Halifax Harbour
Water Quality Monitoring Program
Quarterly Report #1

June – September 2004

HALIFAX
REGIONAL MUNICIPALITY

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Water Quality Monitoring Program
Quarterly Report #1

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February 2005

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1 Introduction

The Halifax Harbour Water Quality Monitoring Project (HHWQMP) is based on weekly sampling at over 30 sites located from the Bedford Basin to Outer Halifax Harbour. Water samples taken at 1m and 10m depths are analyzed for a range of parameters. In addition, continuous profiles of basic hydrographic properties (salinity, temperature and density), dissolved oxygen and chlorophyll *a* are collected. The sample and profile data are presented in weekly reports along with ancillary data including tidal stage, wind, rainfall and other parameters. The weekly reports are generated as inserts into a binder (JWEL and COA, 2004). The detailed datasets are also archived to CD and delivered on a weekly basis with the reports. A detailed description of the program is contained in the Introduction section of the report binder.

The weekly data sets are reviewed on a quarterly basis (13 weeks). The main objective of the quarterly reports is to summarize and evaluate the weekly data sets in terms of water quality objectives and concerns. The quarterly report also provides an opportunity to review the effectiveness of various aspects of the program and recommend changes that will improve the program.

The HHWQMP program is unprecedented in the marine environment in Nova Scotia. It involves an extensive network of personnel including boat operators, field technicians, laboratory technicians and their associated equipment and procedures. The study team also includes managers, oceanographers and water quality experts. The emphasis during the first quarter was to "spin up" this extensive program. This involved development of routines, procedures, weekly report and data archive formats.

This quarterly report represents a summary of HHWQMP data collected from 23 Jun 2004 to 14 September 2004. At this point in the project the water quality data base is still quite small and has not yet been the focus of detailed statistical analysis. However, the data are discussed here in terms of preliminary observations particularly as they confirm/do not confirm initial expectations of the sampling program design and as they affect recommendations for modification of the program.

2 Weekly Reporting

The weekly report format has been developed to follow the approach of Jordan who used graphical cross-sections of the harbour to present contoured data sets (Jordan 1972). Jordan's data consisted only of CTD data on cross-sectional transects so the template was modified somewhat to fit the present more extensive data sets. The result is a format which graphically summarizes the all relevant hydrographic data on two opposing pages. The water quality data is presented in the same format with key oceanographic and meteorological data corresponding to the previous week shown graphically. Electronic copies of the data and report are included with the printed report. The graphics are quite high resolution and can be expanded in the electronic report if greater legibility is required.

All analysis and graphic presentation are performed in the software package MATLAB, perhaps the most advanced mathematical analysis package available. Creation of the graphics involves execution of "scripts". These are a record of the input sources and any processing of the data prior to presentation and archiving and provide a record of any processing applied to the raw data. The initial quarter involves considerable development of the scripts. The area of emphasis has been links with the external data sources, specifically, the standardization of the format for provision of the lab data and the link with the CTD processing software. A final version of the scripts along with data source formats will be provided when complete.

The raw data collected each week is delivered in a spreadsheet format with worksheets containing a cover sheet, a sheet of fecal coliform data, a sheet of chemistry data (if applicable) and individual sheets for each of the sampling stations containing the depth profile data for salinity, temperature, chlorophyll *a*, dissolved oxygen and oxygen percent saturation. This format allows easy 'browsing' and low level analysis of the data, particularly when guided by the graphic presentation.

3 Sampling Program

Survey sampling was conducted from one of two vessels based at the Armdale Yacht Club (AYC). The locations of the 34 sampling sites are presented in Figure 1. These sites follow the locations of Jordan's sites when possible with the exception of his line A and the addition of a line in the Inner Harbour (line EE) plus sites associated with recreational usage. A summary of the sampling and analysis schedules and relevant established criteria is presented in Table 1. Issues and changes in the sampling procedure occurring during the first quarter are summarized in the following sub-sections.

3.1 Sampling Schedule

In general surveys occur on Tuesday to provide time for laboratory analysis within sample age limitations. Wednesday and Thursday are used as contingency days.

3.2 Sampling Order

Sampling order was varied to minimize aliasing the collected data with respect to diurnal variations in sewage load (i.e. we do not sample at a particular site at the same time of day with respect to the morning and mid-day 'flush'). A variable circuit was designed that results in 'quasi' random sampling subject to certain operational constraints.

The sampling circuit involved visitation of the stations on one side of the harbour followed by the other side, with the center stations being collected with one side or the other depending on the week. In addition to this, the circuit starting point is offset and the circuit direction (clockwise/anti-clockwise) varies from week to week with the following limitations. Because of time constraints, HC and B2 are always collected together (i.e. the survey never starts at B2 and ends at HC). Also, the circuit never starts north of the EE transect, precluding the survey starting and ending in Bedford Basin. In addition, the sites in the Northwest Arm are always collected together as are the sites in Eastern Passage. This system was put into effect starting with Week 3. The resulting sampling order for the Weeks 3 to 13 is presented in Table 2.

