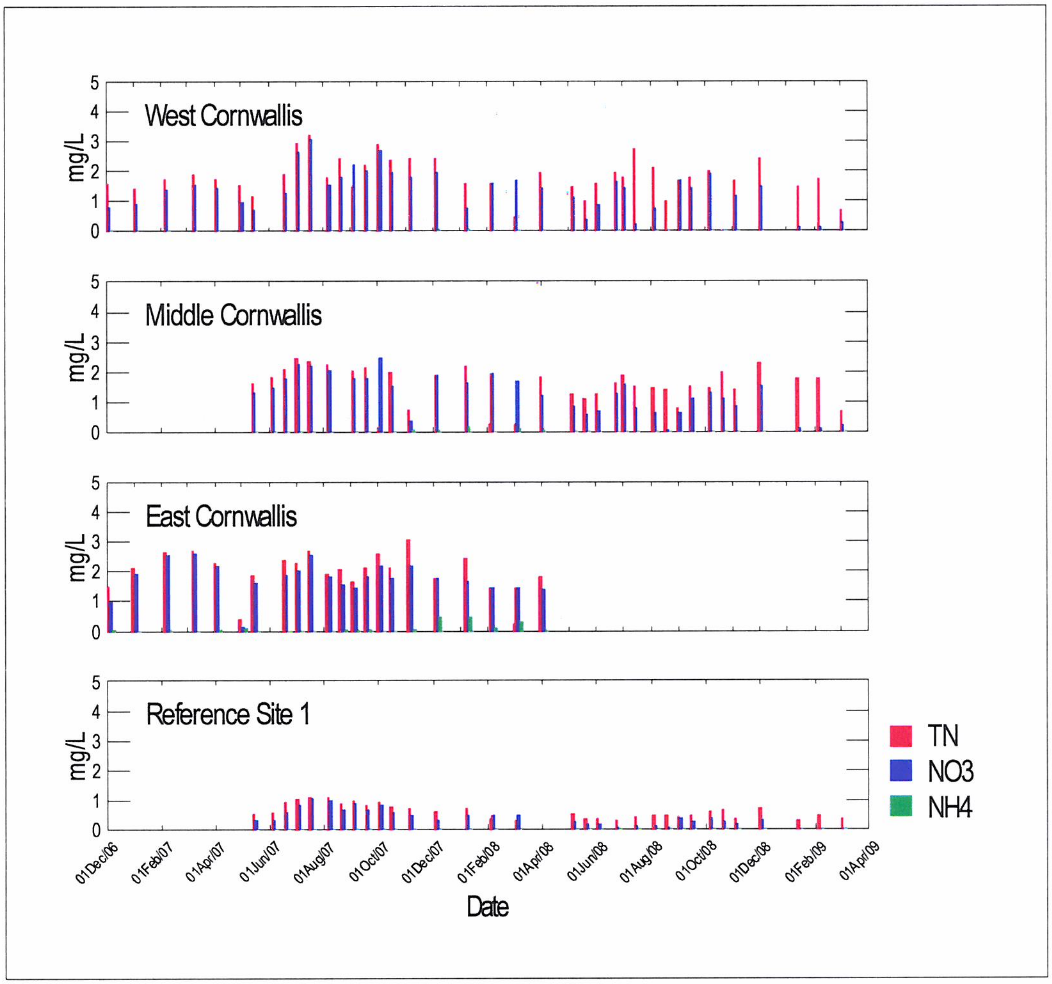


Fig. 4.10 Total nitrate and ammonia nitrogen concentrations at secondary monitoring sites.

Comparison of the mean values of total and nitrate nitrogen for all sites (Fig. 4.11) indicates that the primary monitoring sites are for the most part only slightly higher in total nitrogen than are the secondary sites, but that the relative proportion of nitrate to total nitrogen is greater at the primary monitoring sites.

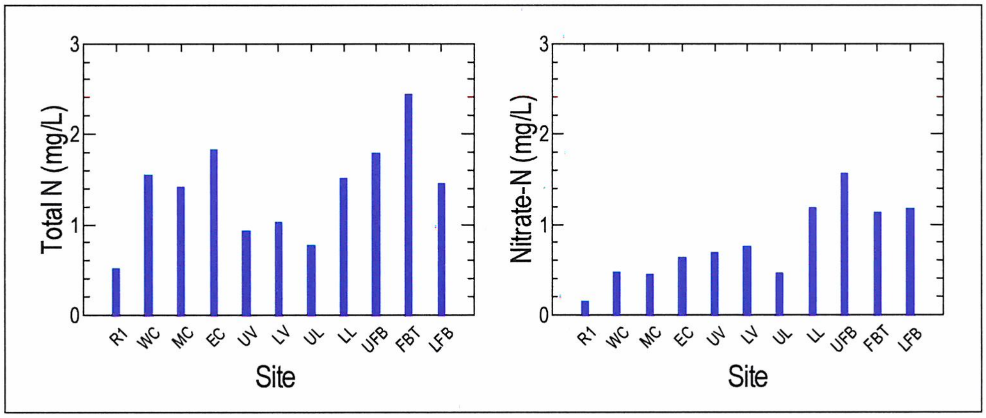


Fig. 4.11 Comparison of mean values of nitrogen at the primary and secondary monitoring sites.

4.5.2 Phosphorus

In contrast to nitrogen, total phosphorus levels at the primary monitoring sites were exceptionally high, often exceeding levels greater than 0.1 mg/L (Fig 4.12). Much of the total phosphorous was present in the labile phosphate form which is typically present in concentrations below the analytical limits of detection in unimpacted aquatic systems. The highest phosphorus levels generally occurred during the summer months.

