Severn Sound

Environmental Association

An Investigation of Water Quality of Beaches on the Coast of the Township of Tiny

MAY 2004

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For

The Corporation of the Township of Tiny

Foreword

This document reports on technical investigations conducted at three coastal beach areas in the Township of Tiny during 2003 by Severn Sound Environmental Association for the Township.

The report received technical review prior to its publication. This does not necessarily signify that the contents reflect the views and policies of the municipality supporting the work, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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Acknowledgements

Funding support from the Township of Tiny for the survey is gratefully acknowledged. Thanks also to the Council and staff for their valuable input on the survey. In particular, the authors wish to acknowledge Township of Tiny staff Earl Evans, Henk Blom and Glen Desroches for their assistance in the project and Rebecca Cunningham and Crystal Ladouceur for conducting weekend beach use surveys.

The following technical and scientific authorities are greatfully acknowledged for helpful comments on the survey and their review of the report text.

Murray Charlton of Environment Canada's National Water Research Institute
Ted Devine, Bernie Mayer and Bruce Beauchamps of the Simcoe County District Health Unit

Special thanks to local residents Roger Neal and Judith Skelton-Grant for their interest in the survey and helpful comments.

Paula Madill, Ecosystem Technologist, SSEA conducted most of the field work for the investigation and assisted with data analyses. Lex McPhail, SSEA Applications Specialist, produced the mapping and assisted with spatial analysis. The following SSEA staff braved occasional sunshine, darkness, waves, wind and rain to collect the samples: Paula Madill, Mike Sharpe, Violet Compton, Michelle Hudolin, Michele Locke, Aaron Roininen, Matthias Crystl, Lex McPhail and the author.

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SUMMARY

The Severn Sound Environmental Association (SSEA), in partnership with the Township of Tiny and the Simcoe County District Health Unit(SCDHU), is investigated the factors affecting beach quality along the west coast of the Township. Three beaches investigated were Balm Beach, Jackson Park Beach and Woodland Beach including the immediate watershed draining to each beach area.

Questions that the investigation would seek to answer include:

- What are the potential sources of bacterial contamination influencing the beaches?
- How do the densities of the indicator bacteria E. coli vary at or between beaches and with time in relation to potential sources and other factors?

Throughout the recreational season beach quality was monitored by Health Unit staff. Stream and ditch locations discharging on or near beaches were sampled by SSEA during dry and wet weather for E. coli, temperature, flow, basic chemistry and nutrients.

The streams and outfalls flowing to all the beaches in this study are sources of bacteria, often having E.coli densities above 100 orgs/100 ml during dry weather and especially during wet weather. Upstream/downstream increases in E. coli densities could be the result of sources originating in the urban zone. Further investigation of potential sources could be carried out through walking the streams and investigating discharges and pipes.

Even the relatively small rain events sampled showed that runoff into the streams increases E. coli densities that are carried to the beaches during storms. The timing and magnitude of the increases in bacterial densities are sufficiently high in the case of Balm Beach to account for the peak resulting at the beach stations. The impact of the rain events declined with the stream peak, within 5 hours. The response of Jackson Park Beach to the stream discharges was also apparent but was not as pronounced as that of Balm Beach. Woodland Beach E. coli densities were not so closely linked to the impact of streams sampled. The bacterial densities in Woodland Beach were three times higher than the highest stream densities measured during rain events suggesting that some other source of bacteria was influencing the quality of the beach during rain events.

From this investigation, a conceptual model was developed of how the beaches respond to various factors affecting E.coli bacteria densities including storm events, run off, temperature, lake bed conditions and bather load. Streams appear to be influencing the quality of Balm Beach and Jackson Park Beach during rain events and possibly during dry weather in combination with wind and wave action. The cold water streams discharging to warmer lake water tend to sink, pooling in local troughs oriented along shore, especially during calm weather. Mixing and dispersing of

these waters during higher winds would disperse the elevated bacteria densities carried by these waters into the beach area and result in higher E. coli densities.

In order to reduce the number of days where geometric mean E. coli exceed the provincial objective of 100 orgs./100 ml the following remedial options should be considered.

1. Continue to inspect and abate faulty or substandard private sewage systems.
2. Consider treatment of stormwater runoff to provide retention and reduction of solids and bacteria prior to discharge near beaches.
3. Consider moving the stream outlets discharging directly onto the Balm and Jackson Beaches. Where feasible these outlets should be directed off the points where disperion and mixing of their discharge would be accomplished more effectively.

The following considerations should be given to future surveys of beach quality.

- Use of PCR/DNA fingerprinting E. coli strains to detect the source (animal vs. human) if high densities of E. coli are identified in a beach

- Establish tipping bucket rain gauges along the coast for comparison with upland gauges.

- Use more continuous methods of tracking the impact of discharges on the beach area.

- Survey the lake bed and the temperature regime in the vicinity of the beaches.

- Redesign the Woodland Beach event sampling survey to allow broader sampling of time frames and spatial extent of the beach area.

- Follow up surveys of the streams to examine sources in a more detailed fashion.

1. Introduction

The Severn Sound Environmental Association (SSEA) was requested by the Township of Tiny to investigate the factors affecting beach quality along the coast of Tiny Township in partnership with Township staff and the Simcoe County District Health Unit (SCDHU). The investigation was approved by council resolution. Three Beaches were selected for investigation Balm Beach, Jackson Park Beach and Woodland Beach.

According to the Beach Management Protocol (1998), a pollution survey of a beach is conducted to provide information needed to determine pollution sources and their potential impact on the suitability of beach water for public bathing purposes. An analysis of the information gathered by the survey should reveal any existing sources of pollution and their potential impact on beach water quality. Factors that could influence the quality of a beach include: rainfall, peak use, danger of accidental spillage of pollutants, and sources of pollution from adjacent areas.

The potential sources of bacteria that could influence the beaches include:

- discharge from faulty or substandard private sewage systems,
- runoff from built up areas adjacent to beaches,
- the impingement of streams and ditches discharging at or near the beaches,
- the bathers themselves (in case of high densities of bathers),
- animals and birds which defecate on the beach or in the water.

Each of these potential sources can be constant or fluctuate in impact due to storm events or use.

In addition to direct or indirect sources of bacteria discharging to a beach, studies point to other factors could influence the density of E. coli along beaches, including:

- the degree of sheltering of the beach from wind and wave action and lake currents,
- temperature,
- the lake bed conditions, and
- water column turbidity.

The most basic source of variability in bacterial densities results from sampling and analysis of the E. coli. Each beach presents a unique combination of the above mentioned factors because of the configuration of the beach, the soil and overburden conditions and land use in the immediate watershed draining to the beach are different. Some of the above sources and factors have been documented by previous work (SSRAP 2002, Bilyea and Sherman 1990, Cayley 1996, Mayrand et al. 2000, Seyfried et al. 1997 . But other factors were measured as part of this study.

The questions that the investigation would seek to answer include:

- What are the potential sources of bacterial contamination influencing the beaches?
- How do the densities of E. coli vary at or between beaches and with time in relation to potential sources and other factors? Specifically:
- Are there changes in bacterial counts seasonally from July to September.

In order to answer these questions the study design took the following approach.

1. The SCDHU staff sampled the beach quality and shared past and current information with the SSEA. SSEA monitored the beach locations during rain event sampling for E.coli and included additional parameters with the collection of bacteriological samples.
2. The SSEA collected samples at selected sites within the immediate watershed of each beach to characterize sources of bacteria that could impinge on the beach. These samples were collected during dry weather (no rain in previous 48 hrs). Rain event sampling was intended to collect samples during approximately three rain events at each beach. Other area rain gauges were used to supplement the SSEA recording rain gauge at the Wye Marsh Centre.
3. The beach use on weekends was documented by Township staff through the SSEA beach use surveys (BUS) and photo-documentation.

2. Methods

Study area

The study area is located along the eastern coast of Nottawasaga Bay. The shoreline area along the coast of the Township of Tiny is dominated by the ancient shoreline bluffs that mark the division between the Simcoe Lowlands and the Simcoe Uplands Physiographic Regions (Chapman and Putnam 1984). The area at the top of the bluffs is part of a drumlinized till plain characterized by clay-silt overburden in the southern part of the Township near Woodland Beach and coarse textured glacio-lacustrine deposits in the Jackson and Balm Beach areas. At the base of the bluffs the area is dominated by coarse-textured lacustrine deposits. A system of dunes near shore and old dune systems back from shore predominates in the southern part of the study area to the base of the bluffs. Back from the shoreline are low-lying wetland areas underlain by clay or silt backing into the base of the bluffs also occur. The Balm Beach wetland is a provincially significant wetland located between the bluffs and the urbanized shore areas from Balm Beach to Jackson Park areas. There are also some municipal drains located within the areas draining to Jackson Park Beach.

Off shore the sand, gravel and boulder deposits on the lake bed have been influenced by the regional currents and major storms into a system of general north to south transport of materials as evidence by the sand and gravel build up on the southern side of groynes and breakwaters. This pattern of transport is not as clear in the Woodland Beach area where deposition occurs on both sides of groynes. Superimposed on this general transport pattern is a system of large and small-scale sand ripples that reflect the wind and wave action of the beach coast bordering the large expanse of the open waters of Georgian Bay. Sheltering was provided, in-part, at Balm and Jackson Beaches by Rock breakwaters placed to protect launch ramps.

Surveys were conducted by SSEA at three Beaches during 2003: Balm Beach, Jackson Park Beach and Woodland Beach. These areas are located at the ends of Balm Beach Road (the 10th Concession), the 8th Concession and Lawson Road (2nd Concession) respectively. The study area included the streams flowing into or adjacent to these beach areas and their immediate drainage areas (Figure 1 a & b).

The area draining to Balm Beach excluding the stream discharging south of the area was approximately 260 ha (2.6 km^2). The area draining to Jackson Park Beach included a relatively large stream (JP 3) that discharged directly onto the beach (draining 300 ha). A smaller intermittent stream discharges to an area north of the Beach (stn JP5 draining approximately 40 ha). Two streams discharge to Woodland Beach. The northern stream has a drainage area of 300 ha and the southern stream has a drainage of 490 ha. All three beaches have "miscellaneous" drainage along the shoreline from local ditches and catchments associated with the roads network. The streams have drainage courses extending above the bluffs. However, the main base flow originates at the base of the bluffs. The upper portions of the streams are intermittent in summer.

Land use

The shoreline development consists of permanent and seasonal residential dwellings with some commercial development, especially at Balm Beach. This development forms a ribbon-like urban or sub-urban zone of varying width along the coast. The dwellings are serviced by private, in-ground sewage systems and private wells or communal water supplies from municipal wells. Behind this urban zone is a zone of wetland that backs onto the foot of the bluffs. Above the bluffs the land use is more open with varying proportions of cropland. Balm Beach sub-watershed has approximately one-third of the upper area in intensive cropland (soy beans and grains) with one-third being idle farmland and one-third forest covered. Additional commercial properties are located along Balm Beach Road within this area. The majority of the Jackson Park Beach sub-watershed consists of swamp land with about 20 % farmland. The Woodland Beach sub-watershed is predominantly farmland (approximately 70%).

Sampling locations

In order to assess the beach quality, SSEA staff were oriented by SCDHU staff on the locations sampled during routine monitoring of the beaches. Locations from shore were noted for each point. The distance out from shore to obtain a proper sample depth (1-1.5 m) varied depending on water level fluctuations and wind conditions at the time of sampling. Five sampling locations are routinely sampled at Balm and Woodland Beaches and six locations are sampled at Jackson Park Beach (additional site because of length of beach).

Streams were investigated early in the field season in order to select sample locations that would reflect conditions upstream of the shoreline, urban zone and locations near the stream mouths, but sufficiently upstream to avoid lake backwater effects. This would allow comparison of the quality of water upstream and downstream of the urban zone. Figures 1a & 1b show the locations of sampling stations.

Data Sources and Field Methods

Precipitation

Of the few rain gauges available for this study, only one gauge (Collingwood) was located along the coast of Nottawasaga Bay. The principal, long-term gauge was located at the Midland Water Pollution Control Plant(MWPCP) near the shoreline within Severn Sound. The closest gauge to the study area was operated by Mr. P.P. Maurice south of Lafontaine during the ice-free period of the year. The last gauge was operated by SSEA at the Wye Marsh Wildlife Centre during the the study 2003. The study design required that sampling could only occur if the rain event started after a period of dry weather (at least 48 hours) and during the day Monday to Thursday (to allow lab submissions). During each rainfall event sampled, event start time, duration and end time was noted during the sampling and the amount of rainfall was estimated using local rain gauges and observations at the beaches.

Wind data

Wind speed and direction data collected from the Environment Canada Station on Beausoleil Island and the Southern Georgian Bay Marine Weather Buoy (station 45) was used for the summer and each event date. Observations of wind speed, direction and wave height were also collected during event sampling at each beach.