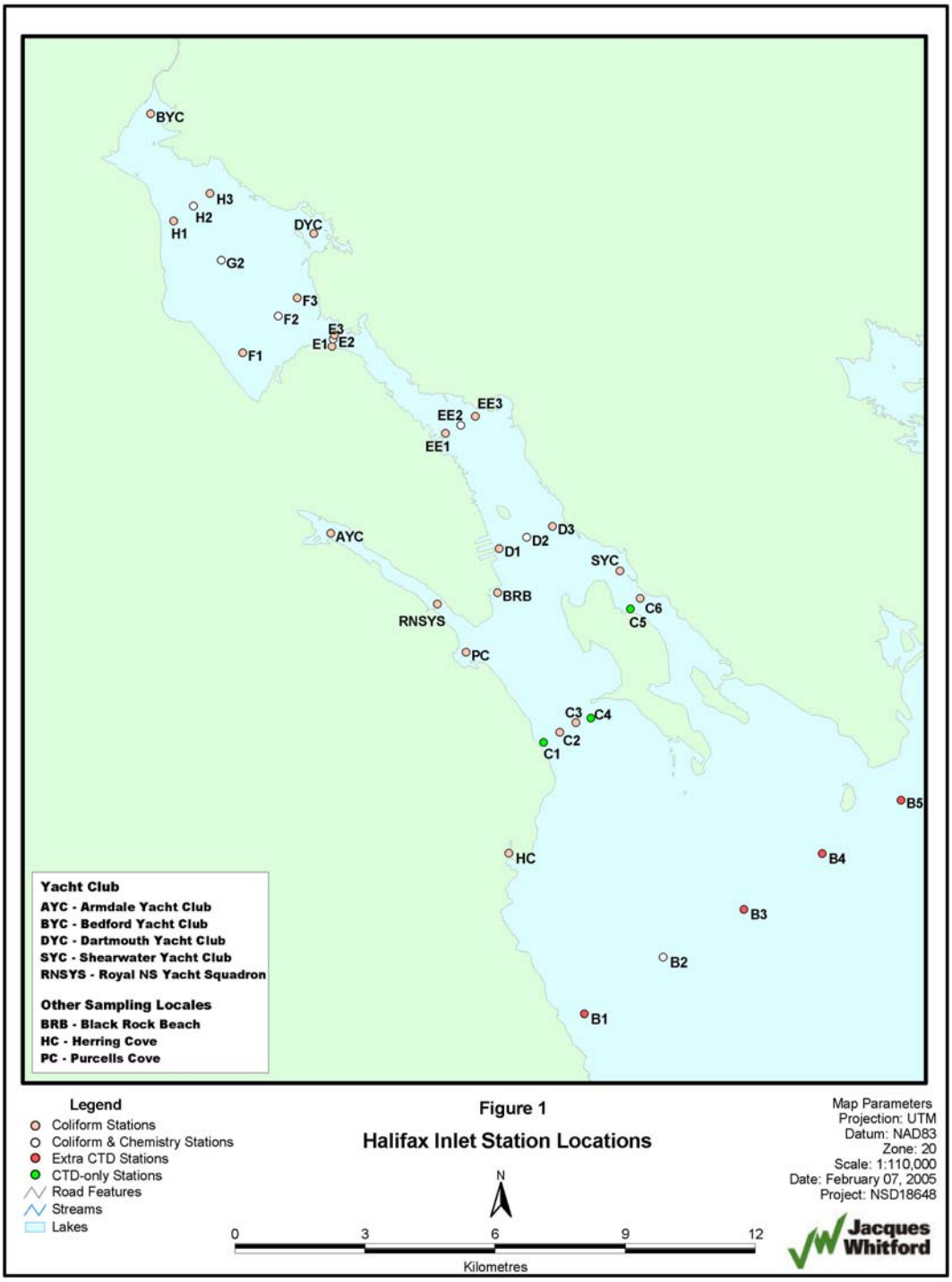

Figure 1 Location of the Water Quality Monitoring Sampling Sites

Table 1 Summary of Measured Parameters

	EQL		Harbour Task Force Guideline	Water Use Category	Sampling Stations (refer to Fig. 1)	Sampling frequency
	value	units				
Profile Data					All	weekly
Salinity	n/a	PSU	none	n/a		
Temperature	n/a	C°	none	n/a		
Chlorophyll	n/a	ug/L	none	n/a		
Dissolved Oxygen	n/a	mg/L	8.0	SA		
			7.0	SB		
			6.0	SC		
Secchi depth	n/a	m	none	n/a		
Bacteria Samples					Bacteria + Chemical	weekly
Fecal Coliform	0	CFU/ 100mL	14	SA		
			200	SB		
Chemical Samples					Chemical sites	bi-weekly
CBOD	5	mg/L	none	n/a		
Ammonia Nitrogen	0.05	mg/L	none	n/a		
TSS	0.5	mg/L	<10% background	all		
Total Oil and Grease	5	mg/L	10.0	all		
Metal scan					Chemical sites	bi-weekly
Cadmium	3	ug/L	9.3	all		
Chromium	20	ug/L	50.0	all		
Copper	20	ug/L	2.9	all		
Lead	5	ug/L	5.6	all		
Manganese	20	ug/L	100.0	all		
Nickel	20	ug/L	8.3	all		
Zinc	50	ug/L	86.0	all		
Aluminum	100	ug/L	none			
Antimony	20	ug/L	none			
Arsenic	20	ug/L	none			
Barium	50	ug/L	none			
Beryllium	20	ug/L	none			
Bismuth	20	ug/L	none			
Boron	500	ug/L	none			
Cobalt	10	ug/L	none			
Lithium	20	ug/L	none			
Iron	500	ug/L	none			
Molybdenum	20	ug/L	none			
Selenium	50	ug/L	none			
Strontium	50	ug/L	none			
Thallium	1	ug/L	none			
Tin	20	ug/L	none			
Titanium	20	ug/L	none			
Uranium	1	ug/L	none			
Vanadium	20	ug/L	none			