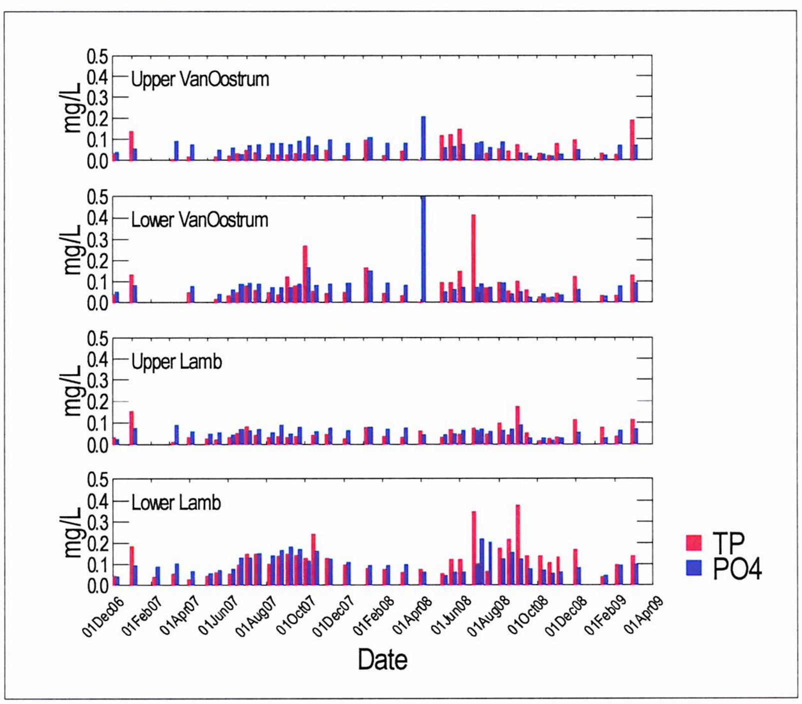


Fig. 4.12 Total phosphorus and phosphate concentrations at each primary monitoring site.

At all of the primary monitoring sites, but especially at the Lamb site, both total phosphorus and phosphate levels were most often greater at the Lower than Upper monitoring sites (Figs. 4.13 and 4.14) suggesting that land use activities within the watershed of each site are resulting in an export of phosphorus to the River.

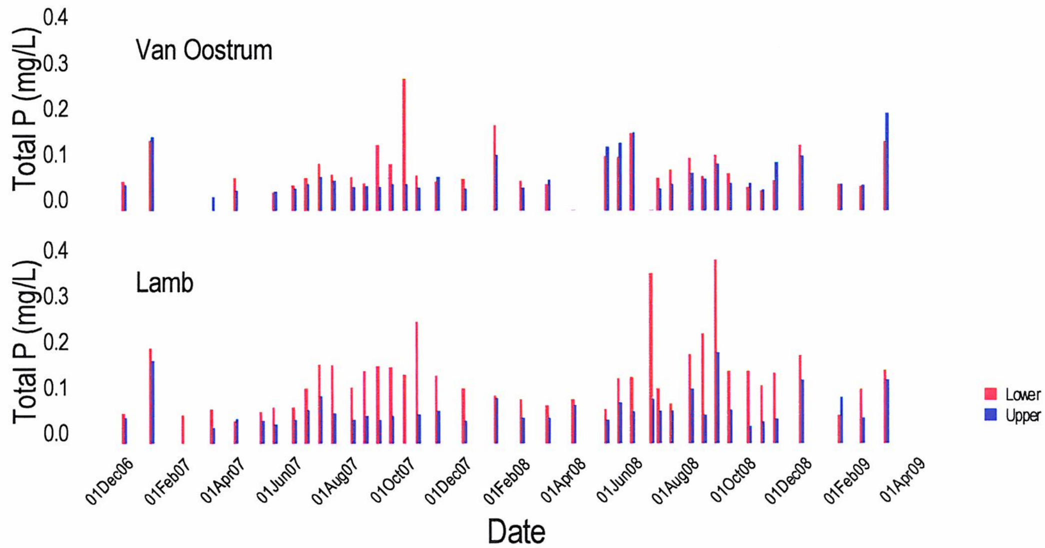


Fig. 4.13 Seasonal variation in total phosphorus at the primary monitoring sites.

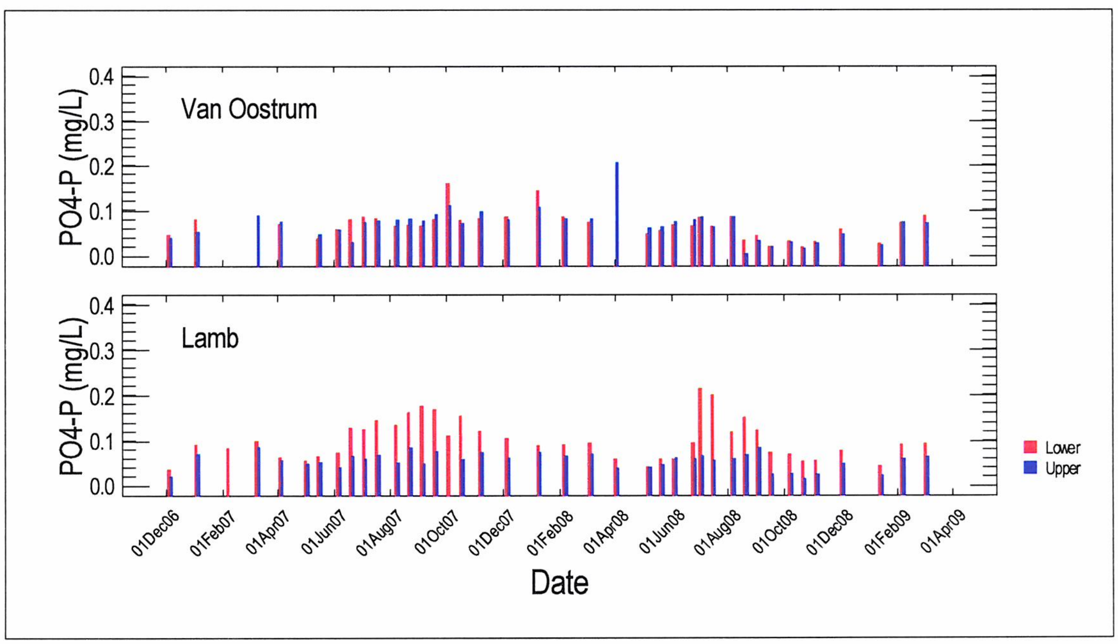


Fig. 4.14 Seasonal variation in phosphate at the primary monitoring sites.

As was the case with nitrogen, the highest values of phosphorus occurred at the Fisher Brook tributary where at times total phosphorus concentrations exceeded 0.4 mg/L (Fig. 4.15). Also, like nitrogen, the ratio of total phosphorus to phosphate varied considerably at all of the sites associated with Fisher Brook.