Water level data

Hourly water level data for the federal station at Collingwood was obtained from Environment Canada.

Open water temperatures

Temperature was measured using StowAway Tidbit Temperature Loggers ® (TB132-5+37 Onset) installed at 0.5 metre depth at Balm Beach and at Jackson Park Beach from June to October, 2003. Loggers were set to record temperature every 30 minutes. Temperatures were also taken during sampling events and during the routine sampling by SCDHU staff using a hand-held thermometer.

Routine Beach Monitoring and Use

Routine monitoring results from the SCDHU were used to evaluate factors effecting beach quality. In addition, staff of the Township made weekend observations of beach use including number of bathers (in and out of the water), the presence of birds, etc. Panoramas of photos from pre-determined monitoring locations on each of the three study beaches were collected by Township staff on weekends to provide further documentation of weekend use.

Stream flow and temperature measurements

Flow gauging was carried out according to Water Survey of Canada spot flow methods using a Marsh-McBirney flow meter at stream stations where cross-sections could be established. Spot flows were measured at culverts and other less accessible locations using either "bucket" measurements or short-term (1 minute) timed average velocities over a short distance. These measurements were made on two dates during the summer (July 4th and August 21st). Measuring points from a selected point on the culvert down to the water surface where available at each site to assess the changes in flow during rain and dry weather events.

Temperature was measured at stream locations using StowAway Tidbit Temperature Loggers ® (TB132-5+37 Onset) installed at approximately mid-depth. Loggers were set to record temperature every 30 minutes. Spot temperatures were collected during dry weather sampling runs using a thermometer or a field meter.

Sample Collection

Dry Weather Survey

Dry weather samples were collected during seven sampling runs from the main discharge stations at the three beaches. These samples were collected in order to characterize the quality of streams and discharges to the beach areas. Field analysis of temperature, dissolved oxygen, conductivity and pH were measured using a calibrated YSI 650 multiparameter meter (Sonde). Water samples were collected within the main stream flow at the upstream end of culverts wherever possible and from mid-depth. In some cases (eg station BB2, JP4) water samples were collected from the end

of the culvert emerging from underground prior to discharge onto the beach. Bacteria samples were collected using sterile technique and immediately stored on ice for transport to the laboratory within 12 hours of sampling. Chemistry samples were collected and transported on ice to the laboratory within 36 hours of sampling.

Wet Weather Survey

Wet weather surveys were collected on three occasions July 15th, September 15th and September 22nd during 2003. During each survey samples of the streams and discharges were collected prior to the onset of rain (time zero) and then approximately 30 minutes, 1 hour, 2 hours, 6 hours and 12 hours after the start of the rain event. Additional samples (24 hours) were obtained if the rain event continued. While sampling of streams and discharges were occurring, samples of beach monitoring locations (SCDHU locations) were also collected in the same schedule. For logistical reasons, each beach was sampled during two rain events during the study.

Special Surveys

During a relatively calm period, a survey was conducted on Balm Beach and Jackson Park Beach to characterize the discharge of the main stream flowing onto the beach at both locations. Temperature and conductivity field measurements through the water column were made at numerous points in the beach off the stream discharge using a YSI meter and a Differential Global Positioning System (DGPS) with accuracy of +/- 2 meters. This sampling was carried out to investigate the dispersion characteristics of the streams discharging onto the beaches.

On July10th additional sampling was carried out on Balm Beach in order to investigate the E. coli densities along transects from the routine beach sampling location to the shore (1-1.5 m, 0.5 m, 20 cm and a pit on shore) at the five beach monitoring sites.

Laboratory Analyses

Microbiological Samples

All microbiological samples were analysed at Central Ontario Analytical Laboratory (COAL) in Orillia, Ontario. COAL is an accredited and certified laboratory and was selected because it uses the identical analytical protocol for *Escherichia coli* (E. coli) as the Ontario Public Health Laboratory in Orillia where the routine beach monitoring samples are analysed. Sample bottles were sterile polyvinyl bacteria sample bottles obtained from Central Ontario Analytical Laboratory (COAL), similar to those used by the Ontario Public Health Laboratory and Health Unit staff for routine sampling.

Water Chemistry Samples

The chemical samples for basic chemistry and nutrients were analyzed by Trent University Laboratory at Dorset, Ontario. This laboratory has an identical analytical protocol to the Ministry of the Environment Laboratory. Samples were analysed for lab pH, alkalinity, calcium, potassium, magnesium, sodium, chloride, sulphate, total ammonia, total nitrate, total Kjeldahl nitrogen, total phosphorus, dissolved inorganic and organic carbon, colour, lab conductivity and turbidity.

3. Results

Beach Quality and use

The surveys of weekend use of the beaches showed that the beaches received little concentrated use during 2003. Balm Beach was the most heavily used beach with up to 100 bathers at one time and Woodland Beach was the lowest at 10 bathers. According to the SCDHU, posting was recommended on several occasions on all three beaches with beach geometric mean values exceeding the objective of 100 orgs/100 ml on about half the routine monitoring days. Balm Beach and Jackson Park Beach were sampled 15 times throughout the monitoring season by the Health Unit and Woodland was sampled 13 times. Balm exceeded the objective 5 times, Jackson 4 and Woodland Beach 10 times.

Physical measurements

Rainfall

The long-term rainfall characteristics were examined as part of the North Simcoe Municipal Groundwater Study (Dixon and Golder 2004). In general, there is a slight, south-to-north increase in long-term mean annual rainfall along the coast of the Township ranging between 975 and 1000 mm. Lapen and Hayhoe (2003) analysed data for the Grey-Bruce area east of Lake Huron, showed a lake effect on precipitation with an increase in precipitation for July with distance westward from the coast. They point out that the scarcity of rain gauges in the coastal areas below the escarpment make generalizations about rainfall comparisons between the coast and inland difficult. Of the few rain gauges (4) available for this study, only one gauge (Collingwood) was located along the coast of Nottawasaga Bay. The principal, long-term gauge was located at the Midland WPCP near the shoreline but inside Severn Sound. The closest gauge to the study area was operated by Mr. P.P. Maurice, operated south of Lafontaine during the ice-free period of the year. The last gauge was operated by SSEA at the Wye Marsh Wildlife Centre during the summer months of 2003 and is located close to the Midland WPCP site.

Rain data was examined for events sampled during July 15, September 15 and September 22, 2003. The rainfall events all started in the afternoon following a period of dry weather. The event duration varied as did the rainfall intensity during each event (Table 1). The amount of rain falling during the events sampled ranged from approximately 10 to 20 mm. The rain events generally lasted for two hours, however, rain did not fall with a simple peak but rather, with multiple peaks.

Wind and Water levels

The predominant wind was from the northwest during the summer of 2003. Wind speed and direction varied over the period of the rain events. During the September 15th event strong winds were noted from the north east, the east and the southeast over the 24 hours sampled (Figure 2a-c).

Observations of noticeable currents during sampling were also made. These currents were especially noted at Woodland Beach where along-shore currents were noted from the south and from the north during different events sampled.

Interflow from the beaches to the Bay was observed during seiche events when Bay water level was declining. This was especially evident at Woodland Beach.

Water levels fluctuated between below chart datum during June and September to just above chart datum during July and August. During two rain events sampled, water levels rose gradually (during the July 15th and September 15th events) or abruptly (September 22nd) (Figure 3a-c). Also of note was the water level oscillations or seiche during the events on an approximately 2-hour period.

Temperature

Beach area water temperatures rose to 24^{o} C by the end of July 2003. The discharges were almost all cold water streams during dry weather conditions indicating that the base flow was heavily influenced by groundwater discharge. Even after the lake water started to warm up in June, the temperatures of discharges remained at least 3^{o} C cooler than the lake (Figures 4a-c).

Flow measurements

The flow measurements reflected differences between the base flow contributed by the different sub-watersheds. The Jackson Park Beach tributary (JP1 to JP3) yielded the highest base flows while the Woodland Beach streams (WB1 and WB2) yields were very low (Table 2).

Dry weather sampling

Dry weather sampling indicated that the basic chemistry was similar for most streams with the exception of the upstream waters at stations BB3, JP1, JP2 and WB1 which had lower conductivities and lower concentrations of sodium and chloride (Table 3). These findings suggested that, for the upstream stations, downstream waters were being influenced for these substances from local sources in the urban zone.

The spring to early summer increase in E. coli densities in the stream discharges suggests that there may be an effect of the active occupation of dwellings at the start of the recreation season on the quality of the streams (Table 4). The remainder of the dry-weather sampling suggested that upstream densities tended to be lower than downstream for BB3-BB4 and BB1-BB2 paired stations. This was not the case in the Jackson Park stream which had some elevated densities at the upstream station (JP1). Further study of these areas is indicated to investigate sources.

The local tile outlets into BB5 at the shore have elevated ions during dry weather - especially calcium, sodium and chloride. In addition, this same station had elevated total phosphorus indicating that local sources of contamination may be present. Bacteria densities in this station remain low throughout the season.

Nitrate concentrations are elevated especially at station BB1 (9.7 mg/L). It appears that the concentrations are elevated at the upstream station over the downstream station for both BB1 and BB3. However, BB5 which has local drainage originating near shore also has elevated nitrate concentration. Seasonally, the concentrations peak in July. Streams at Jackson Park Beach and Woodland Beach had moderate to low nitrate concentrations (Table 5a). Total phosphorus concentrations were widely varying at BB2 and BB5 indicating some source was indicated (Table 5b).

Conductivity during dry weather was highest at BB5 followed by BB2 (Table 6).

On July 10th additional sampling was conducted at Balm Beach. E. coli levels were investigated along five transects starting at the Health Unit sampling sites (1-1.5 m depth) to shore during a calm day. All of the 1-1.5 m locations had less than 10 E. coli orgs/100 ml but the E.coli densities tended to increase closer to shore. The highest density was 4000 orgs/100 ml at a pit (on shore) at station B1 (Table 7).

During dry, calm weather the behaviour of the discharges of streams flowing onto Balm Beach and Jackson Park Beach was tracked using temperature and conductivity to establish how the stream water was dispersed. The cooler (and denser) stream water sank and followed the troughs in the beach area parallel to the shoreline in a southerly direction.

Wet weather sampling

Even the relatively small rain events sampled showed that runoff into the streams increases E. coli densities that are carried to the beaches during storms. The timing and magnitude of the increases in bacterial densities are sufficiently high in the case of Balm Beach to account for the peak resulting at the beach stations. The impact of the rain events declined with the stream peak, within 5 hours. The response of Jackson Park Beach to the stream discharges was also apparent but was not as pronounced as that of Balm Beach. Woodland Beach E. coli densities were not so closely linked to the impact of local streams sampled. The bacterial densities in Woodland Beach were three times higher than the highest stream densities measured during rain events suggesting that some other source of bacteria was influencing the quality of the beach during rain events.

The Balm Beach streams responded within 1 hour to the July 15th rain event (20 mm) to peak E. coli densities of over 6,000 orgs/100 ml. The area of Balm Beach closest to the main stream discharge (BB4) responded shortly after with E.coli densities of more than 1,000 orgs/100ml (Figure 5a and 5b). The September 15th event showed a similar pattern of response for Balm Beach (Figure 6a and 6b).

The response of Jackson Park Beach to July 15th event was relatively small at the beginning of the storm or delayed for more than 20 hours after the onset of the event (Figure 7a and 7b). The September 22nd storm also showed a similar response. The peak did not occur until 10 hours after the event started and returned to normal levels by the 24 hours after the onset of the event (Figure 8a and 8b).

Woodland Beach did not immediately respond to the rain event of September 15th or the September 22nd. The magnitude of E. coli densities in the streams reached a peak of over 1,000 orgs/100 ml. However, the beach values exceeded 6,000 and 3,000 orgs/100 ml respectively. This suggested that the streams were not the only source of contamination influencing Woodland Beach during rain events (Figure 9a & b and 10a & b).

On Monday August 11th SCDHU weekly beach monitoring results showed low geomeans of 6 and 5 orgs/100 ml at Balm and Jackson Park Beach respectively. Woodland Beach geomean was elevated at 187 orgs/100 ml. Three days after sampling (August 14) there was a power black out across Ontario. The black out lasted approximately 3 days in many areas of the Township. Another rain event occured on August 15th but could not be sampled because of the lack of power at the labs. On Tuesday, August 19th (the next date that routine sampling by SCDHU could resume) all three beaches showed elevated E. coli geomeans of 917 at Balm, 707 at Jackson and 477 at Woodland. The storm event could have been responsible, in-part, for these elevated counts however it was two full days after the event had occured. Another possible factor could be the lack of electricity for septic pumps that transport septic tank effluent to the weeping beds.