Table 2 Sample Collection Order (green sites are CTD only)

Date	7-Jul	15-Jul	22-Jul	28-Jul	3-Aug	11-Aug	18-Aug	24-Aug	31-Aug	7-Sep	14-Sep
Survey #	3	4	5	6	7	8	9	10	11	12	13
Code	A1	A2	B19	A3	B18	B17	A4	A5	B16	B15	A6
1	AYC	BRB	EE2	C2	D3	EE3	B2	C3	C4	C5	SYC
2	RNSYS	D1	EE1	C1	SYC	E3	HC	C4	C3	C6	C6
3	PC	EE1	E2	HC	C6	F3	C1	C6	B2	SYC	C5
4	C1	E1	E1	B2	C5	DYC	C2	C5	HC	D3	C4
5	C2	F1	F2	C3	C4	H3	PC	SYC	C1	EE3	C3
6	HC	G2	F1	C4	C3	BYC	NSYS	D3	C2	E3	B2
7	B2	H1	G2	C5	B2	H2	AYC	D2	PC	F3	HC
8	C3	BYC	H1	C6	HC	H1	BRB	EE3	NSYS	DYC	C1
9	C4	H2	H2	SYC	C1	G2	D1	EE2	AYC	H3	C2
10	C6	H3	BYC	D3	C2	F1	EE1	E3	BRB	BYC	PC
11	C5	DYC	H3	D2	PC	F2	E1	E2	D1	H2	NSYS
12	SYC	F2	DYC	EE3	NSYS	E1	F1	F2	D2	H1	AYC
13	D3	F3	F3	EE2	AYC	E2	G2	F3	EE2	G2	BRB
14	D2	E2	E3	E3	BRB	EE1	H1	DYC	EE1	F1	D1
15	EE3	E3	EE3	E2	D1	EE2	BYC	H3	E2	F2	EE1
16	EE2	EE2	D3	F2	D2	D2	H2	H2	E1	E1	E1
17	E3	EE3	SYC	F3	EE2	D1	H3	BYC	F2	E2	F1
18	E2	D2	C6	DYC	EE1	BRB	DYC	H1	F1	EE1	G2
19	F3	D3	C5	H3	E2	AYC	F3	G2	G2	EE2	H1
20	F2	SYC	C4	H2	E1	NSYS	F2	F1	H1	D2	BYC
21	DYC	C5	C3	BYC	F2	PC	E2	E1	H2	D1	H2
22	H3	C6	B2	H1	F1	C2	E3	EE1	BYC	BRB	H3
23	H2	C4	HC	G2	G2	C1	EE2	D1	H3	AYC	DYC
24	BYC	C3	C1	F1	H1	HC	EE3	BRB	DYC	NSYS	F3
25	H1	B2	C2	E1	H2	B2	D2	AYC	F3	PC	F2
26	G2	HC	D2	EE1	BYC	C3	D3	NSYS	E3	C2	E2
27	F1	C2	D1	D1	H3	C4	SYC	PC	EE3	C1	E3
28	E1	C1	BRB	BRB	DYC	C5	C6	C1	D3	HC	EE2
29	EE1	PC	PC	PC	F3	C6	C5	C2	SYC	B2	EE3
30	D1	NSYS	NSYS	NSYS	E3	SYC	C4	HC	C6	C3	D2
31	BRB	AYC	AYC	AYC	EE3	D3	C3	B2	C5	C4	D3

3.3 Outer Harbour Sampling

The purpose of stations located in the Outer Harbour (Line B) is to provide a background water quality reference and to help map relevant oceanographic conditions during the survey. During the early surveys it became evident that sampling the Harbour Mouth (Jordan's line A) was not feasible in terms of time and operational limitations and that sampling the next inner transect would be sporadic at best. No further efforts were made to survey Line A. In the interest of obtaining the best possible description of oceanographic conditions (CTD), initially optional stations on line C (C1, C4 and C5)

were made routine and "optional" site B1 was sampled as often as possible based on weather conditions. Most of the exchange with the Scotian Shelf occurs in the deep channel on the west side of the harbour and even a partial section B1 – B2 adds significant oceanographic value to the survey. Therefore, a priority on Stations B1 and B2 (routinely sampled) has been established. The remaining B stations are retained as 'time and conditions permit' stations. However, it is not generally possible to sample all these stations.