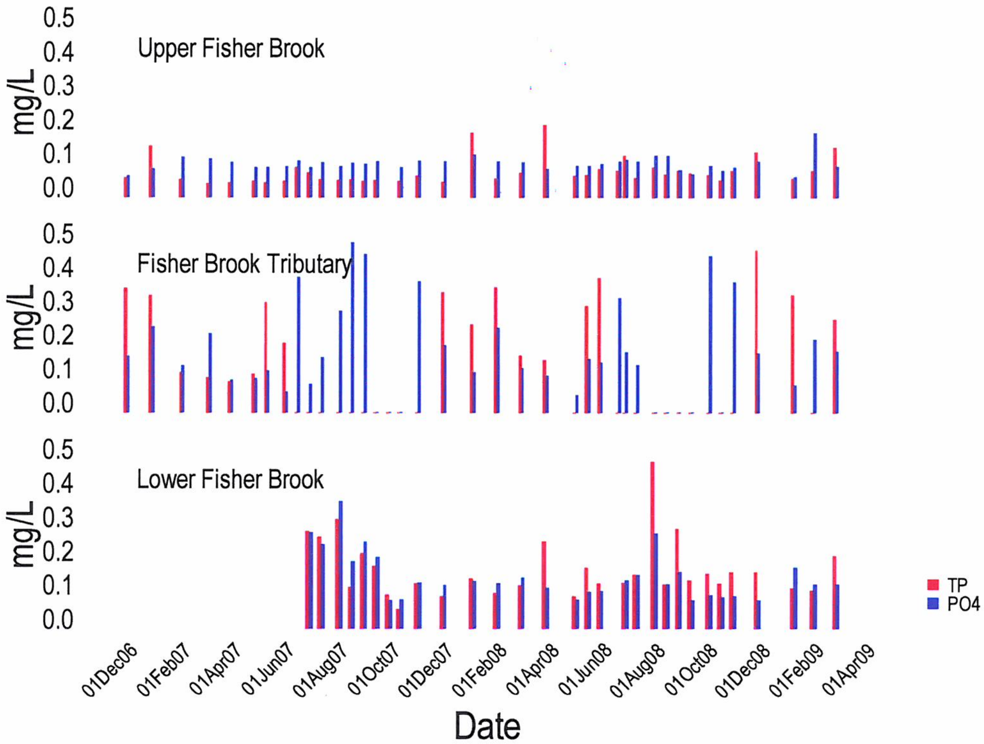


Fig. 4.15 Seasonal variation in phosphorus at the monitoring sites associated with Fisher Brook.

At the secondary monitoring sites located outside of the demonstration sites (Fig 4.16), Reference Site 1 exhibited the lowest phosphorus levels and the East Cornwallis River site exhibited the highest values which were at times as high as the levels observed at the Fisher Brook tributary site.

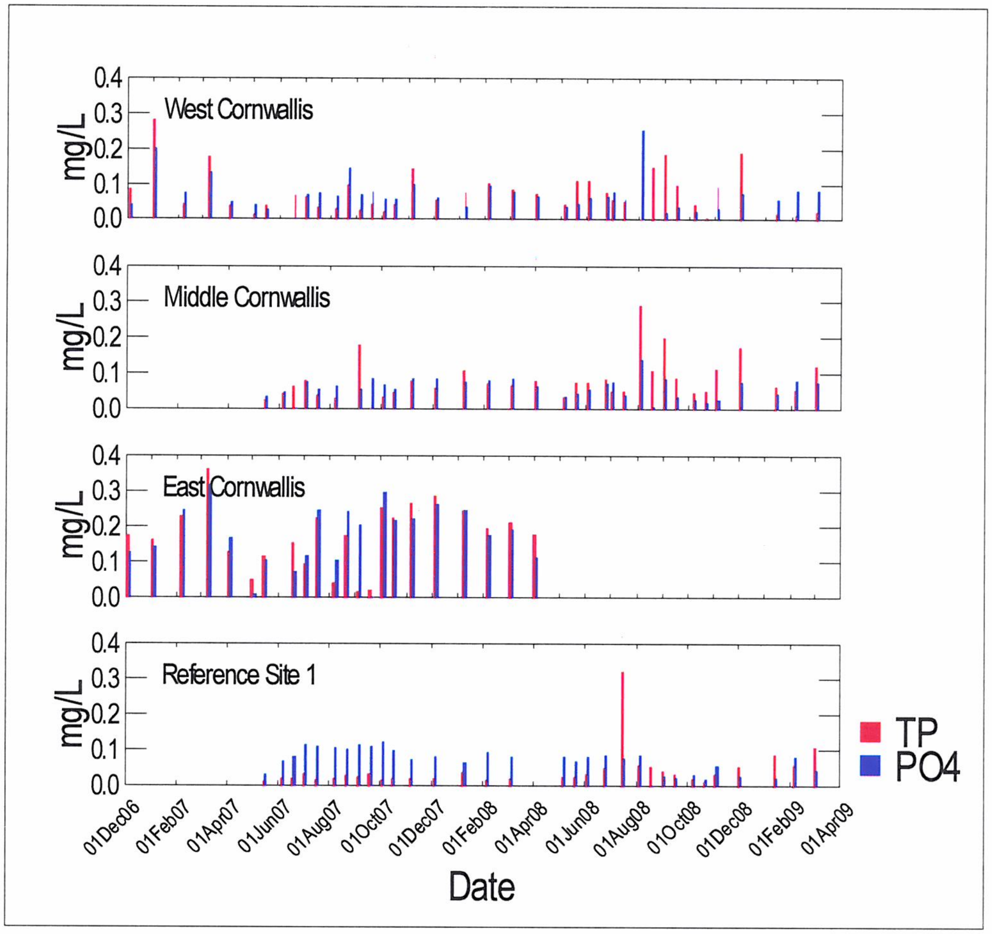


Fig. 4.16 Phosphorous concentrations at the secondary monitoring sites.

Comparison of the mean values of total phosphorus and phosphate for all monitoring sites (Fig. 4.17) indicates that phosphorus levels at the primary monitoring site do not differ greatly from those at the secondary monitoring sites.