4. Discussion

Conceptual model of source impingement on beach

Streams appear to be influencing the quality of Balm Beach and Jackson Park Beach during rain events and possibly during dry weather in combination with wind and wave action. The coldwater streams discharging to warmer lake water tend to sink, pooling in local troughs oriented along shore, especially during calm weather. Mixing and dispersing of these waters during higher winds would disperse the elevated bacteria densities carried by these waters into the beach area and result in higher E. coli densities.

Factors influencing beach quality

The effect of various factors influencing the quality of beaches are discussed below in light of the findings of this survey or in light of their expected significance in the context of the three beaches investigated.

stream discharges and outfalls

- The most obvious finding of the survey was that streams and outfalls flowing to all the beaches in this study are sources of bacteria, often having E.coli densities above 100 orgs/100 ml during dry weather and especially during wet weather. Studies of stream quality in Severn Sound streams have shown that typical E.coli densities often exceed 100 orgs/100ml during dry weather (Mayrand et al. 2001, Cayley 1996, Mattson, et al. 2000).

bather density

- This factor was not considered to be relevant in the context of the three beaches studied. Peak bather load on the beach and in the water was approximately 100 at Balm Beach and could not, by itself (i.e. body contact with the water in the beach area), have influenced quality appreciable. However, individual behaviour could influence quality through faecal matter from dogs or young children being deposited immediately prior to sampling. Individual bathers were often observed wading or sitting in the water at the mouth of the streams at Balm Beach and Jackson Park Beach. These bathers could be at higher risk of being exposed to water flowing into the beach with elevated indicator bacteria.

sheltering of beach

- The sheltering effect of the breakwaters at Balm and Jackson Park Beaches could have contributed to higher indicator bacteria densities at beach stations. This factor may combine with or confound the influence of the stream discharges into the same sheltered areas.

distance from shore on indicator bacteria density

- Preliminary sampling at Balm Beach showed an increase toward shore but the same survey highlighted the influence of stream discharge in influencing beach station quality. It should be noted that the Beach Management Protocol (1998) takes into consideration the depth of routine sampling in relating the geomean to risk to bathers.

time after onset of storm event

- This investigation has demonstrated that beach quality is adversely affected during and immediately following storm events. The rain events sampled were relatively small and commonly occurring. In the case of Balm Beach the response time of beach quality to onset of the storm event was within one hour. The other beaches sampled showed more variable responses but with longer response times, in excess of five hours. Beach quality returned to levels consistent with dry weather within 24 to 48 hours.

dry weather sources

- All stream stations and outfalls sampled during dry weather were found to have elevated E.coli densities during dry weather, especially by early summer. Upstream/downstream increases in E. coli densities could be the result of sources originating in the urban zone. Further investigation of potential sources could be carried out through walking the streams and investigating discharges and pipes. The stream discharges were of sufficient base flow to be influencing the quality of the beaches at both Balm and Jackson Park Beaches. The base flow was not very large at the two Woodland Beach streams and these may not have significantly influenced the quality on the beach during dry weather.

wind

- As a potential mixing agent for stream discharges wind may have a significant effect on the beach quality. In addition, suspension of particulate organic matter from discharges or from sediment in the beach area could be adversely influencing the beach quality.

temperature

- This was not considered a significant factor except in the spring when temperatures were below 15^{o} C and may have corresponded to the time of seasonal occupancy of many dwellings.

birds and other animals

- Few birds were observed when SSEA staff sampled or during the weekend and were not considered a significant source.

lake bed conditions/sediment and water column turbidity

- Seyfried et al. (1997) found that fine-grained organic sediment in sheltered areas of Georgian Bay had significantly more indicator bacteria than overlying water and could contribute to elevated densities when entrained from the lake bed into the water column. Re-suspension of particulate organic matter may be occuring in the swimming areas, especially in Balm and Jackson Park Beaches off the streams. There was a significant relationship between E.coli and turbidity for the Balm Beach stream quality but no significant relationship was found between beach quality samples of E. coli and turbidity.

beach grooming

- Kinzelman et al. 2003 found that E.coli counts in sand that was mechanically groomed were significantly higher than hand rakings and control beaches. Based on the preliminary results from the special sampling on July 10th at Balm Beach, there is little that suggests that mechanical grooming of the beaches is adversely influencing beach quality.

5. Conclusions

Dry weather sampling indicated that the basic chemistry was similar for most streams with the exception of the upstream waters at Stations BB3, JP1, JP2 and WB1 which had lower conductivities and lower concentrations of sodium and chloride. This suggested that downstream waters were being influenced for these substances from local sources in the urban zone.

Even the relatively small rain events sampled showed that runoff into the streams increases E. coli densities that are carried to the beaches during storms. The timing and magnitude of the increases in bacterial densities are sufficiently high in the case of Balm Beach to account for the peak resulting at the beach stations. The impact of the rain events declined with the stream peak, within 5 hours. The response of Jackson Beach to the stream discharges was also apparent but was not as pronounced. Woodland Beach was not so closely linked to the impact of local drainage on E. coli densities. The bacterial densities in Woodland Beach were three times higher than the highest stream densities measured during rain events suggesting that some other source of bacteria was influencing the quality of the beach during rain events.

Streams are influencing the quality of the beach during rain events and possibly during dry weather in combination with wind and wave action. The coldwater streams discharging to warmer lake water tend to sink pooling in local troughs oriented along shore, especially during calm weather. Mixing and dispersing of these waters during higher winds would disperse the elevated bacteria densities carried by these waters into the beach area and result in higher E. coli densities.

The spring to early summer increase in E. coli densities in the stream discharges suggests that there may be an effect of the active occupation of dwellings at the start of the recreation season on the quality of the streams. This could be due to a decrease in sewage system use over the winter months causing a reduction in active bacteria in the system for the first stage of occupancy.

The local tile outlets into BB5 (catch basin) at the shore have elevated ions during dry weather - especially calcium, sodium and chloride. In addition, this same station had elevated total phosphorus indicating that local sources of contamination may be present. Bacteria densities in this station remain low throughout the season.

Nitrate concentrations are elevated especially at station BB1 (9.7 mg/L). It appears that the concentrations are elevated at the upstream station over the downstream station for both BB1 and BB3. However, BB5 which has local drainage originating near shore also has elevated nitrate concentration. Seasonally, the concentrations peak in July.

6. Recommendations

Remedial Options

In order to reduce the number of days where geometric mean E. coli exceed the provincial objective of 100 orgs./100 ml the following remedial options should be considered.

1. Continue to inspect and abate faulty or substandard private sewage systems.
2. Consider treatment of stormwater runoff to provide retention and reduction of solids and bacteria prior to discharge near beaches.
3. Consider moving the stream outlets discharging directly onto the Balm and Jackson Beaches. Where feasible these outlets should be directed off the points where disperion and mixing of their discharge would be accomplished more effectively.

Future Surveys

The following considerations should be given to future surveys of beach quality.

- Use of PCR/DNA fingerprinting E. coli strains to detect the source (animal vs. human) if high densities of E. coli are identified in a beach

- Establish tipping bucket rain gauges along the coast for comparison with upland gauges.

- Use more continuous methods of tracking the impact of discharges on the beach area.

- Survey the lake bed and the temperature regime in the vicinity of the beaches.
- Redesign the Woodland Beach event sampling survey to allow broader sampling of time frames and spatial extent of the beach area.
- Follow up surveys of the streams to examine sources in a more detailed fashion.

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Table 1 Precipitation for selected stations in the study area during 2003

Station ID	NSSCIA	AES6115127	AES6111792	SSEA	Local Observations
Name	Maurice	Midland WPCP	Collingwood	Wye Marsh	
Latitude	44° 44'	44° 45'	44° 30'	44° 44'	
Longitude	80° 03'	79° 53'	80° 13'	79° 50'	
Elevation (masl)	200	180	180	187	
Precipitation(mm)					
June total	38	61.7	84.8		
July total	50	57.8	43		
Jul 15 event	21	20	15.6	nd	-started 14:45, raining steady to 16:40 then easing by 19:00, clear skies and calm by 23:00
Aug total	46	29.4	43		
Aug 15 event	20	9.5	4.8	5.8	
Sep total	55	88.1	66.4		
Sep 15 event	11	13	5.2	9.8	-started to rain lightly at 11:00, downpour by 14:00 slight drizzle by 15:00, hard rain again by 16:00, rain tapered to clear skies by 23:15 but strong W winds
Sep 22 event	10	16	16.2	14.2	-started to rain heavily at 13:00, still hard by 14:00, light by 15:00 and hard again at 17:00, stopped after 19:00, clear by 23:20 but with strong S winds

Source: Environment Canada - National Climate Archive - http://climate.weatheroffice.ec.gc.ca

Table 2 Areas and spot flows for selected stations in the study area during 2003

Station	Date	Station Drainage (ha)	Station Flow (L/s)	Station Unit Flow (L/s/km^2)	Comments
BB3	04-Jul-03	75.8	11	15.1	
	20-Aug-03		12	16.5	
BB4	04-Jul-03		18		
	20-Aug-03		19		
BB1	04-Jul-03	21.9	5	21.3	
	20-Aug-03		5	21.4	
BB2	04-Jul-03		2		stream is below ground
	20-Aug-03		3		emerging as piped outfall
JP6	04-Jul-03	532.5	7	1.3	
	20-Aug-03		7	1.3	
JP5	04-Jul-03	37.2			no flow after June 25th
	20-Aug-03				except during rain events
JP1	04-Jul-03	143.9	35	24.1	
	20-Aug-03		34	23.9	
JP2	04-Jul-03	298.1	43	14.4	
	20-Aug-03		73	24.3	
JP3	04-Jul-03	301.6	81	26.8	
	20-Aug-03		63	21.0	
WB1	10-Jul-03	293.6	0.3	0.1	
	20-Aug-03		0.3	0.1	
WB2	10-Jul-03	488.2	0.6	0.1	
	20-Aug-03		4	0.8	

Table 3 Mean dry weather basic chemistry and major ions in streams at three beaches in the Township of Tiny 2003

(mean of 7 dry weather samples May through September)

Stations	pH	Alkalinity	Ca	Mg	Na	K	Cl	SO_4	$NH_4 + NH_3$	Cond	Colour	DOC
Balm Beach												
BB1	8.29	207.3	83.51	15.86	12.78	2.00	23.28	19.58	135	535	5.75	2.45
BB2	8.20	207.1	86.31	15.32	16.38	2.36	32.61	19.64	142	569	6.93	2.51
BB3	8.26	206.7	78.15	14.23	4.53	1.35	4.54	16.75	130	447	10.28	2.73
BB4	8.20	217.2	83.89	13.67	9.09	1.82	15.39	17.93	132	492	10.27	3.01
BB5	7.86	220.6	102.42	12.62	34.02	3.57	86.22	23.28	196	726	7.75	3.92
Jackson Park												
JP1	8.26	154.0	56.38	11.95	4.46	1.76	9.93	17.13	24	337	12.19	3.12
JP2	8.19	166.9	59.48	12.04	4.34	1.56	10.40	13.83	45	339	18.49	4.63
JP3	8.22	152.6	59.70	12.01	4.41	1.56	10.46	13.76	34	348	18.26	4.33
JP4	7.98	200.5	77.09	9.05	8.11	1.83	20.38	6.85	30	434	26.00	6.02
JP5(1)	8.19	247.7	108.73	9.61	23.32	2.40	54.72	16.31	81	617	19.11	4.02
JP6	8.24	202.9	69.57	13.25	10.00	1.52	26.03	11.81	55	456	22.27	7.46
Woodland Beach												
WB1	8.30	212.9	76.34	13.80	5.40	1.46	6.91	27.16	88	437	16.50	3.94
WB2	8.10	225.5	98.00	9.51	5.18	1.47	11.02	31.87	52	506	33.28	8.76

(1) only two samples were taken before the stream dried up

Table 4 Densities of E. coli (orgs/100 ml) in stream stations at three beaches in the Township of Tiny 2003

Stations	May-27	Jun-25	Jul-09	Jul-15	Jul-30	Aug-13	Sep-08
Balm Beach							
BB1	<10	10	60	640	320	280	60
BB2	<10	>600	320	280	60	220	40
BB3	10	340	330	220	40	40	200
BB4	40	>600	460	420	60	180	120
BB5	60	70	40	80	260	140	140
Jackson Park							
JP1	30	>600	160	360	80	440	40
JP2	150	180	40	80	60	120	40
JP3	70	>600	90	60	40	220	40
JP4	10	20	7100	400	40	<10	40
JP5	30	>600					
JP6	20	220	110	80	60	180	160
Woodland Beach							
WB1	130	>600	440	800	120	<10	80
WB2	80	190	40	1000	300	320	640

Table 5 Nitrate (a) and total phosphorus (b) concentrations in streams at three beaches in the Township of Tiny 2003

a Nitrate (ug/L)