3.4 Recreational Areas

Several sampling stations were included in the survey to reflect areas of recreational activity (aside from boating community's use of the entire harbour). These include yacht clubs and Black Rock Beach in Point Pleasant Park. Herring Cove Harbour is also sampled as a recreational area though this is perhaps a moot point as the sampling site is also important as a record of input from MacIntosh Run. Other areas in which recreational activities take place include Eastern Passage Beach, Wreck Cove Beach, Mauger's Beach and Dartmouth Marina. In addition, an argument can be made for recreational use at least in terms of aesthetic enjoyment at waterfront locations in Halifax and Dartmouth.

3.5 Sampling Protocol

Sampling protocol has been directed by experience and lab directions. CTD casts are performed according to the manufacturer's recommendation. These protocols will be documented and added to the project binder with weekly and quarterly reports.

4 Water Quality Results and Discussion

Preliminary results are discussed in the following sections with emphasis on any need for modifications to the initial program.

4.1 Fecal Coliform

Fecal coliform (FC) serves as an indicator of water quality from a human health perspective and, of course, is a main focus of the sampling program. The FC results are discussed in more detail than the other water quality parameters.

4.1.1 Preliminary Results

Fecal coliform concentrations are generally high throughout the Inner Harbour. The median FC values over the first thirteen weeks are shown in Figure 2. In general the values at 1 m are greater than those at 10 m. The exception to this is in southern Bedford Basin where the 10 m samples are almost always higher than the 1m samples. Water density data indicates that the coliform are associated with a deeper layer representative of the water in the Inner Habour, while the 1 m sample generally occurs in a slightly less dense layer likely reflecting the input of the Sackville River. This suggests that the source of the bacteria over much of the Basin is likely the Inner Harbour rather than a local source or the Mill Cove STP. At station F1 higher values periodically occur in the 1m sample than in the 10m sample. These occurrences initially appear to be associated with rainfall and may reflect the input from the CSO in Fairview Cove.

Significant variations in FC levels from week to week appear to correlate with meteorological and oceanographic phenomena. These correlations will be investigated analytically in future reports as the data base builds.

4.1.2 Criteria Exceedance

The criteria applicable to bacterial levels (14 CFU/100mL shellfish standard and 200 CFU/100 mL swimming standard) have been established by the Halifax Harbour Task Force (HHTF 1990). However, the preferred protocol for interpretation of the data with respect to this criterion has not been specified. As mentioned above, there is considerable variability in fecal coliform concentrations. As a result, the application of a criterion always involves a composite of several samples. Central tendency in bacterial data is generally expressed in terms of the median or geometric mean rather than the arithmetic mean. A protocol usually also includes a restriction on the concentration distribution over all the samples. For example a protocol which has been used is: “a median value less than 200 CFU/100mL with 90% of the samples less than 400 CFU/100mL”. The median values (Fig 2) would violate the 200 CFU/100ml criteria from the narrows (section E) to site D1 near pier A in the south end Halifax. If the 90% criterion is invoked the violation would extend further to the north, to include Site F3 in Bedford Basin and E1 in the Narrows, and in the south, to include all of Section D as well as site C6 in Eastern Passage.