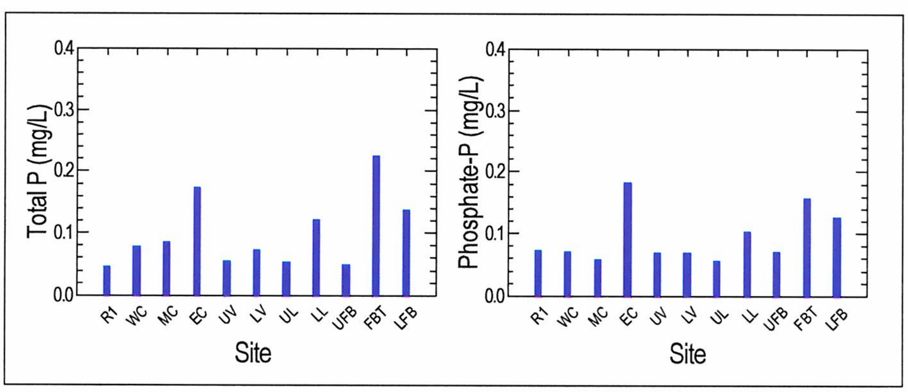


Fig 4.17. Comparison of mean values of phosphorus at the primary and secondary monitoring sites.

4.6 Fecal Coliform Bacteria

With few exceptions, fecal coliform numbers at the primary monitoring sites were very high at all times (Fig. 4.18). Numbers were seldom less than 100/ml and often exceeded 1000/ml. The highest values occurred during the summer months. At both the Van Oostrum and Lamb sites, fecal coliform numbers did not vary greatly between the Upper and Lower monitoring sites.

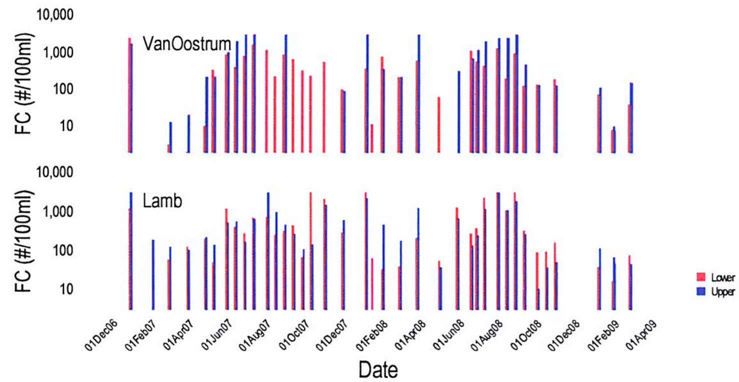


Fig. 4.18 Seasonal variation in fecal coliform bacteria numbers at the primary monitoring sites (blue bars represent Upper sites and red bars represent Lower sites).

Fecal coliform numbers were very high at all the secondary sites associated with Fisher Brook, especially at the Fisher Brook tributary site (Fig 4.19).

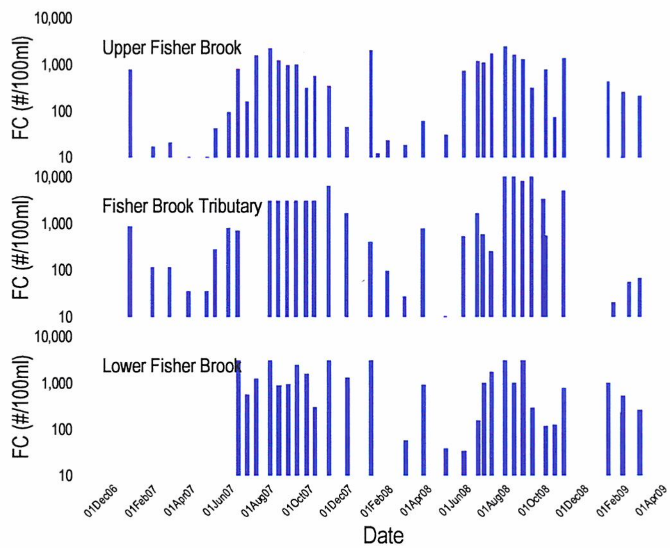


Fig. 4.19 Seasonal variation in fecal coliform bacteria numbers at the Fisher Brook monitoring sites

At the other secondary sites they were especially high at both the West and Middle Cornwallis River sites (Fig.4.20). When compared to all other sites (Fig 4.21) fecal coliform numbers were only slightly higher at the sites located at the demonstration sites.

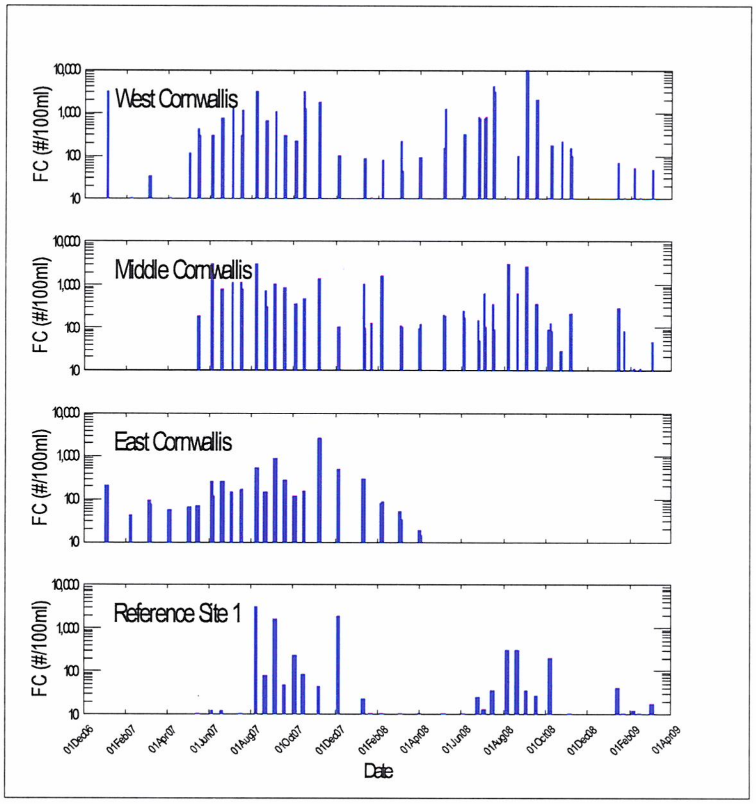


Fig. 4.20 Fecal coliform numbers at Reference Site 1 and the secondary monitoring sites located on the main River.