Stations		May-27	Jun-25	Jul-09	Jul-15	Jul-30	Aug-13	Sep-08	Mean
Balm Beach									
	BB1	7128	6374	12400	10400	10600	10100	10867	9696
	BB2	7128	10200	10600	11200	7800	9710	9941	9511
	BB3	2397	4030	6040	5490	5630	4790	5114	4784
	BB4	2347	3200	5310	4590	4890	4290	4840	4210
	BB5	4015	6060	6310	7780	10300	7010	5673	6735
Jackson Park									
	JP1	298	310	331	307	284	261	352	306
	JP2	388	288	348	321	350	260	410	338
	JP3	377	268	340	314	361	299	419	340
	JP4	97	75	29	10	65	63	51	56
	JP5	976	2249						1612
	JP6	1049	1040	1078	1067	996	785		1002
Woodland Beach									
	WB1	655	1088	1189	1187	1830	1280	1364	1228
	WB2	4180	318	180	161	113	127	137	367

b Total Phosphorus (ug/L)

Stations		May-27	Jun-25	Jul-09	Jul-15	Jul-30	Aug-13	Sep-08	Mean
Balm Beach									
	BB1	5.9	2.1	10.8	9.2	9.8	12.0	8.3	8
	BB2	13.5	4.4	23.0	23.9	304.2	18.2	8.3	57
	BB3	9.1	1.9	25.5	18.4	21.3	16.2	11.2	15
	BB4	16.7	6.7	21.7	19.7	21.8	22.4	16.0	18
	BB5	63.7	276.5	93.2	237.3	15.9	278.5	64.7	147
Jackson Park									
	JP1	8.1	4.3	10.3	9.7	10.0	11.9	8.3	9
	JP2	8.4	4.8	7.6	10.3	8.4	11.8	17.3	10
	JP3	7.8	5.4	8.8	10.0	9.2	14.6	15.9	10
	JP4	15.7	10.4	23.2	18.4	36.4	50.9	28.2	26
	JP5	112.6	134.5						124
	JP6	10.3	6.8	29.0	19.4	16.8	16.0	51.7	21
Woodland Beach									
	WB1	10.0	10.0	22.4	22.6	17.7	18.2	22.3	18
	WB2	14.8	16.6	43.4	47.2	28.4	56.5	75.3	40

Table 6 Field measurements of temperature (a) and conductivity (b) in streams at three beaches in the Township of Tiny 2003

a Temperature (º C)

Stations	May-27	Jun-25	Jul-09	Jul-15	Jul-30	Aug-13	Sep-08
Balm Beach							
BB1	8.7	11.8	12.1	12.4	11.5	13.0	11.2
BB2	9.9	14.6	14.6	14.9	13.6	15.1	12.7
BB3	8.2	11.5	12.2	12.4	11.8	13.4	11.4
BB4	8.8	12.5	13.0	13.6	12.8	14.4	12.8
BB5	12.6	14.2	16.6	15.8	16.1	17.8	17.7
Jackson Park							
JP1	10.7	13.7	13.7	14.4	13.5	14.8	12.9
JP2	10.8	16.2	15.7	17.1	15.0	17.2	13.8
JP3	10.6	16.0	15.7	17.0	14.8	16.9	13.7
JP4	10.6	14.2	15.9	15.1	15.4	16.7	16.7
JP5	10.3	13.0					
JP6	9.1	14.4	15.0	15.5	14.7	16.9	14.1
Woodland Beach							
WB1	13.4	18.4	17.7	18.2	17.7	18.6	15.1
WB2	10.9	13.5	15.3	14.6	15.4	16.5	13.72

b Field Conductivity (uS/cm)

Stations	May-27	Jun-25	Jul-09	Jul-15	Jul-30	Aug-13	Sep-08
Balm Beach							
BB1	362	308	581	583	588	585	582
BB2	594	560	573	571	570	576	557
BB3	451	477	454	478	476	479	476
BB4	322	540	510	526	531	520	536
BB5	771	513	788	848	789	837	664
Jackson Park							
JP1	336	369	368	363	365	352	374
JP2	357	382	387	380	385	372	387
JP3	350	383	387	381	387	377	389
JP4	461	477	462	428	473	429	470
JP5	362	391	dry	dry	dry	dry	dry
JP6	360	496	507	503	515	506	524
Woodland Beach							
WB1	518	499	268	480	490	470	471
WB2	557	521	532	531	538	540	536

Table 7 Density of E. coli from samples collected on transects from Health Unit stations to shore at Balm Beach July 10, 2003

Transect	1-1.5 m		0.5 m		0.2 m	shore
B1	10	<	20		40	4000
B2	10	<	10	<	280	500
B3	10	<	20		170	180
B4	10	<	10	<	20	120
B5	10	<	10	<	40	400

Shore= approx 1 m from waters edge away from wave action
<= less than 10 orgs/100 ml
- water temperature 19.5 o C
- air temperature 19.0 o C
- note that B1 is located 6m north of the stream mouth

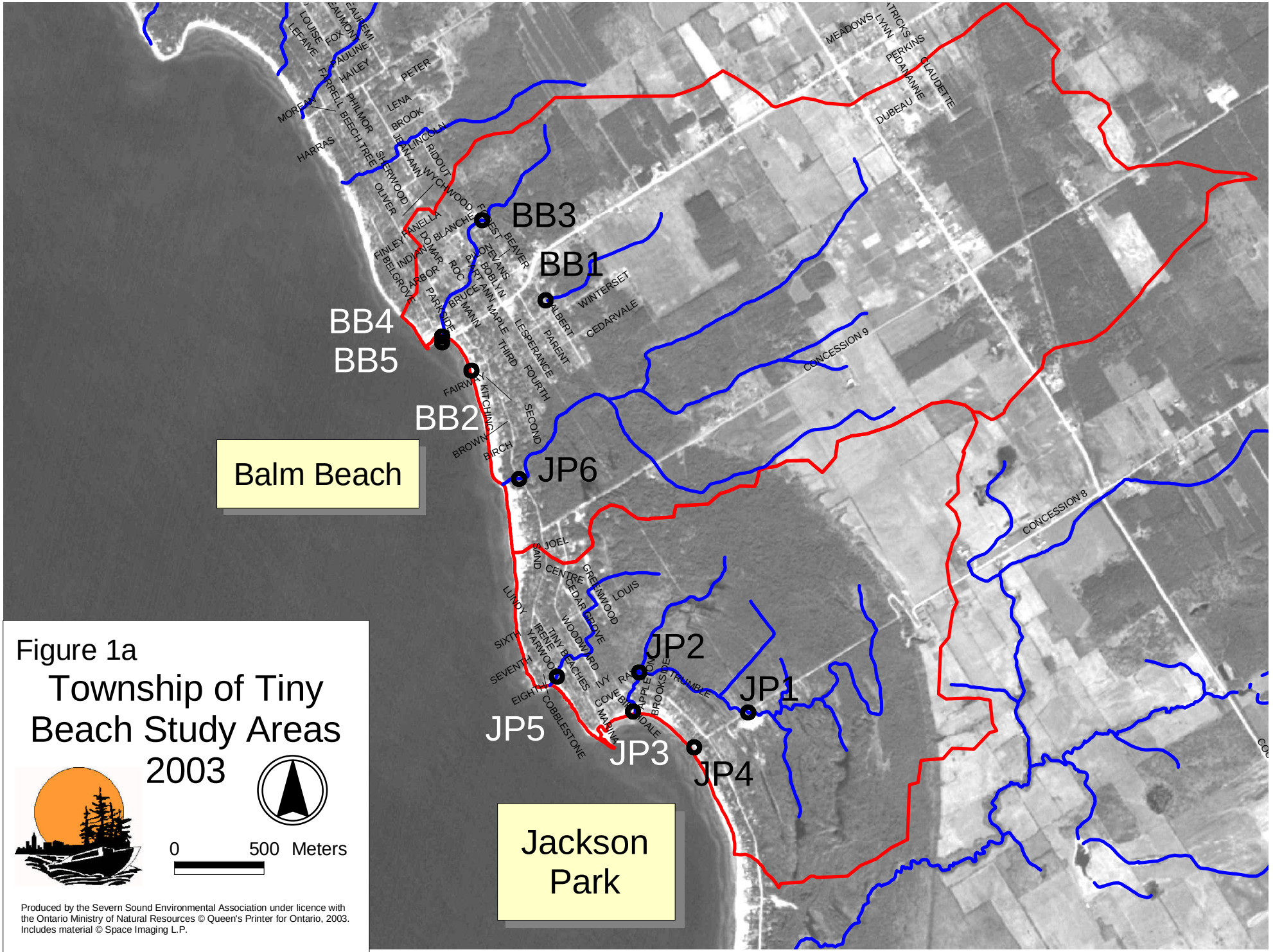


Figure 1a

Township of Tiny Beach Study Areas 2003

0 500 Meters

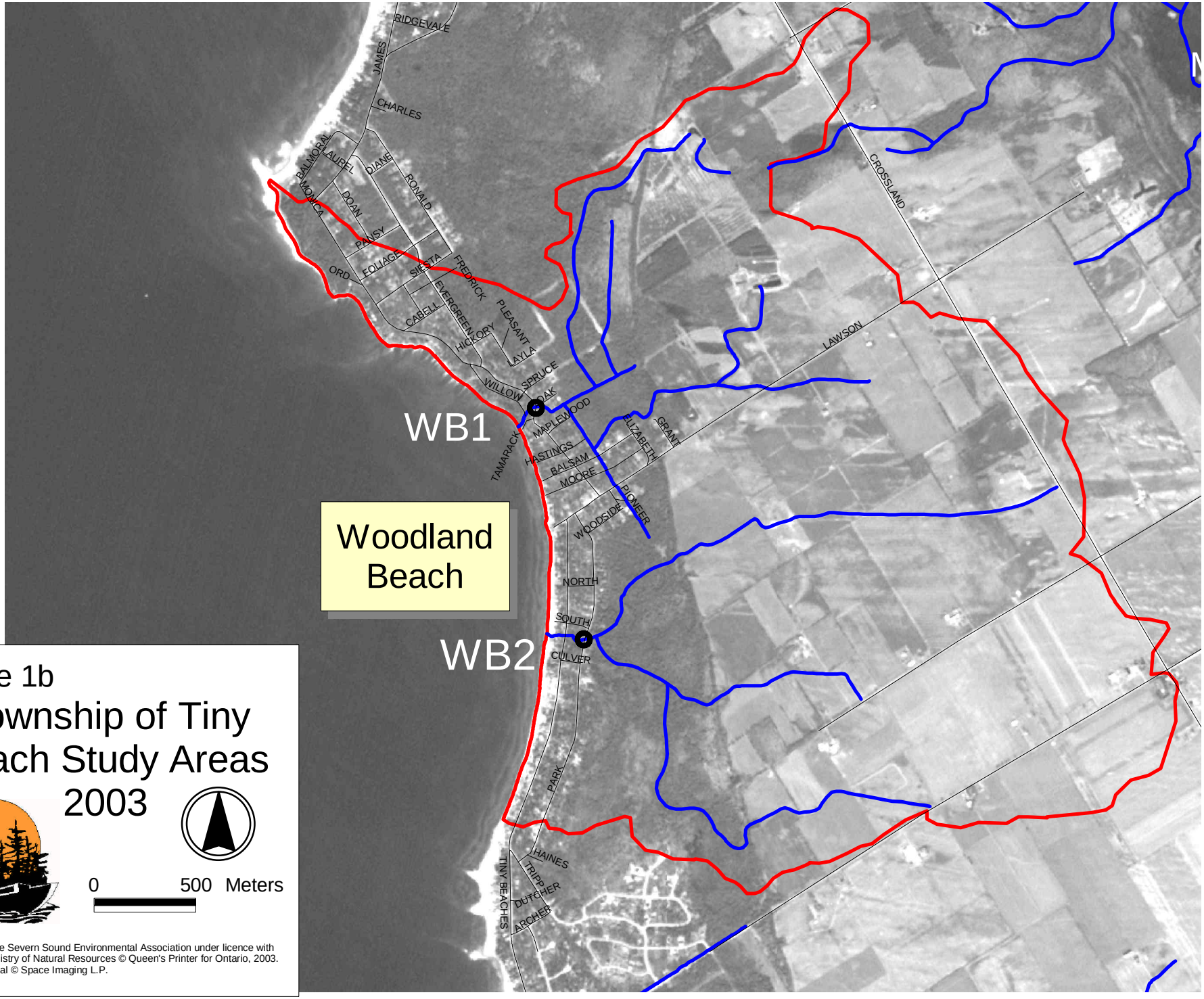
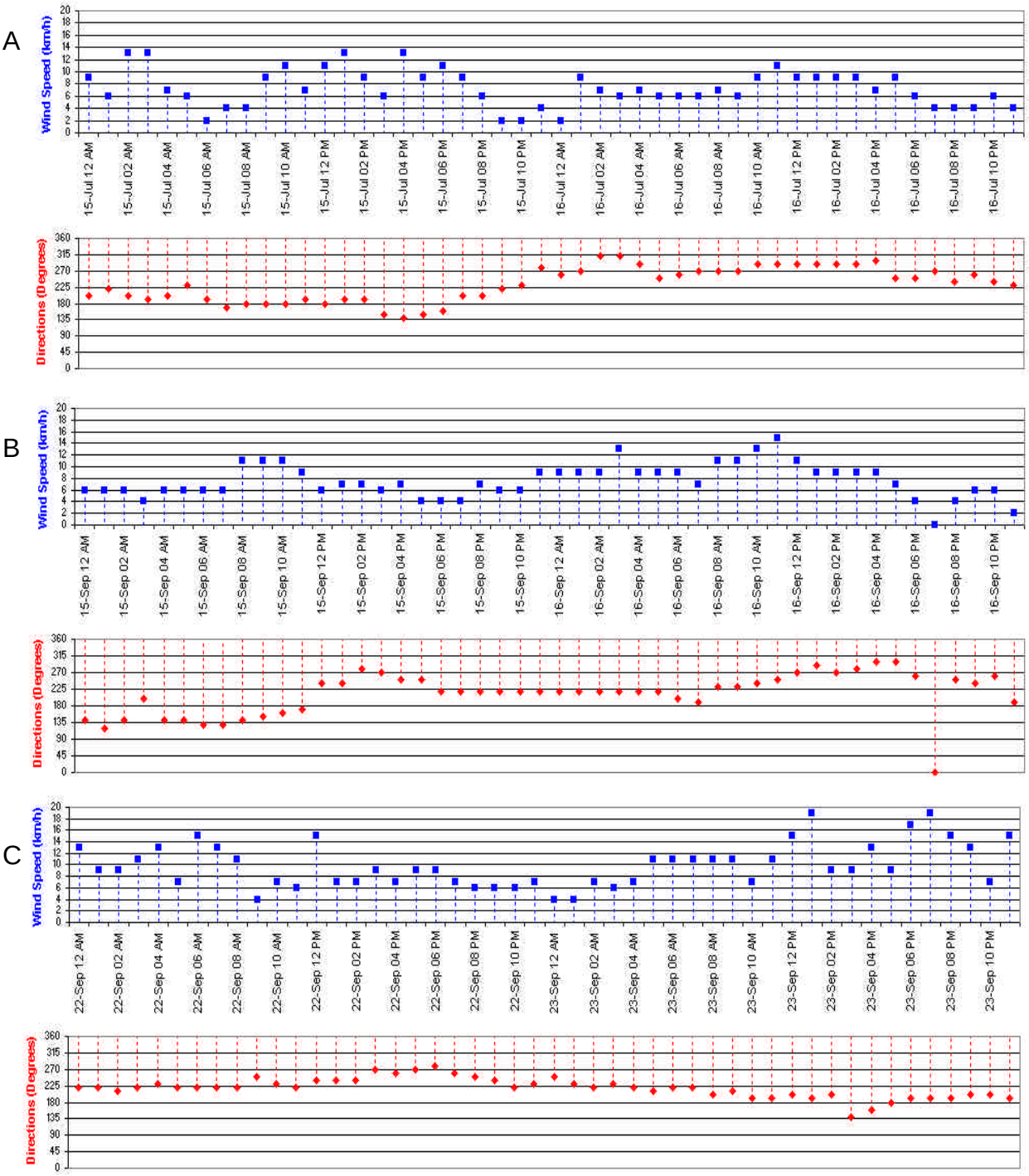