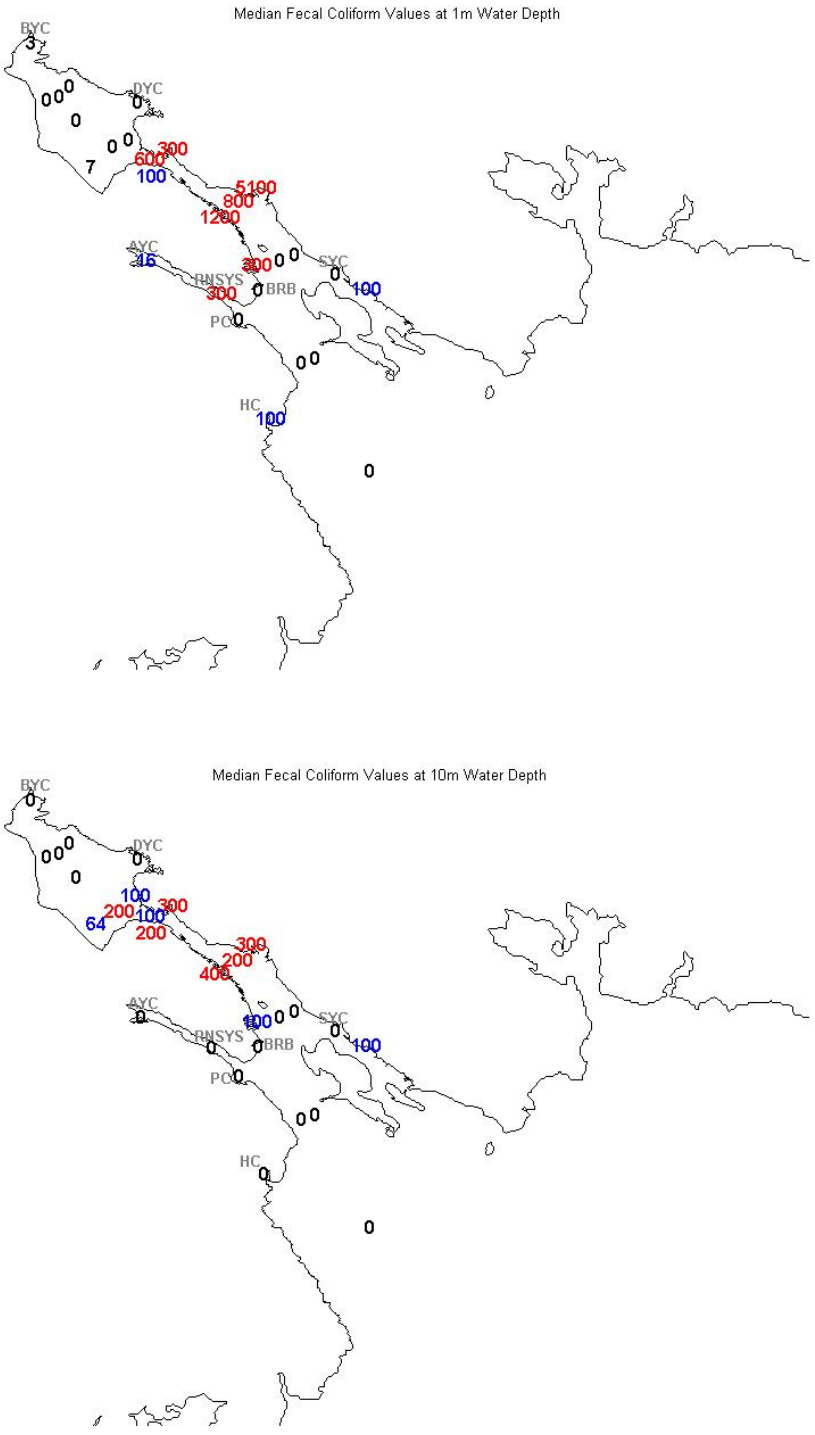

Figure 2 Fecal Coliform Median Levels (values in red exceed guidelines)

The Guidelines for Canadian Recreational Water Quality (Health and Welfare Canada 1992) recommends that for fecal coliform the geometric mean of at least 5 samples taken within 30 days should not exceed 200 CFU/100mL, and any sample with values > 400 CFU/100mL should trigger re-sampling. It is unclear what would occur if re-sampling produced a similar result i.e. GM<200 CFU/100mL with some samples exceeding 400 CFU/100mL. Presumably, some degree of judgment occurs here. If the geometric mean, rather than the median, is taken over all samples the violation region is reduced to the center of the Inner Harbour (*i.e.* the EE transect and Station E2). However, this is not a valid test under the criterion as the samples span thirteen weeks, rather than 30 days as specified in the protocol.

A relatively strict application of the GCRWQ criterion for swimming to our data can be accomplished by using a five sample floating geometric mean, since five samples occur over a 28 day period, plus or minus a day or two. This procedure would result in a weekly assessment, at three levels (acceptable, questionable and not acceptable) water quality relative to primary body contact. As an example: at the RNSYS the thirteen week median value is 300 CFU/100mL, the 13 week geometric mean is 86 CFU/100mL. The floating five week geometric mean (nine averages, allowing for the starting 4 weeks) violates the 200 CFU/100ml limit one week out of nine (not acceptable). The water quality would be deemed "acceptable" on four of the nine weeks and high counts would trigger re-sampling four of the nine weeks (questionable). While additional sampling is not an issue in our case, as re-sampling is occurring on a regular basis, the water quality in these cases could reasonably be termed "questionable". This procedure, using an established Canadian protocol, would seem to generate the most useful statistic for future evaluation of adherence to the water quality criterion.

4.1.3 Lab Resolution

The lab analysis for fecal coliform bacteria can be performed to resolve different concentrations. The analysis can resolve 0-10^4 CFU at resolutions of /ml, /10mL or /100mL. At the outset of the project, the analysis was performed at the labs standard resolution of CFU/mL, which has a full scale value of 10^4 CFU/mL (equivalent to 10^6 CFU/100mL). While this procedure resulted in no out of range values, the values of primary interest, for our purposes, are in the range 0 to 200 CFU/100mL, which is under resolved. The concentrations in this range are all represented by 0, 1, or 2 CFU/mL values. To address this, the procedure was changed to increase resolution at selected stations and subsequently to all stations. Now, all samples are analyzed at the CFU/100ml range. This analysis has a full scale concentration of 10,000 CFU/100mL and will result in periodic out of range values. Analysis of the first thirteen weeks of data indicate that 550 samples had concentrations in the 0-2 CFU/mL range, and would be under represented in the CFU/mL range, while 10 samples would be out of range in the higher resolution CFU/100mL analysis. Of these 10 occurrences, eight are along the EE transect at a depth of 1m. Further analysis indicates that these sites were also the only sites with no zero values over this period. Therefore, the near surface samples from transect EE will now be processed at the intermediate scale (CFU/10ml). This will provide sufficient resolution at lower values and would have eliminated all of the out of range values. (full scale = 10^4 CFU/10ml or 10^5 CFU/100ml) at these sites. The other

two stations with out of range values also had occurrences of zero values and will be not be processed at lower resolution. This assessment is based on summer values. Winter values are likely to be higher, so this will be reviewed on a quarterly basis.