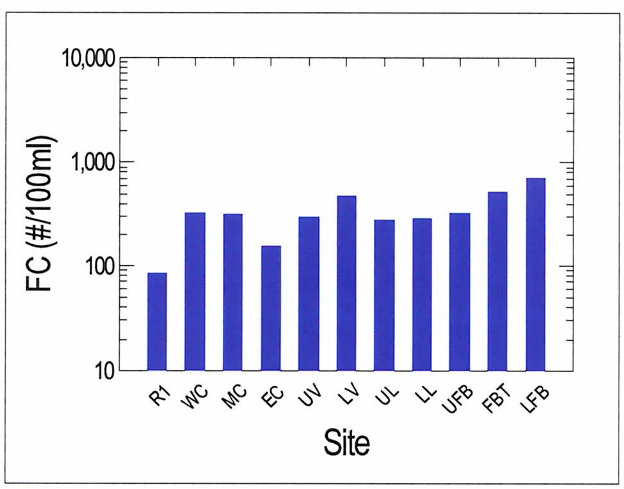


Fig. 4.21 Mean fecal coliform numbers for all sites monitored.

4.7 Water Discharge and Loadings

4.7.1 Water Discharge

Total daily precipitation and daily water discharge at each monitoring site during the times for which the data necessary to calculate discharge were available are illustrated in Fig. 4.22.

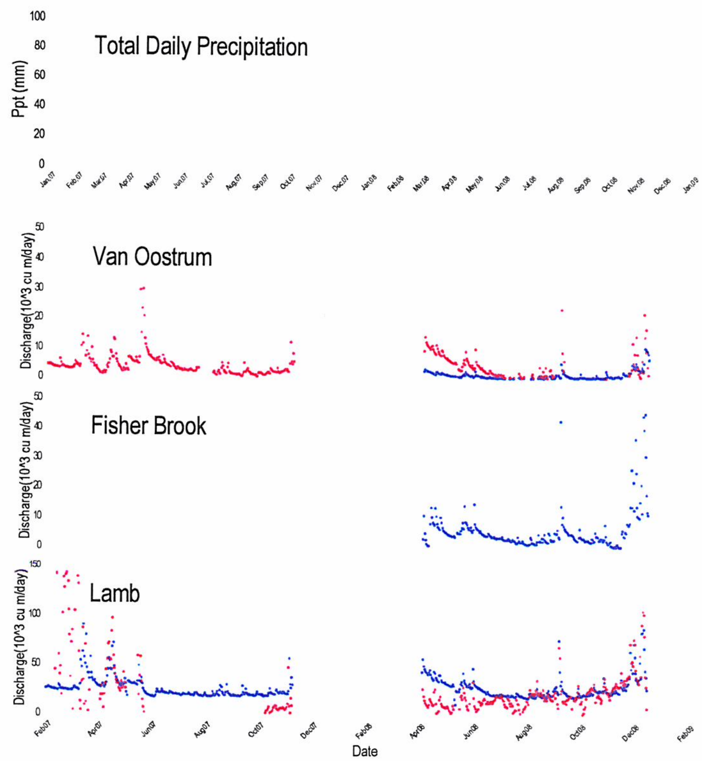


Fig. 4.22 Seasonal variation in daily total precipitation and water discharge (blue bars represent Upper sites and red bars represent Lower sites).

It is obvious that there are problems with the data used to calculate discharge, especially for the Lamb site where discharge at the Lower site is often less than that at the Upper site. This is probably related to an incorrect rating curve for the Lower Lamb site where, because of its wide and shallow nature, it is difficult to obtain accurate current velocity measurements. We plan to correct this deficiency during the 2009 monitoring period by increasing the number of current velocity measurements made at this site as well as at all of the other monitoring sites equipped with water depth loggers

4.7.2 Loadings

Despite the problems associated with estimates of water discharge at the Lamb site, estimates of loading for SPM and nutrients were calculated based on the data currently available[3]. SPM loadings, which were measured continuously at 15 min. intervals, were calculated on a daily basis using average daily values of water discharge and SPM concentration. Nutrient loadings, which were measured at biweekly intervals, were calculated only on a monthly basis using monthly mean values of water discharge. With a few exceptions, daily SPM loadings (Fig. 4.23) were much higher at the Lower monitoring sites indicating that land use activities at both the Van Oostrum and Lamb sites result in significant sediment input to the River. The Upper Fisher Brook site also experiences high SPM loadings at times, some of which may be related to Department of Transportation ditching activities that were observed along Somerset Road during mid-October 2008.

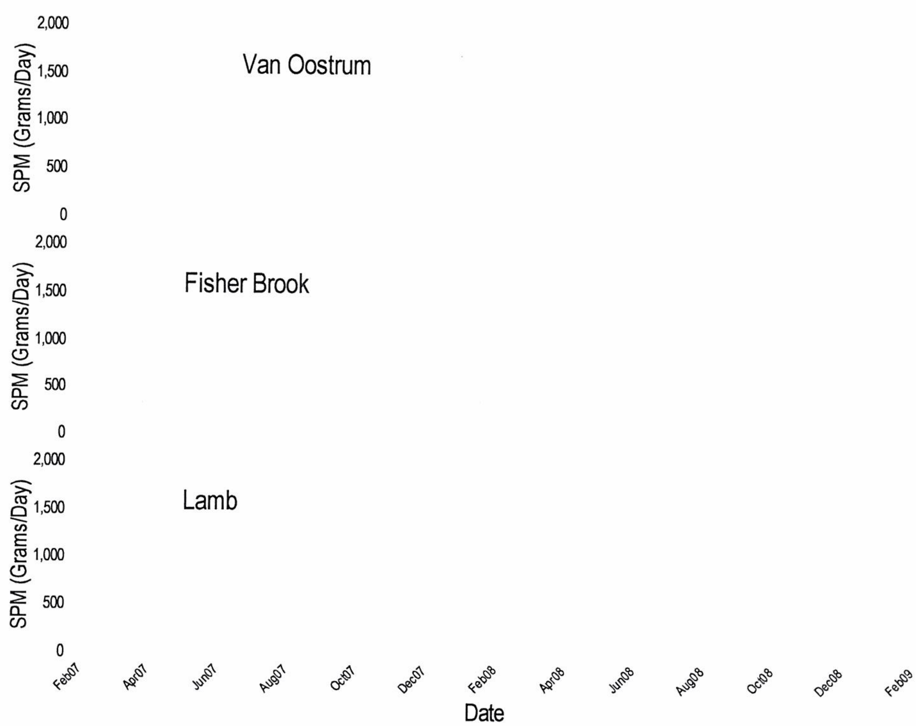


Fig. 4.23 Daily variation in total SPM loadings (blue lines represent Upper sites and red lines represent Lower sites).