Figure 1b

Township of Tiny Beach Study Areas 2003

0 500 Meters

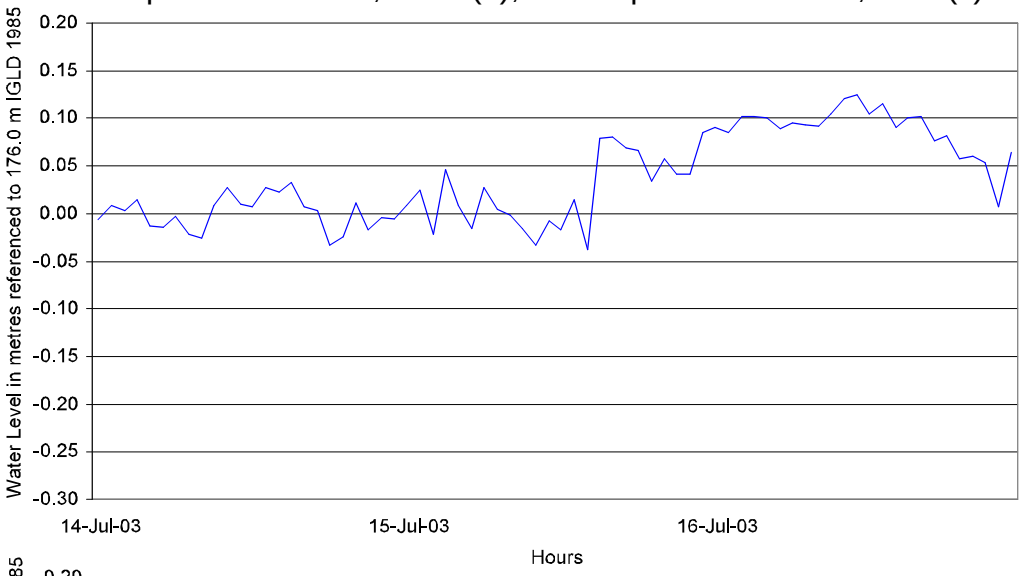
Figure 2 - Wind direction and Speed at Beausoleil Is. Climate Station during storm events sampled on July 15th(A), Sept.15th(B) and Sept.22nd(C) in 2003.



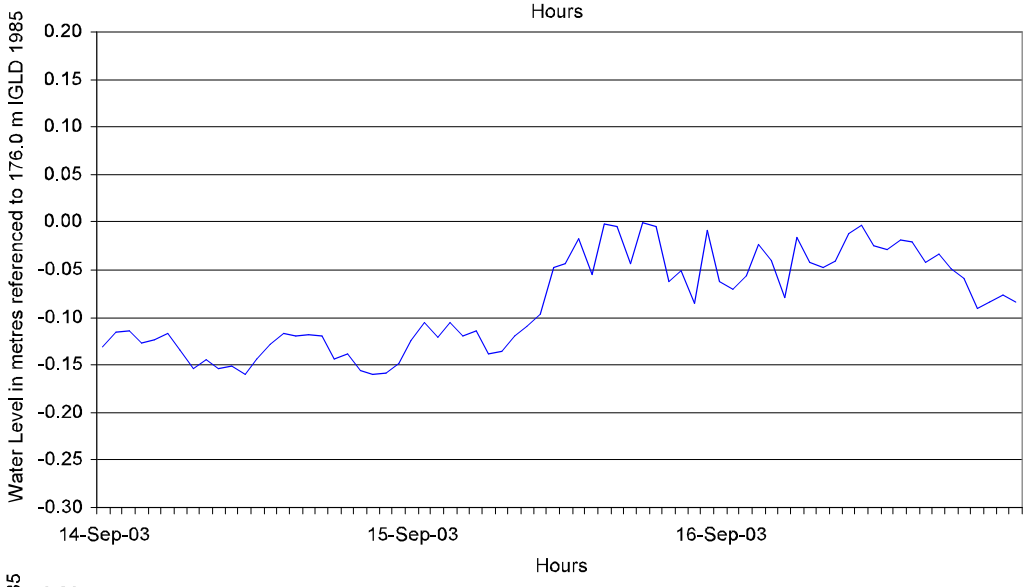
Wind Speed (km/h) - Observed at 10 m above the ground. Wind Direction (10's Deg) - The direction (true or geographic, not magnetic) from which the wind blows. Expressed in degrees- 90 degrees indicates an east wind, and 360 degrees indicates a wind blowing from the geographic north, a value of zero (0) denotes a calm wind.
Source: Environment Canada - National Climate Archive - www.climat.meteo.ec.gc.ca

Figure 3 Hourly water levels at Collingwood during July 14 - 16, 2003 (a), September 14 - 16, 2003 (b), and September 21 - 23, 2003(c)

a



b



c

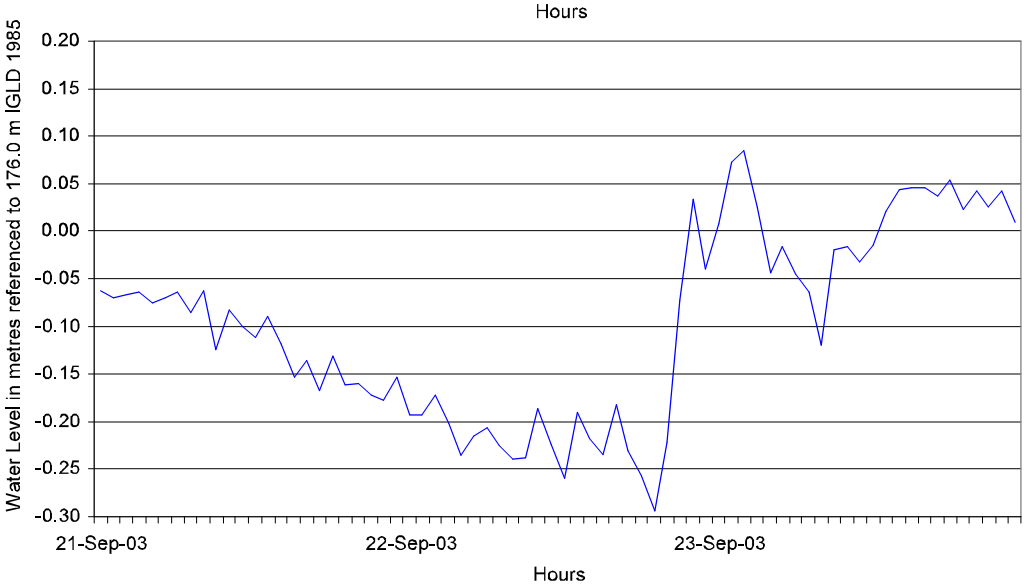


Figure 4 **Temperature at Balm and Jackson Park Beaches and Tributaries during events a) July 15th b) September 15th c) September 22nd**
(Hourly results taken with temperature loggers)

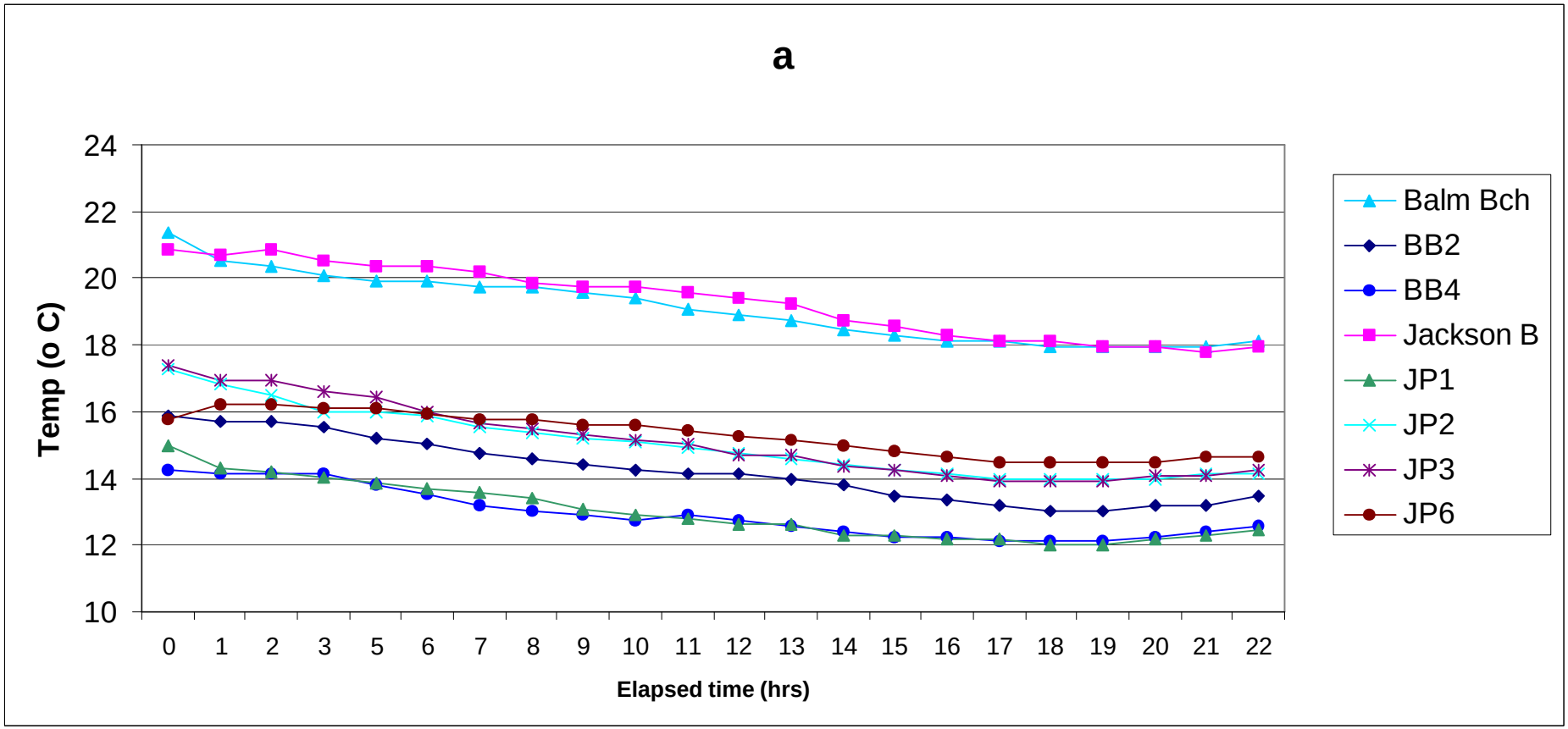


Figure 4 **Temperature at Balm and Jackson Park Beaches and Tributaries during events a) July 15th b) September 15th c) September 22nd**
(Hourly results taken with temperature loggers)