4.1.4 Alternate Bacteria Tracers

Selection of indicator parameters for water quality has evolved since the Task Force recommendations. A summary of the use of alternative bacteria tracers, Enterococci and fecal strep, is presented below for discussion.

Enterococci:

The GCRWQ (1992) and the recent Guidelines for Safe Recreational Water Environments (WHO 2004), both recommend Enterococci as the indicator organism of choice for marine waters.

Advantages:

1. Considered best indicator of fecal contamination from warm blooded animals in marine environment (35/100 mL – 70/100 mL resample).
2. Better survivability than FC in marine waters (particularly when considerable time/distance between source and area of concern).
3. Positive correlation between gastrointestinal illness and levels of Enterococci in marine waters.
4. Less affected by chlorination, and therefore, a more conservative estimate of risk.

Disadvantages:

1. Not reflective of Halifax Harbour Task Force (1990) guidelines.
2. Not specified monitoring requirement (Public Works and Government Services Canada, 2003. Halifax Harbour Solutions Project Screening Report. Jan 2003).
3. No historical data.
4. Potentially costly.

Fecal Strep

The fecal strep analysis includes Enterococci plus additional strains including those which only occur in animals not humans. This test is not generally considered as good an indicator as Enterococci or fecal coliform. Assuming animal waste is not a concern in Halifax Harbour, fecal strep might correlate strongly with Enterococci, that is, the fecal strep in Halifax Harbour may in fact be almost all Enterococci. We would have to run both analyses and correlate. The only reason for doing this would be if analysis for fecal strep was a more economical choice than the analysis for Enterococci.

4.2 Ammonia Nitrogen

The laboratory estimated quantification level (EQL) for ammonia nitrogen is 0.05 mg/L. Overall, 42% of all samples had detectible values of ammonia. There appears to be a relatively consistent pattern with highest values in the lower samples (10 m) in the narrows and Southern Basin (Stations E2 and F2, see Table 2)). This result varies a bit from week to week but the two highest values measured (0.26 and 0.22 mg/L) have been at Site F2-10 m, while Site E2-10 m is most consistently elevated with values above EQL on six of seven surveys.

Table 3 Maximum Value of Ammonia Nitrogen (mg/L) Observed Over All Surveys (number of samples above EQL)

	B2	D2	EE2	E2	F2	G2	H2
1 m	0.05 (1)	0.09 (3)	0.11 (3)	0.14 (3)	0.07 (1)	0.06 (1)	0.1 (2)
10 m	0.08 (3)	0.06 (2)	0.09 (3)	0.14 (6)	0.26 (5)	0.12 (4)	0.09 (4)

This pattern would indicate that the observed values may not be a direct result of a sewage source of ammonia, which would tend to form a “bullseye” pattern around the major sources in the center of the Inner Harbour. Ammonia levels may be affected by sewage through more complex nutrient reactions.

4.3 Carbonaceous Biochemical Oxygen Demand

The laboratory EQL for carbonaceous biochemical oxygen demand ($CBOD_5$) is 5 mg/L. There have been no values exceeding the EQL observed in any samples. This is a parameter regularly monitored in STP effluent. Typical $CBOD_5$ levels in raw sewage are approximately 100 mg/L and the regulated end of pipe value for the Advanced Primary STPs designed for the harbour solutions project is 50 mg/L. A relatively low level of dilution is required to reduce the $CBOD_5$ in raw sewage to levels below the EQL. While most of the existing outfalls in the harbour are very low dilution outfalls, the plumes from these outfalls are unlikely to make it to the sample stations in the center of the harbour without $CBOD_5$ being diluted below detectible levels. With the high dilution outfalls designed for the STP's the discharge of treated effluent would be unlikely to exceed the EQL anywhere even under worst case situations. Based on these arguments and experience to date it is may not be necessary to continue to monitor for $CBOD_5$.

4.4 Total Suspended Solids

TSS values in Halifax Harbour are generally quite low for a coastal inlet, with typical values less than 5 mg/L. In only three of the seven surveys were values greater than 5 mg/L reported and there has been only one value greater than 10 mg/L (13.8 mg/L at site G2 on 23 June). The EQL for the analysis is 1 mg/L (or sometimes 2 mg/L if the sample is split in the lab for duplicate analysis). There were 11 of 98 samples which were below EQL. It is possible to reduce EQL to 0.5 mg/L through a modification of analysis technique.

On the whole, over this period, the TSS values tend to be higher in the surface (1 m) water than at the 10 m depth. The highest values tend to be in Bedford Basin. This pattern seems to support a planktonic source of TSS rather than a direct sewage source. There appears to be a minimum in July and August, consistent with the classic Spring/Fall bloom cycle, with a potentially lengthened Spring bloom. The interpretation of this data will be enhanced by a larger data base and correlation with chlorophyll and dissolved oxygen data.

The TSS data are presented in Table 4. Highlighted cells had values < EQL and were analyzed with EQL/2. Values over 5 mg/L are presented in red.