Total nitrogen loadings (Fig.4.24) varied a great deal between sites. During most periods they were much lower at the Van Oostrum site than at the Lamb Site and, with a few exceptions, were higher at the Lower monitoring sites than at the Upper

[3] These estimates will be reevaluated once better rating curves are developed during the 2009 field season.

monitoring sites. Nitrogen loadings at the Upper Fisher Brook site were intermediate, being higher than at the Van Oostrum site and lower than the Lamb site.

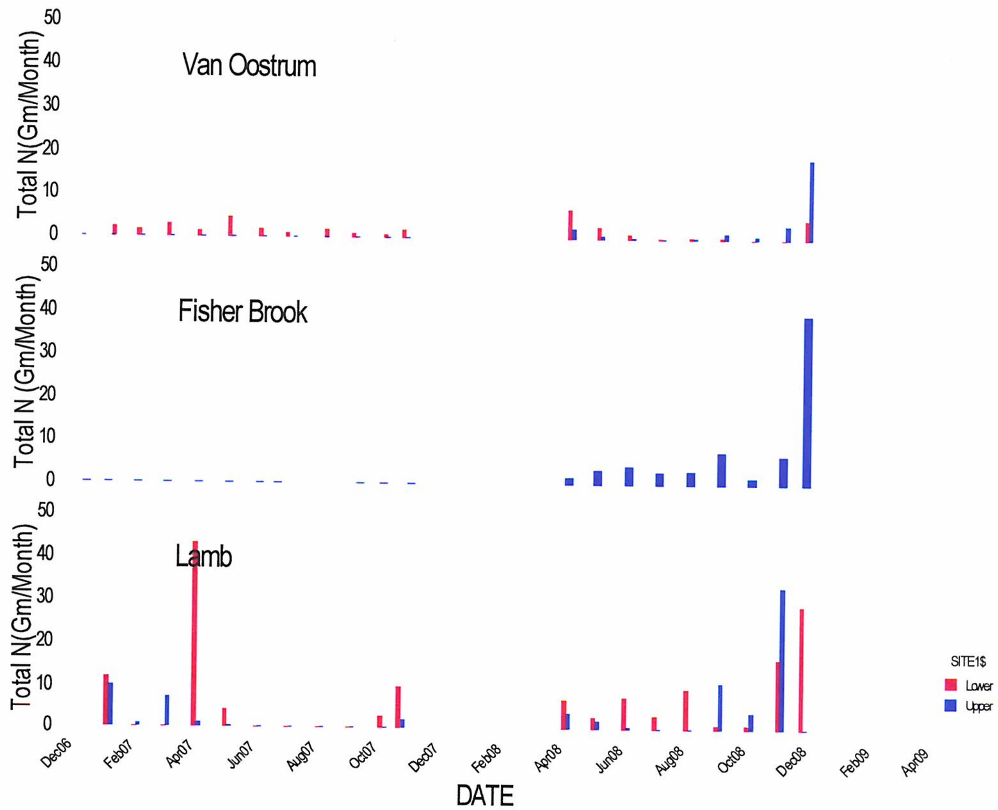


Fig. 4.24 Monthly variation in total nitrogen loadings (blue bars represent Upper sites and red bars represent Lower sites).

Total phosphorus loadings (Fig. 4.25) also varied a great deal between sites but generally showed the same trend of being lowest at the Van Oostrum site, intermediate at the Fisher Brook site and highest at the Lamb site.

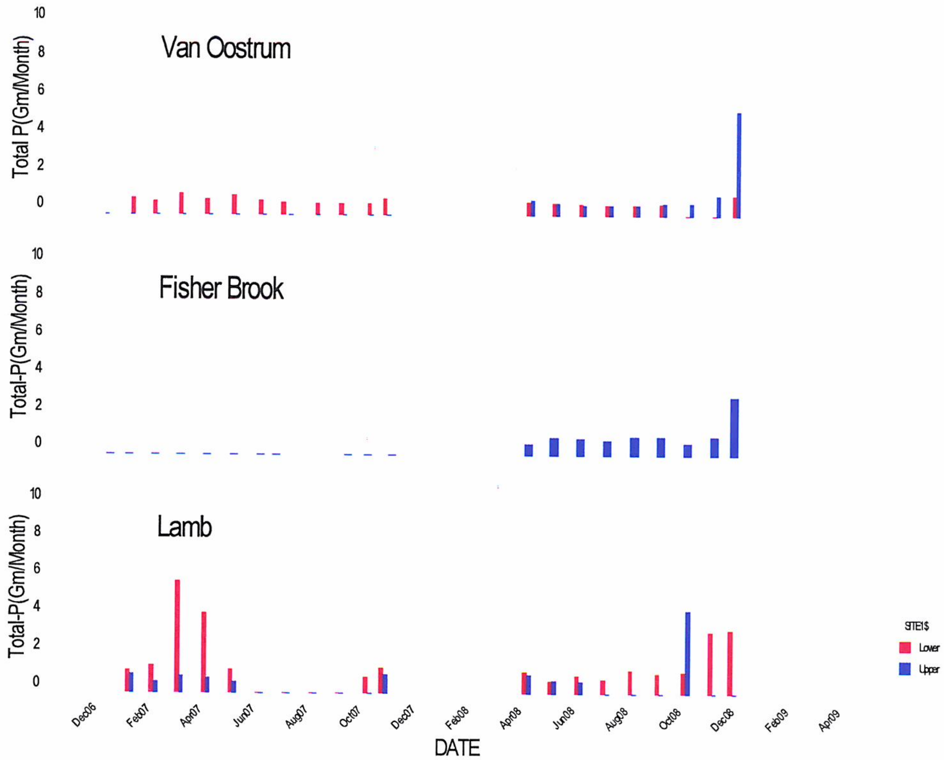


Fig. 4.25 Monthly variation in total phosphorus loadings (blue bars represent Upper sites and red bars represent Lower sites).