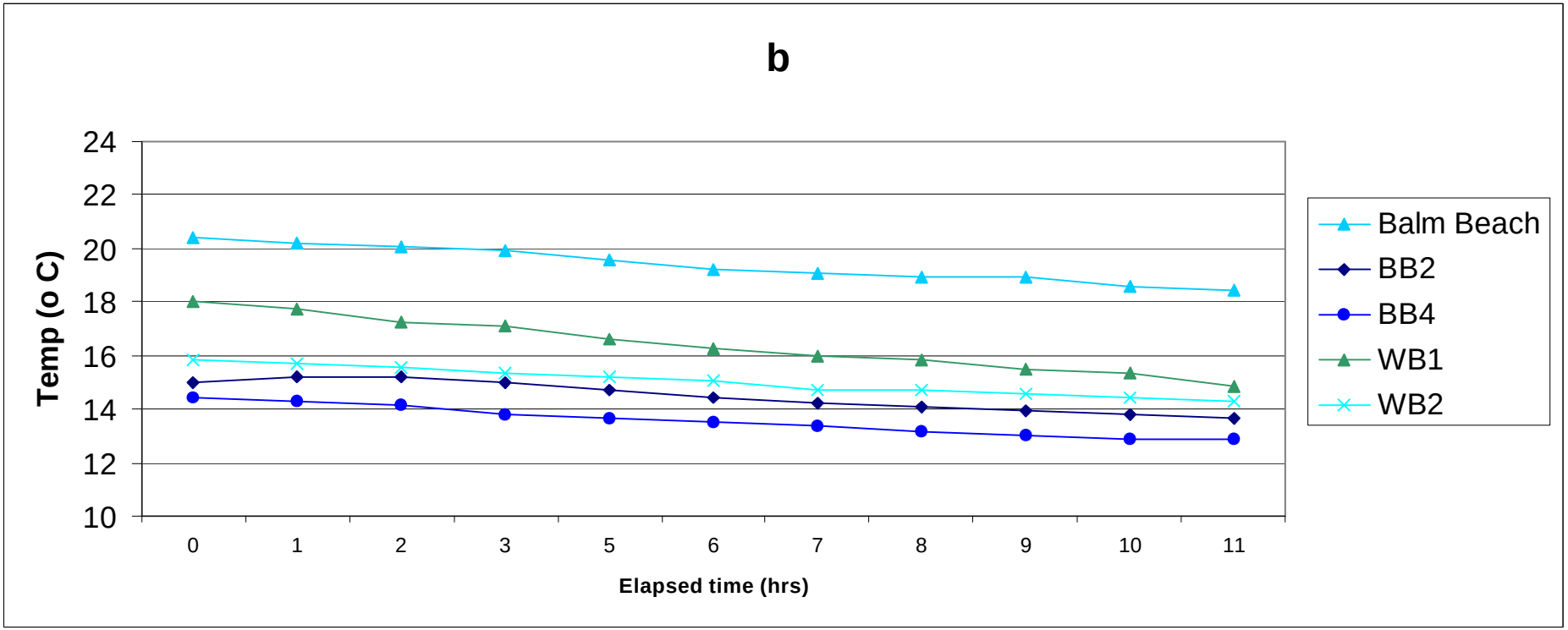


Figure 4 **Temperature at Balm and Jackson Park Beaches and Tributaries during events a) July 15th b) September 15th c) September 22nd**
(Hourly results taken with temperature loggers)

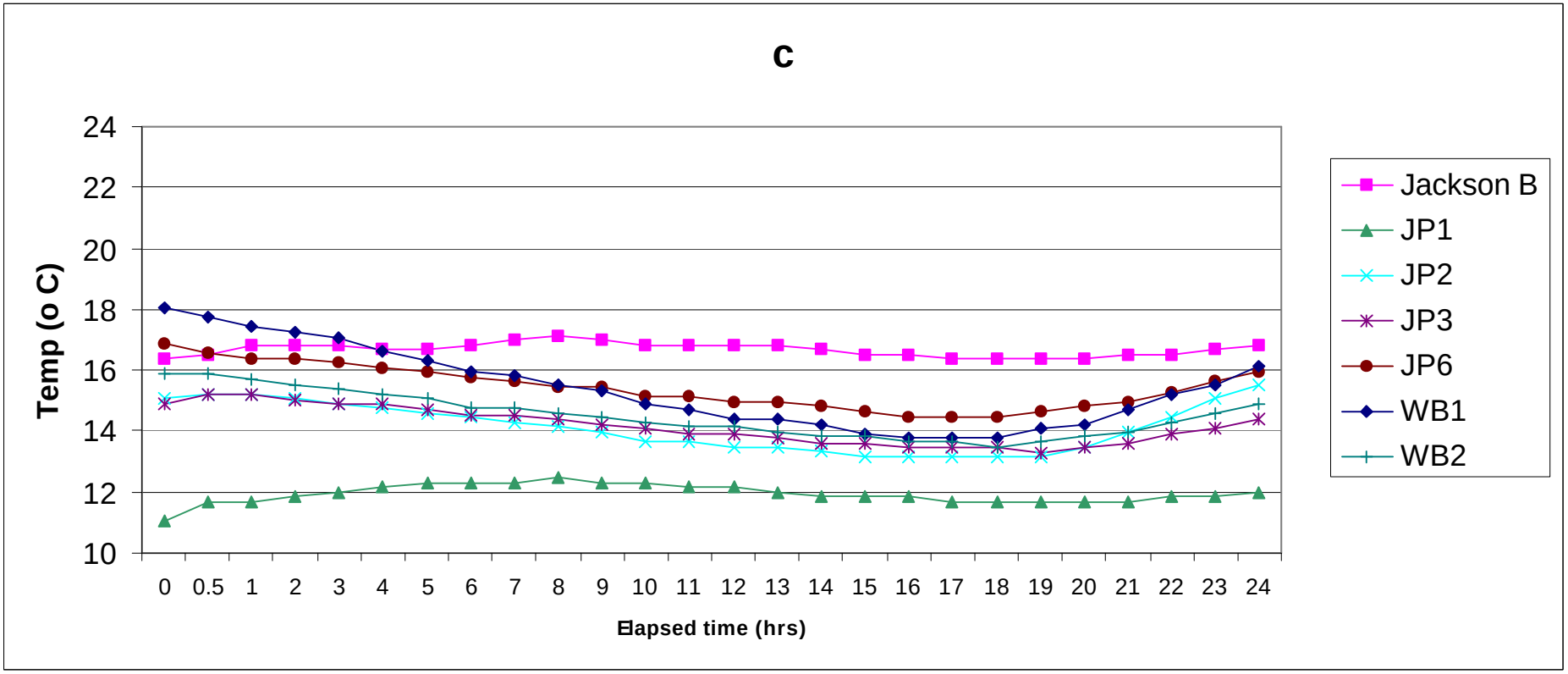
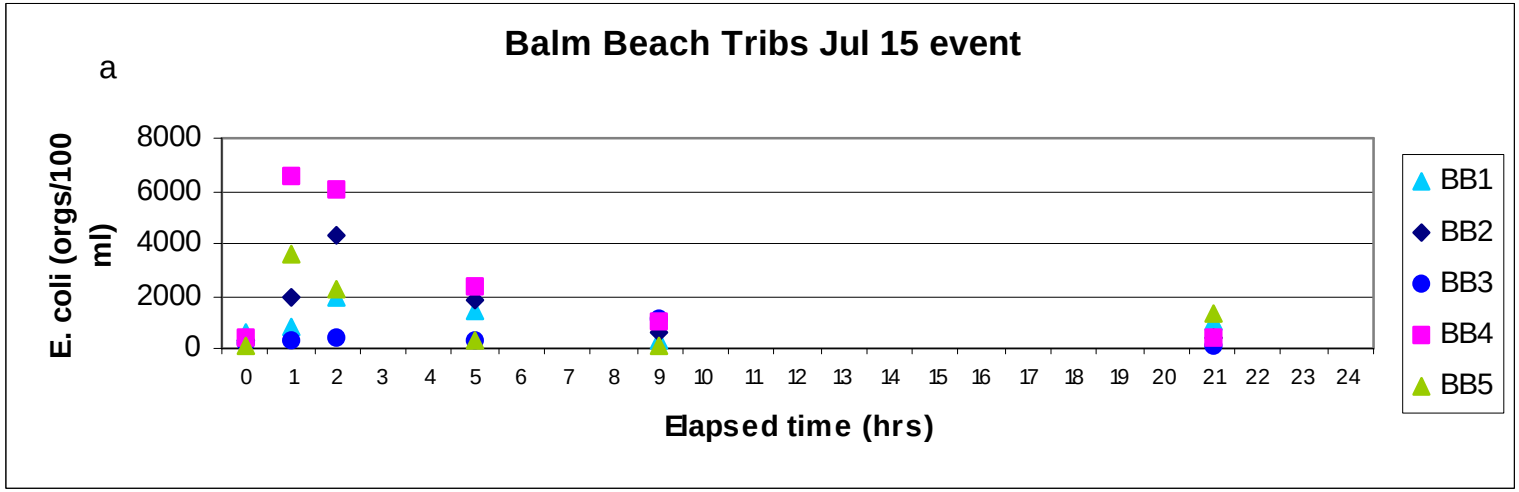


Figure 5 Balm Beach stream (a) and beach(b) quality during the July 15, 2003 rain event