Table 4 Summary of TSS Data (mg/L)

1 Meter									
Survey Number	**B2**	**D2**	**EE2**	**E2**	**F2**	**G2**	**H2**	**mean**	**max**
1	2.0	2.0	1.8	2.9	0.5	13.8	2.6	3.7	13.8
3	1.6	2.4	1.6	1.2	1.0	2.6	1.2	1.7	2.6
5	0.5	2.8	2.4	1.2	1.6	2.6	2.0	1.9	2.8
7	3.4	1.6	2.4	1.6	2.4	3.8	6.4	3.1	6.4
9	1.4	1.4	2.0	3.2	4.0	3.8	4.8	2.9	4.8
11	1.0	3.7	4.0	4.4	3.6	3.3	4.4	3.5	4.4
13	1.4	3.2	3.6	5.8	4.0	4.2	6.0	4.0	6.0
mean	1.61	2.44	2.54	2.90	2.44	4.87	3.91	3.0	
max	3.4	3.7	4	5.8	4	13.8	6.4		13.8
10 Meter									
Survey Number	**B2**	**D2**	**EE2**	**E2**	**F2**	**G2**	**H2**	**mean**	**max**
1	1.6	2.8	2.4	3.0	1.4	5.8	3.1	2.9	5.8
3	1.2	0.5	2.8	1.8	3.4	1.2	0.5	1.6	3.4
5	0.5	1.8	1.6	2.0	0.5	3.0	0.5	1.4	3.0
7	2.2	0.5	1.6	2.8	0.5	1.4	1.6	1.5	2.8
9	1.0	2.2	2.4	1.8	1.0	3.0	1.4	1.8	3.0
11	2.6	2.2	2.4	3.3	1.0	3.7	4.5	2.8	3.7
13	2.0	2.0	2.6	3.2	4.6	3.6	3.8	3.1	4.6
mean	1.59	1.71	2.26	2.56	1.77	3.10	2.20	2.17	
max	2.6	2.8	2.8	3.3	4.6	5.8	4.5		5.8

4.5 Total Oils and Grease

None of the samples contained detectible concentrations of oil and grease.

4.6 Metals

There are eight metals with guidelines established by the Halifax Harbour Task Force. The metal scan analysis includes a suite of 25 metals. Mercury has a HHTF guideline but is not measured in the metal scan. In addition, two of the seven metals, copper (EQL 20µg/L, guideline 2.9 µg/L) and nickel (EQL 20 µg/L, guideline 8.3 µg/L) have EQL values greater than the guidelines so exceedances could be undetected. Of the metals with guidelines only manganese regularly has detectible values. In total, there have been 12 samples, at least one per survey, with values slightly above the EQL of 20 µg/L. The maximum value recorded was 42 µg/L, at Station H2-10 m on 22 July. The established guideline is 100 µg/L, thus no guideline was exceeded.

There have been two exceedances of the metal guidelines in the survey period. On 3 August at Station B2 both the copper and zinc criteria were exceeded. In the 1 m sample a zinc concentration of 1100 µg/L was measured, which compares with the guideline of 86 µg/L, and in the 10 m sample a copper concentration of 24 µg/L was measured. No other detectible values for these metals were recorded during this period.

For the remaining metals for which no guidelines exist boron, lithium, strontium, titanium and uranium, regularly have detectible and quite consistent concentrations across all samples and all surveys. Typical concentrations are: boron (4000 µg/L), lithium (180 µg/L) Strontium (7000 µg/L), titanium (75 µg/L), and uranium (3 µg/L).

The only additional metal to show up on the metal scan was a lone aluminum concentration of 130µg/L (EQL 100 µg/L) which occurred on 7 July.

Copper has been identified as a key metal tracer in previous studies. This is because sewage monitoring data indicates that it has the highest source concentration compared to the water quality guideline. It is therefore the most likely metal to be exceeded the criteria. That copper is under-resolved at the current EQL and the fact that metals for which guidelines exist , save manganese, are generally non-detectible, raises the issue of whether the metal scan strategy is most efficient for monitoring metal contamination.

To summarize, for the metals for which guidelines exist:

- Manganese – found in every survey and at levels 20-40% of the HHTF guideline.
- Copper – found once and exceeded the HHTF guideline (detected at present EQL > guideline).
- Zinc – found once during this period and exceeded the HHTFguideline.
- Nickel – not detected (but EQL > HHTF guideline)
- Mercury – not measured

4.7 Chlorophyll *a*

Chlorophyll *a* profile data has been collected since 7 July 04, the third weekly survey. Typical minimum values over all surveys to date are on the order of 0.40 mg/m^3 and maximum values typical of all surveys on the order of 20 mg/m^3. The main difference between surveys is the areal extent of the high concentrations. The maximum extent of high concentrations occurred during surveys 4, 5 and 6 (15 July to 28 July). In these surveys the maximum profile concentrations were on average over 20 mg/m^3 over the entire inner harbour and Bedford Basin. These concentrations appear to be highest in Week 4, where an overall maximum concentration (51 mg/m^3) was observed in the deeper water at AYC. The highest concentration of 30 mg/m^3 was measured during Week 4 in the Narrows. A rough estimate of the total chlorophyll *a* mass during these three weeks was relatively constant and approximately eight times the standing mass on subsequent weeks. The chlorophyll *a* concentration at our reference Site B2 showed a less pronounced increase during these three weeks. This site has the lowest average chlorophyll *a* concentration of all sites. In general, the average concentrations are higher in the centre of the harbour, with local maximums at the head of the Northwest Arm (AYC site), and head of Bedford Basin (BYC site).