5. Discussion

Based on the results attained after two years of water quality monitoring, it has become obvious that water quality within the River passing through both of the demonstration sites is seriously impaired. It is characterized by high fecal coliform numbers, high nutrient concentrations, periodic episodes of high sediment loads and, at times, low levels of dissolved oxygen. This however, based on coliform and nutrient levels measured at monitoring sites located outside of the demonstration sites, is not atypical of most of the upper reaches of the Cornwallis River.

Although some remedial action has been taken in the form of BMPs implemented to improve water quality, it is difficult to observe any real difference in water quality between 2007 and 2008. This, however, is not unexpected as the actions taken thus far will require time to become effective, especially with respect to the establishment of a well-developed riparian buffer strip.

Future plans for this project include development of a hydrodynamic model in order to better understand how activities that alter water flow influence water quality, and to make better estimates of changes in sediment and nutrient loadings over time. It is also intended to make focused measurements of nutrients at the artificial wetland constructed to treat milkhouse wastes at the Lamb farm to evaluate its efficacy and at other locations within the demonstration sites that are potential point sources of nutrient and coliform inputs into the River.

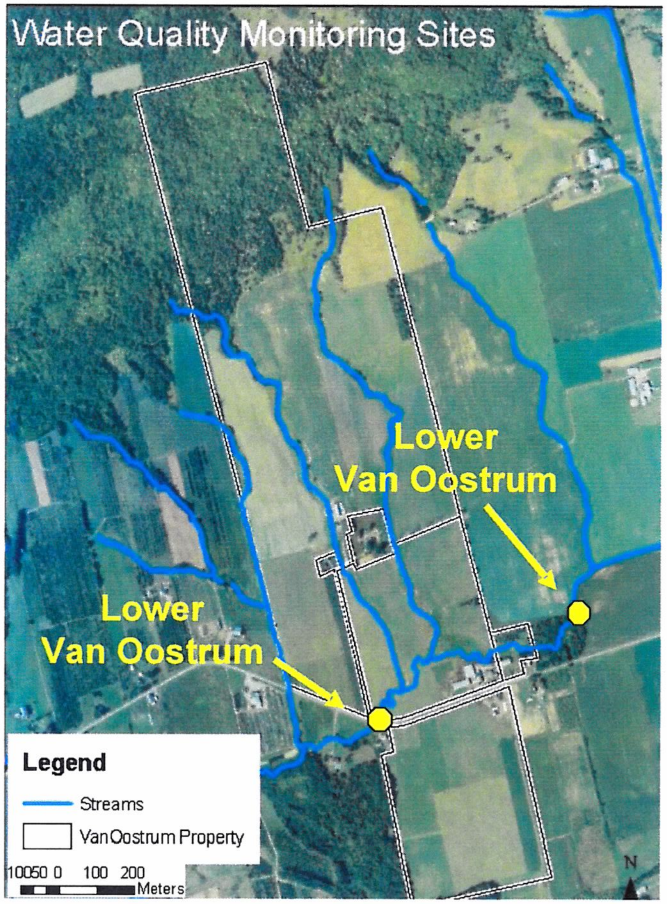
6. References

CCME. 2002. Canadian Council Ministers of the Environment Canadian Environmental Quality Guidelines, Ottawa, Ontario.