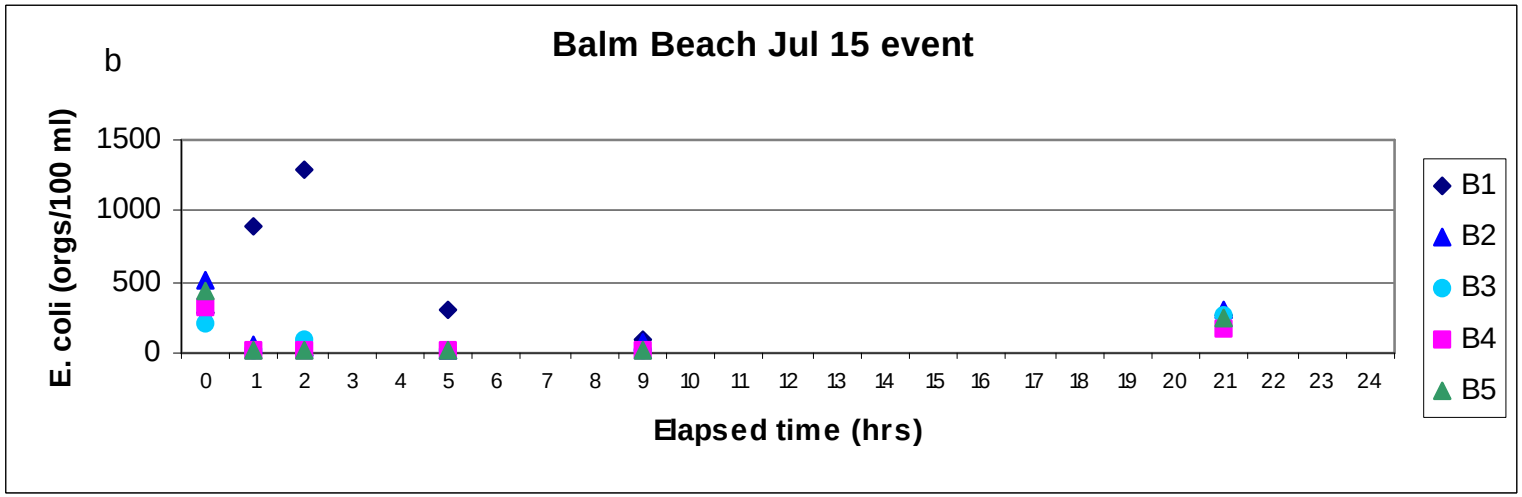
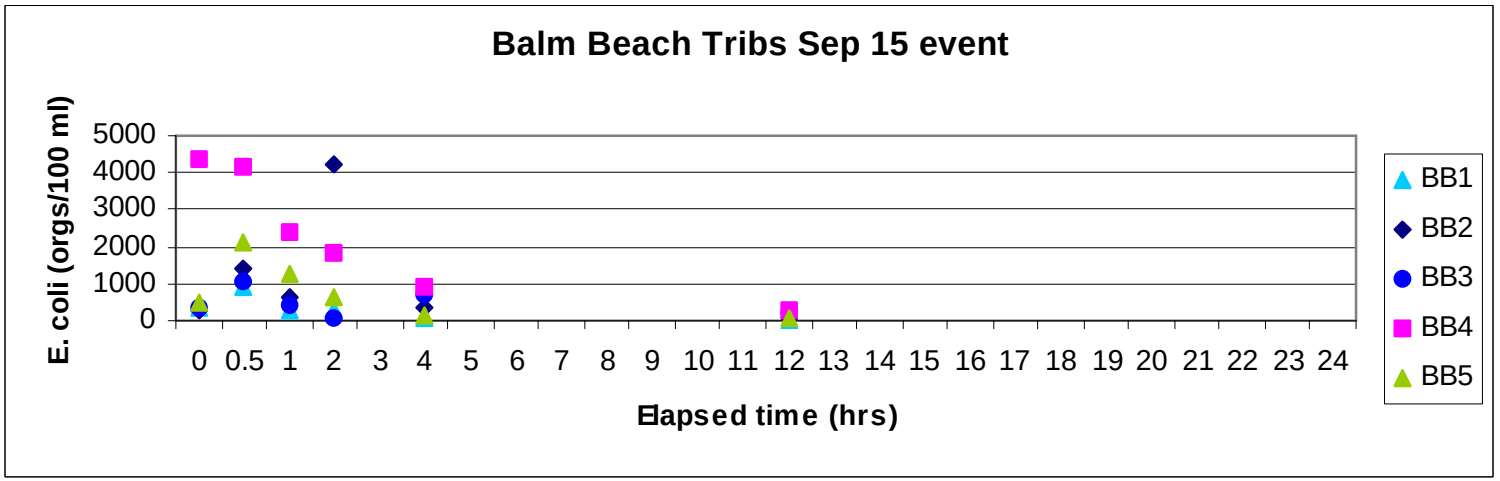


Figure 6 Balm Beach stream (a) and beach (b) quality during the September 15, 2003 rain event

a



b

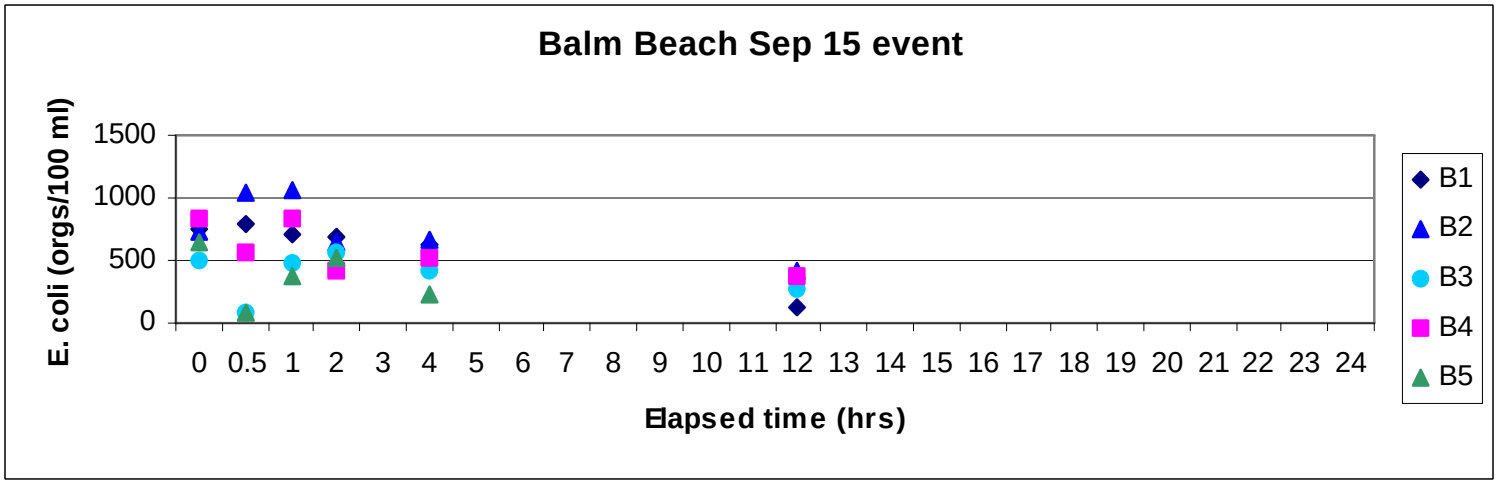
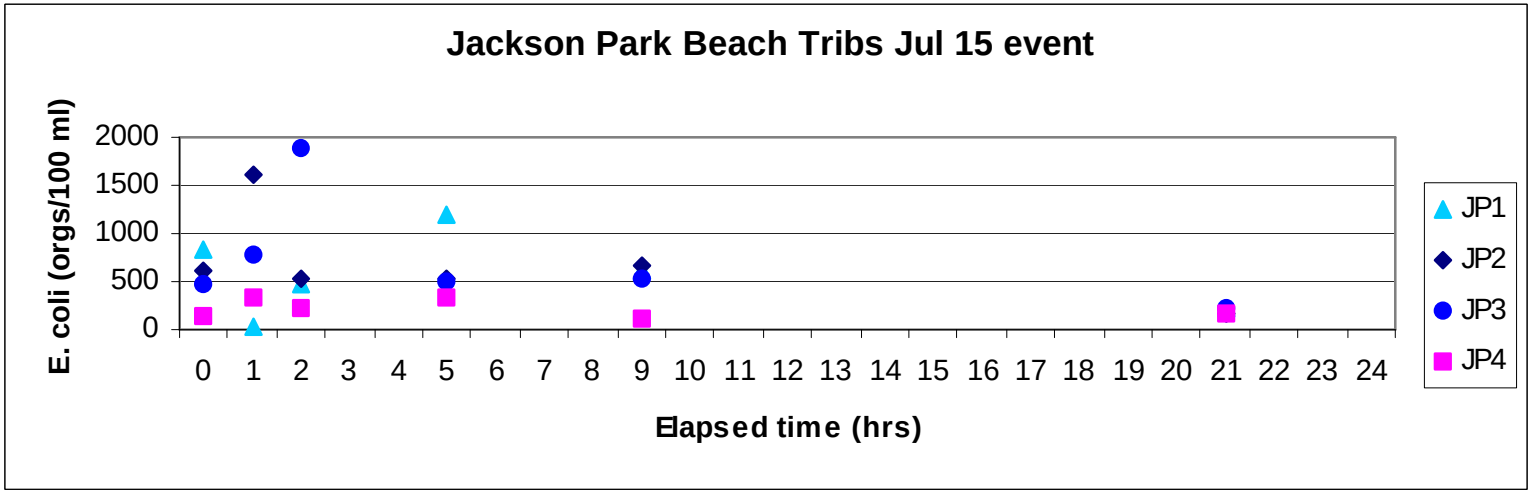


Figure 7 Jackson Park Beach stream (a) and beach (b) quality during the July 15, 2003 rain event

a



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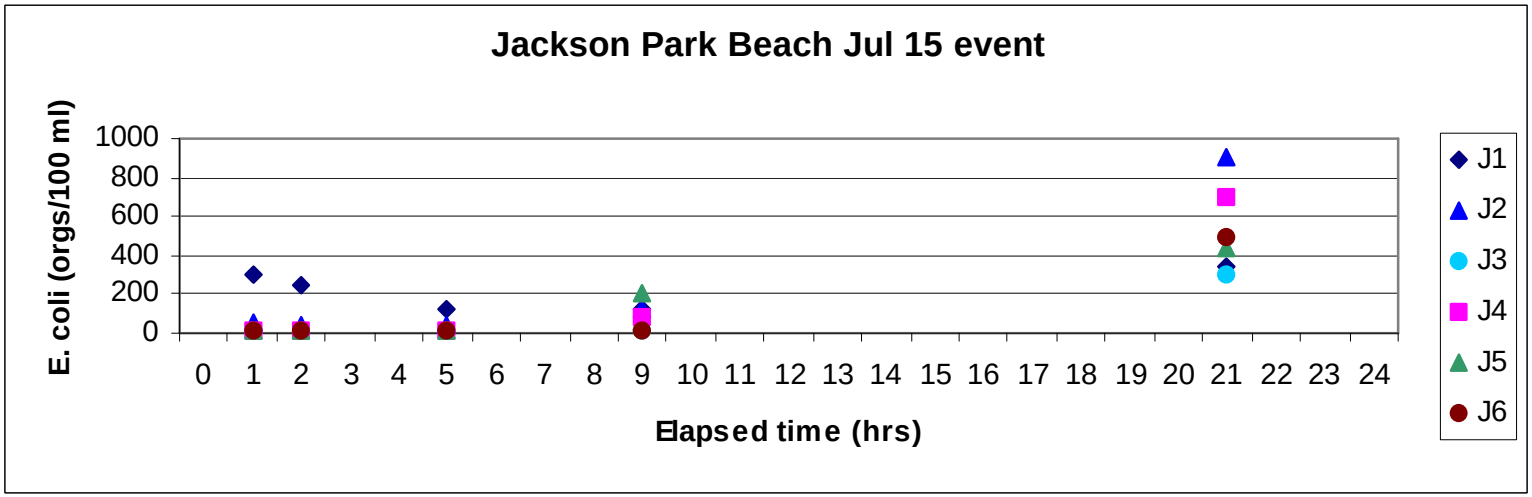
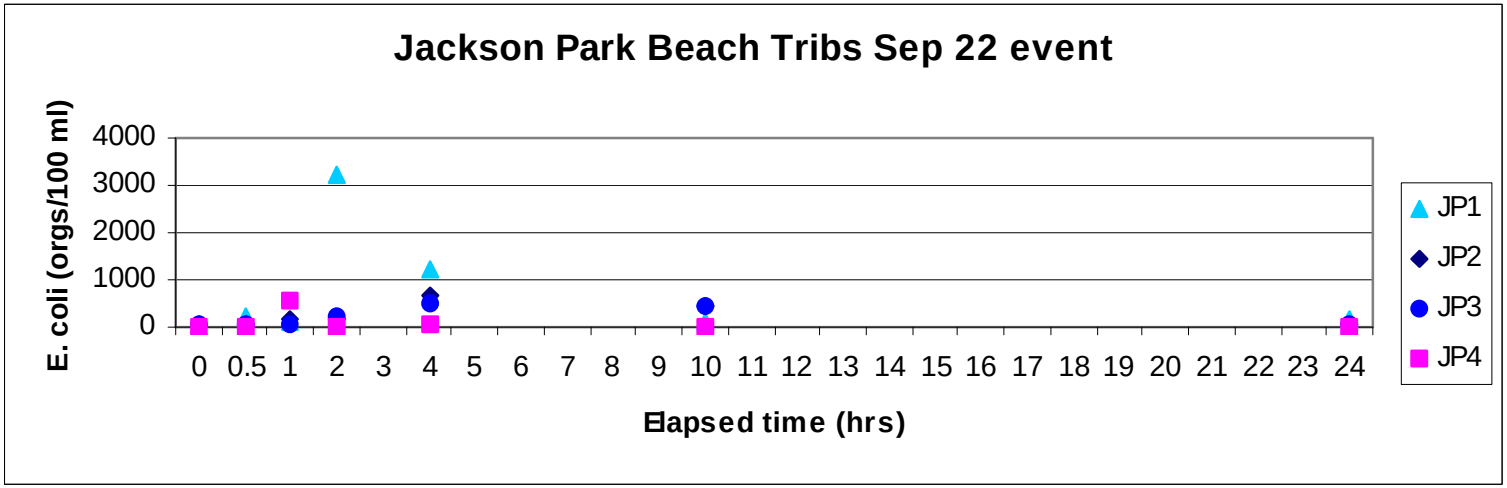