4.8 Dissolved Oxygen

Starting with Week 6 the dissolved oxygen levels started to display relatively low levels near the surface. Closer scrutiny of the pre-cast 'soaking' data, indicated some apparent irregularities in the Dissolved Oxygen data. This is recorded while the instrument sits stationary over the side to flood the tubing in the flow circuits and to allow the sensors to come to temperature equilibrium. There was nothing unusual in the data for the other measured parameters. Subsequent investigations involving technical support from the instrument manufacturer and instrument tests in the field indicated potential flow problems through the sampling circuit. No definitive cause was found, however the irregularities in the soaking data have disappeared. This lead to the speculation that the air bleeder valve in the instrument tubing may have been partially blocked – allowing the air to bleed out but not fast enough so as to not interfere with the flow at the beginning of the casts. This problem would have been corrected by the trouble shooting procedures and its result seems to be consistent with the problem observed.

The DO data taken over this period is questionable, particularly in the near surface waters. There are further steps which could be taken to evaluate the quality of this data, generally looking closer at the soaking data and the up-cast data. This part of the data is generally discarded, but in this case could help indicate if the near surface observations are correct. The re-analysis has not been conducted. The trouble shooting could have expedited if grab samples had been taken for dissolved oxygen determination by Winkler titration.

The DO levels in the bottom water of Bedford Basin continued to decline over this period, indicating that these waters have not been renewed by upwelling over the sill in the narrows. At Site G2, the waters in the deepest part of the Basin have dropped to about 3.5 mg/L. Aside from this finding, the site that most often exhibiting depressed oxygen levels in the bottom water was at the AYC near the head of the Northwest Arm.

5 Summary and Action Items

A brief statement of summary is provided along with any changes that occurred during the quarter and action items that remain to be discussed with the Harbour Solution Project Team.

5.1 Reporting

Summary Statement – A project binder and digital archive have been established and are the essential records of the project.

Changes – Formats for weekly and quarterly reporting were developed.

Action – Documentation of sampling and analysis methods along with QA/QC procedures for inclusion in the project binder.

5.2 Sampling Program

Summary Statement – It was expected that some modification to the sampling program would occur early in the program and this has proven to be the case.

Changes – Minor changes in sampling site locations were made.

Action – Consider modification of sampling sites to include more recreational sites. Modification of analysis suite to include/improve/remove some parameters (see below).

5.3 Water Quality Parameters

Fecal Coliform

Summary Statement – FC levels are high especially in the Inner Harbour as expected. Levels are high at some recreational areas.

Changes – Analysis procedures were modified to provide higher resolution of FC levels.

Action – Consider substitution of alternate and or additional tracers.

Ammonia Nitrogen

Summary Statement – Ammonia nitrogen has detectable values in nearly half the samples.

Changes – None.

Action – Consider monitoring more nitrogen species.

CBOD

Summary Statement – Not detectable at any sampling site at the EQL of 5 mg/L.

Changes – None.

Action – Consider deleting from analysis suite.

Total Suspended Solids

Summary Statement – Measured values are low for coastal waters. About 10% below EQL of 1-2 mg/L.

Changes – None.

Action – Consider value of use of larger samples to reduce EQL to 0.5 mg/L.

Total Oils and Grease

Summary Statement – None detected.

Changes – None.

Action – Consider deleting from analysis suite.

Metals

Summary Statement – The only exceedance of the HHTF criteria was on one day at the reference site, B2. The key metal indicator, copper is under resolved by the present analysis method.

Changes – None.

Action – Consider modification of analysis suite to focus on copper with higher resolution (higher cost) analysis. Consider modification to sampling scheme to document potential metal concentrations nearshore.

Chlorophyll *a*

Summary Statement – Chlorophyll *a* levels vary spatially and temporally throughout the harbour.

Changes – None.

Action – Establish dialogue with BIO basin monitoring program to establish ground truthing.

Dissolved Oxygen

Summary Statement – Oxygen levels are likely normal in surface waters, low in the Bedford Basin and slightly depressed in upper reach of Northwest Arm (lower samples).

Changes – Additional QC procedure implemented.

Action – Establish dialogue with BIO basin monitoring program. Consider collecting samples for Winkler titration.

6 References

Halifax Harbour Task Force. 1990. Halifax Harbour Task Force Final Report. Prepared for Nova Scotia Department of Environment, R. Fournier ed.

Health and Welfare Canada. 1992. Guidelines for Canadian Recreational Water Quality.

Jordan, F. 1972. Oceanographic Data of Halifax Inlet. Bedford Institute of Oceanography Data Rep. Ser. BI-D-72-8.

JWEL and COA. 2004. Halifax Harbour Waster Quality Monitoring Program, Weekly and Quarterly Reports 2004 to 2008, report to the Halifax Regional Municipality, Harbour Solutions Project.

World Health Organization. 2004. Faecal Pollution and Water Quality. Chapter 4 in Guidelines for Safe Recreational Water Environments.