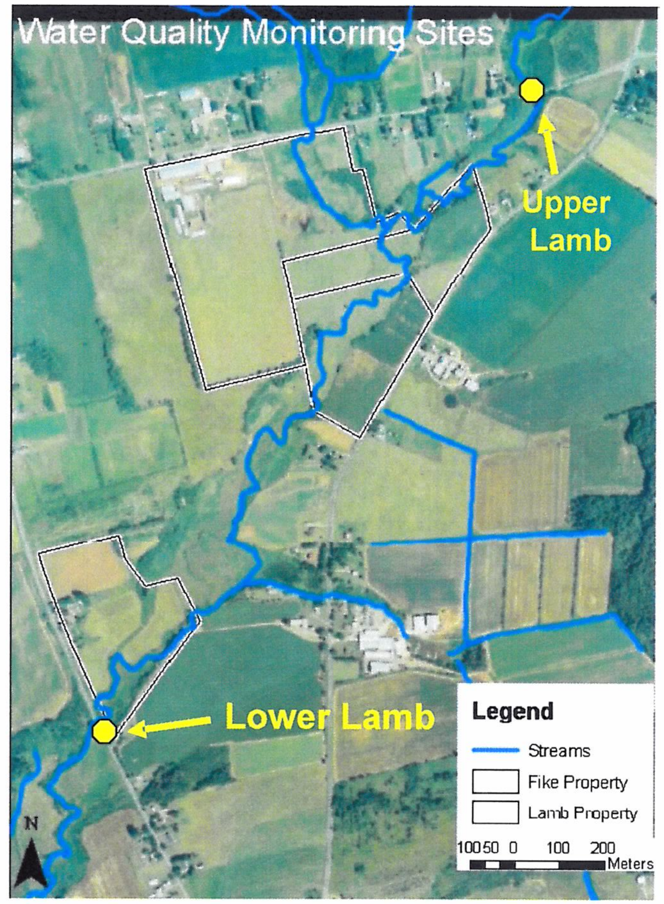
APPENDIX I

Aerial Photos Showing Locations of Primary Water Quality Monitoring Sites

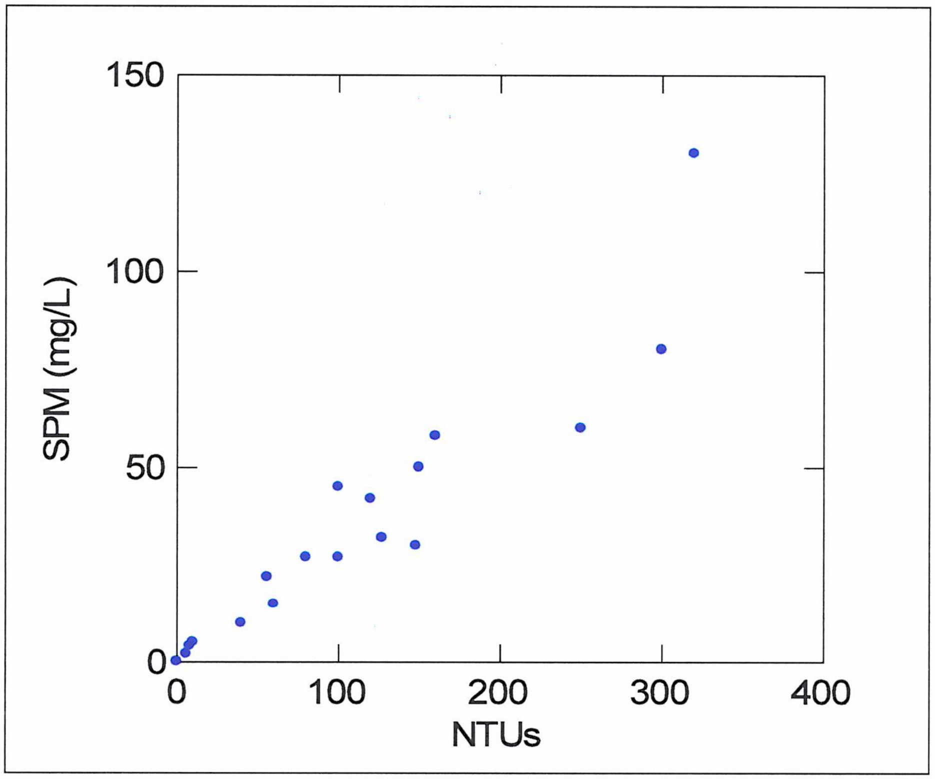
Van Oostrum Farm



Lamb Farm

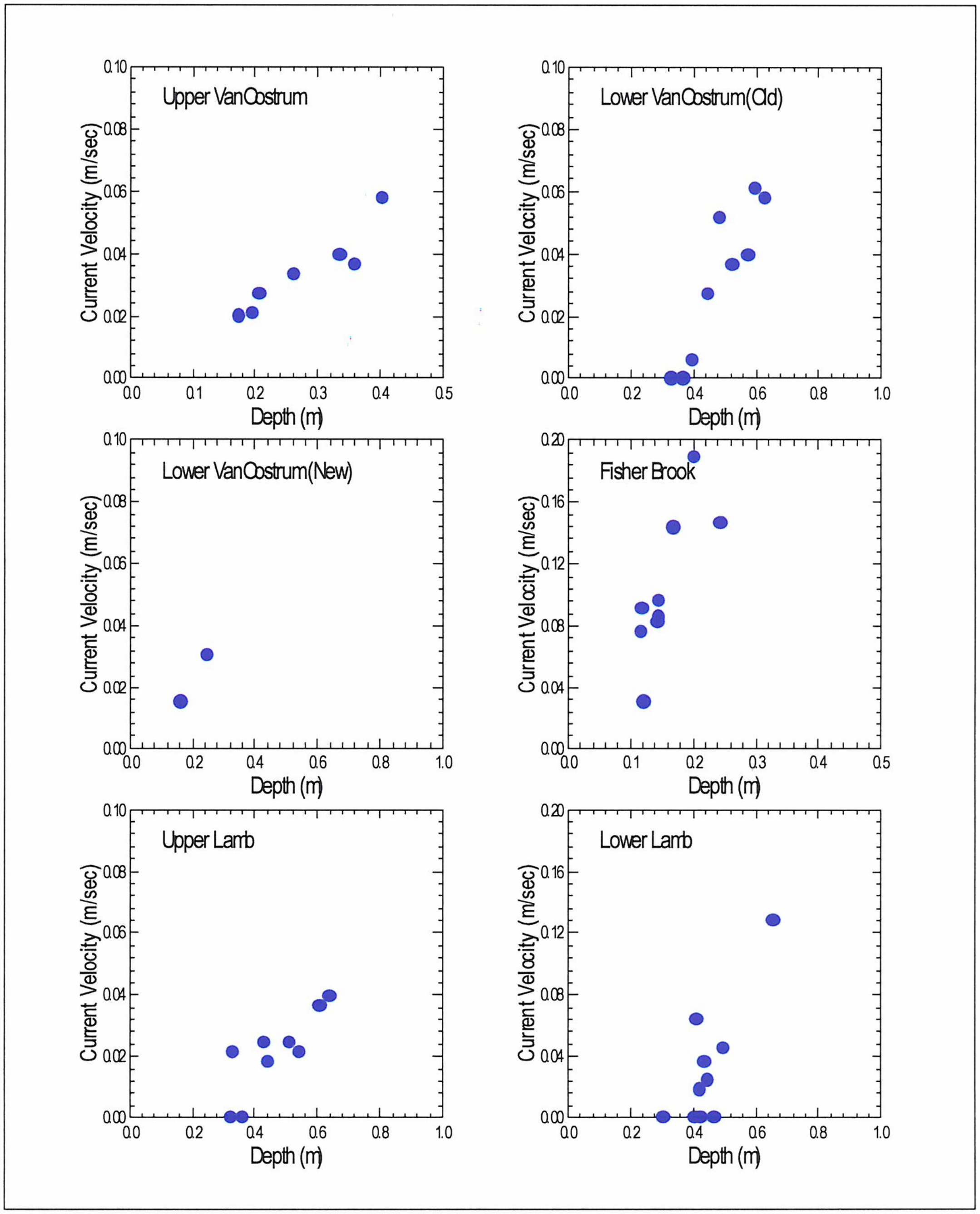


APPENDIX II



Relationship Between NTUs and SPM
(SPM=0.316 x NTU – 0.234; r^2 = 0.885).

Appendix III
Current Velocity-Depth Rating Curves



Appendix IV
Stage-Discharge Relationships