Figure 8 Jackson Park Beach stream (a) and beach (b) quality during the September 22, 2003 rain event

a



b

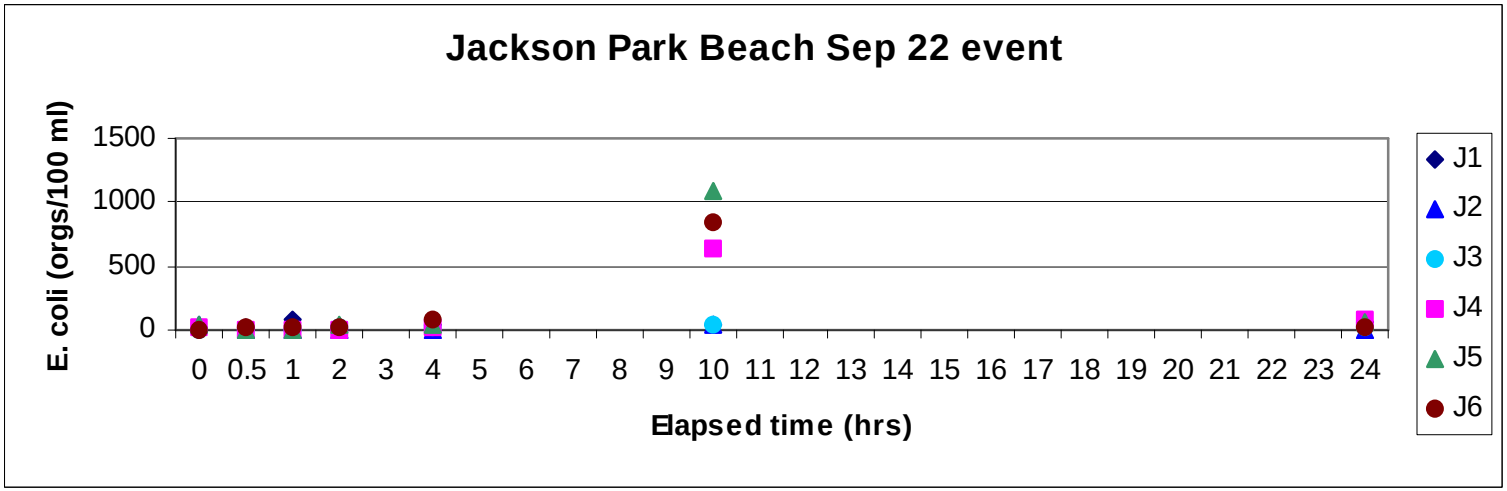
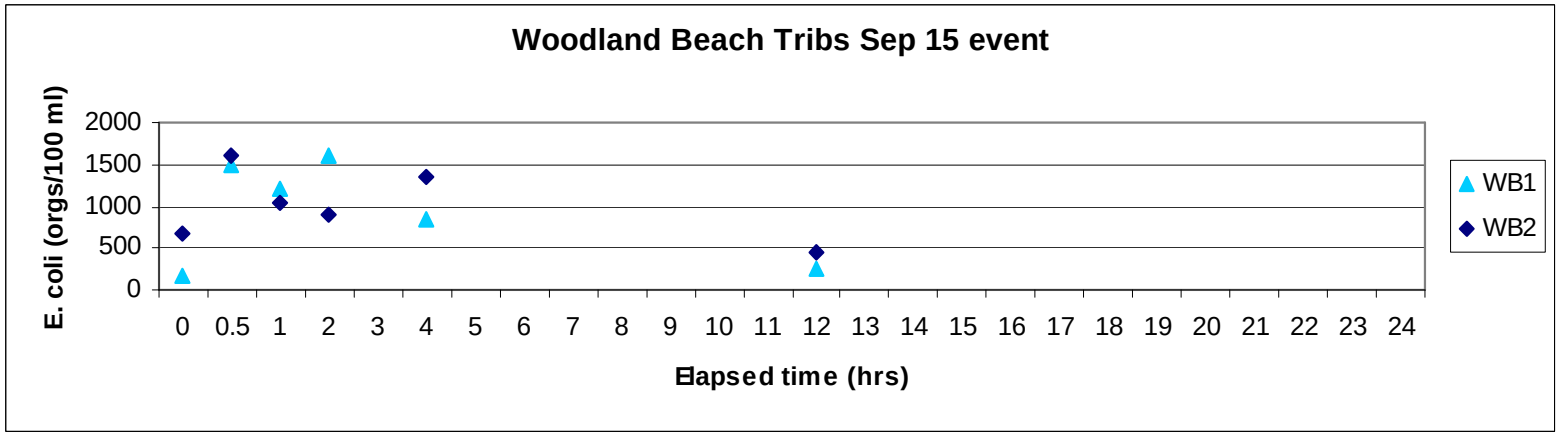


Figure 9 Woodland Beach stream (a) and beach (b) quality during the September 15, 2003 rain event

a



b

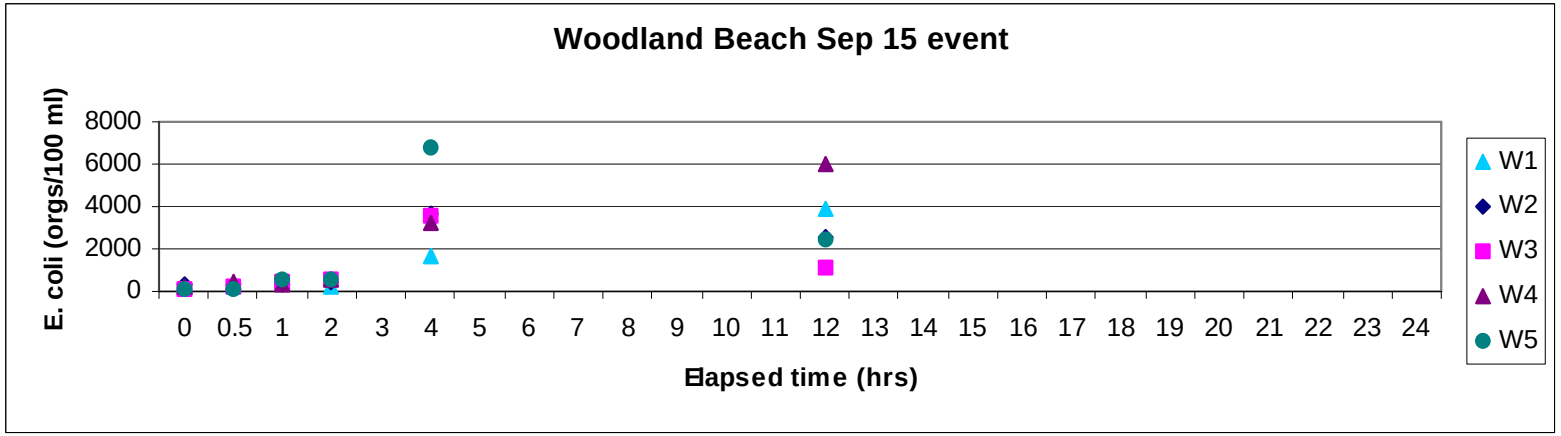
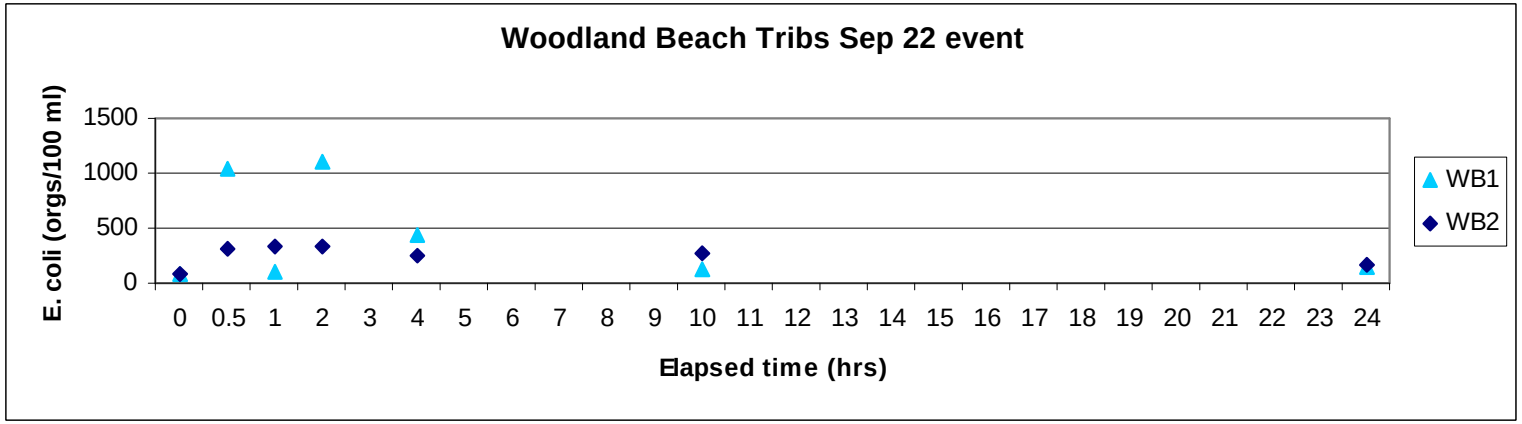
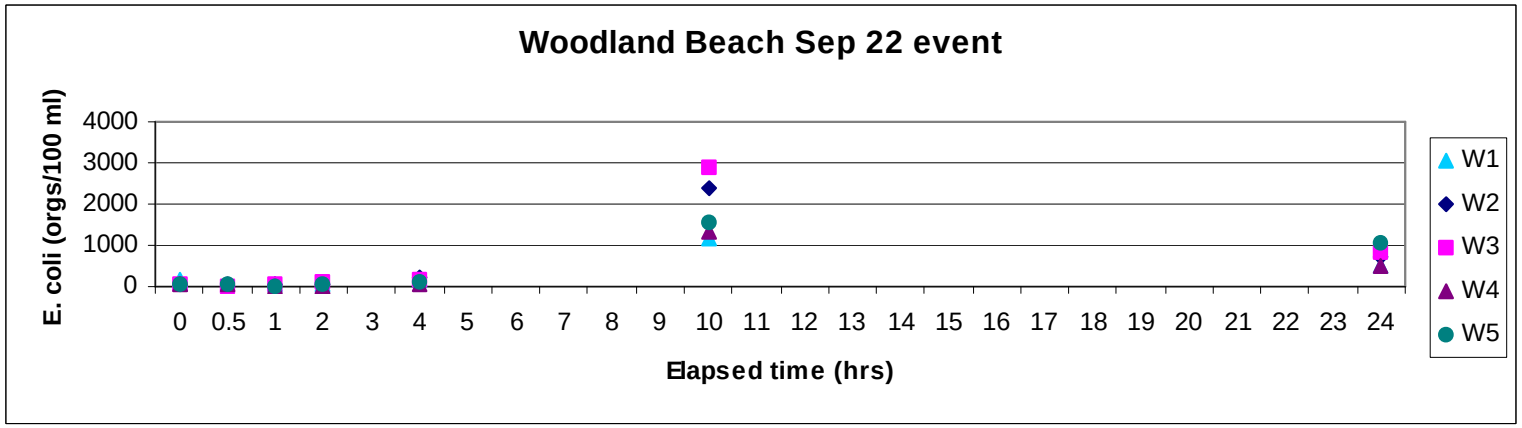


Figure 10 Woodland Beach stream (a) and beach (b) quality during the September 22, 2003 rain event

a



b



8. Appendix A

BEACH USE SURVEY

Date (mm/dd/yy): _____ Time (24 hr clock): _____

Location: _____

Sampler: _____ Observer: _____

Weather Conditions:

AIR TEMPERATURE: _____

Check if appropriate:

Sunny	☐	Partly cloudy	☐
Overcast	☐	Rain	☐
Other	☐	% Cloud cover	_____

Recent Rainfall:

none	☐	last 24 hrs	☐
last 12 hrs	☐	last 48 hrs	☐

Approximate amount of rainfall (incl. unit): _____ in _____ hours

Actual rainfall (source =): _____ (24 hr) _____ (48 hr)

Waves:

none	☐	1.0 - 1.5 m	☐
0 - 0.5 m	☐	>1.5 m	☐
0.5 - 1.0 m	☐		

Winds:

none	☐	direction: (circle)	N	E
light	☐		W	S
medium	☐		NW	NE
high	☐		SW	SE

Water Conditions:

WATER TEMPERATURE: _____

Water quality:

clear (>1m)	☐	warning posted	☐	other: _____
murky (<1m)	☐	beach closed	☐	_____

Algae:

none	☐	on rocks	☐	colour: _____
a little	☐	floating on surface	☐	other: _____
a lot	☐	on bottom	☐	_____

Birds: number _____ type _____

Number of bathers in water: _____

Number of people on beach: _____ Number of fishermen: _____

Sample?: no ☐ yes ☐ Type: _____

Bottom sediment type: _____

Additional concerns, incidences, any questions from public, comments: _____

_____

_____

_____