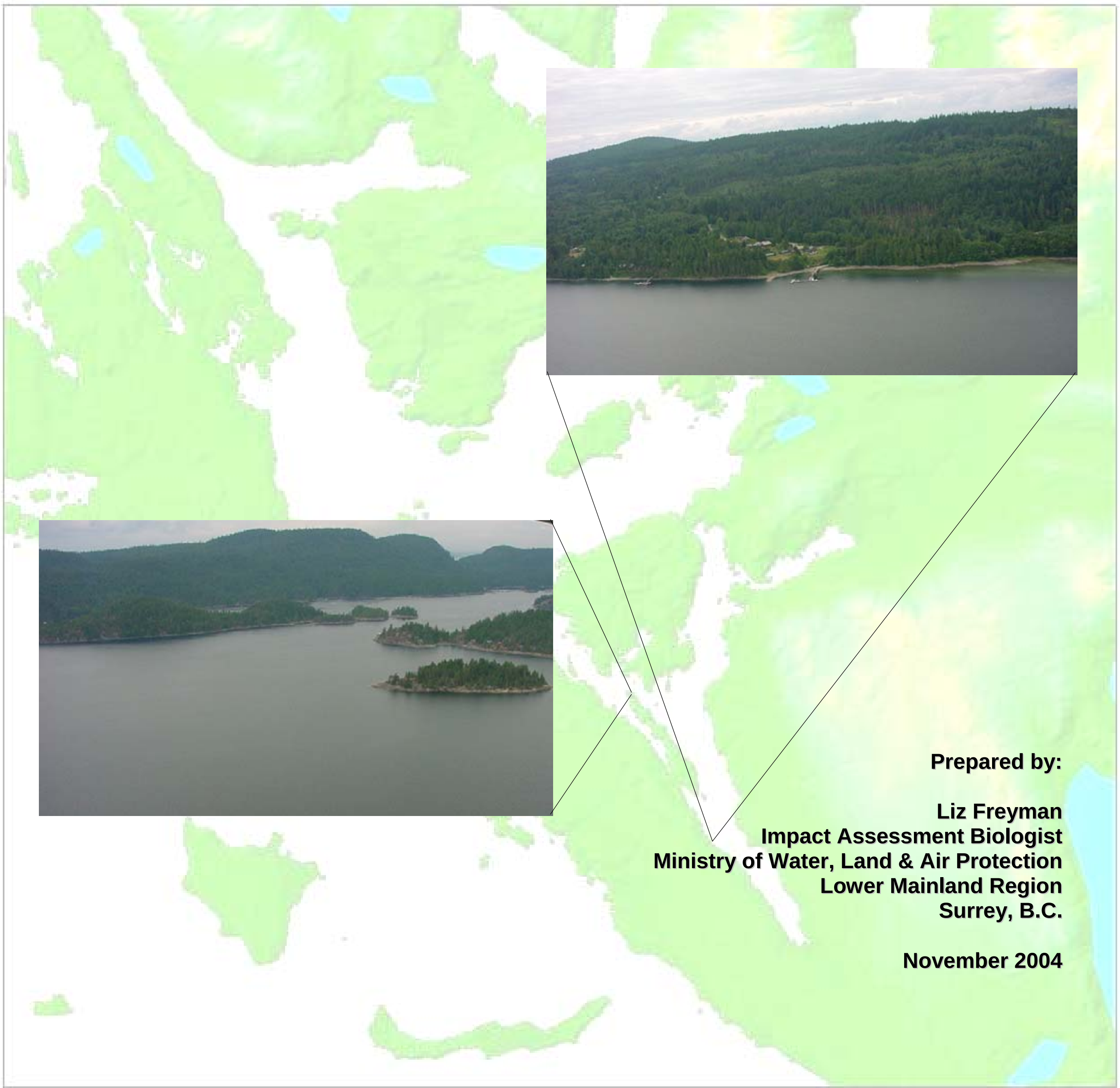
British Columbia Ministry of Water, Land and Air Protection

Lower Mainland Region

Okeover Inlet Water Quality 2001 – 2003 Interim Data Report



Prepared by:

Liz Freyman
Impact Assessment Biologist
Ministry of Water, Land & Air Protection
Lower Mainland Region
Surrey, B.C.

November 2004

Preface

This report is one in a series of water, groundwater, and air quality reports that are being issued by the Lower Mainland Regional Office in fiscal year 2004/05. It is the intention of the Regional Office to publish water, groundwater and air quality reports on our website (http://wlapwww.gov.bc.ca/sry/p2/eq/index.htm) in order to provide the information to industry and local government, other stakeholders and the public at large. By providing such information in a readily understood format, and on an ongoing basis, it is hoped that local environmental quality conditions can be better understood, and better decisions regarding water, groundwater and air quality management can be made.

Acknowledgements

The author would like to thank all the community volunteer samplers: Gary and Shirley Parkinson, Linda Syms, Jeanie Momberg, the late Jeff Shuster, Jerry and Joanne. The assistance of the Sliammon Treaty Society staff with timely sample delivery to the courier and analytical lab is greatly appreciated. Also thanks to the Okeover Round Table members for support and encouragement.

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Background

The Desolation Sound area including Okeover and Lancelot inlets, is a unique marine ecosystem. The area has high valued fish and wildlife habitat and supports multiple resource uses such as mariculture, forestry, pleasure boating, kayaking, fishing and residential/commercial development.

The mariculture industry in Okeover Inlet produces oysters, mussels and other shellfish for the B.C. and export markets. Due to the relatively clean water quality in the Inlet, there are currently no shellfish closures in the mariculture growing areas except for a small area in Freke Anchorage (see Figure 1 Map). Pollution from non-point sources, however, such as upland residential development and recreational boating, threaten to negatively affect water quality. This could eventually lead to increased environmental impacts such as more frequent or widespread shellfish harvesting closures.

Mariculture Operation

This has occurred in other marine waterbodies such as Puget Sound where non-point source pollution is the most common cause of shellfish harvesting restrictions. In the United States as a whole, shellfish closures attributed to non-point sources of pollution have increased, while closures related to industrial and municipal point sources have decreased (Glasoe and Christy, 2004).

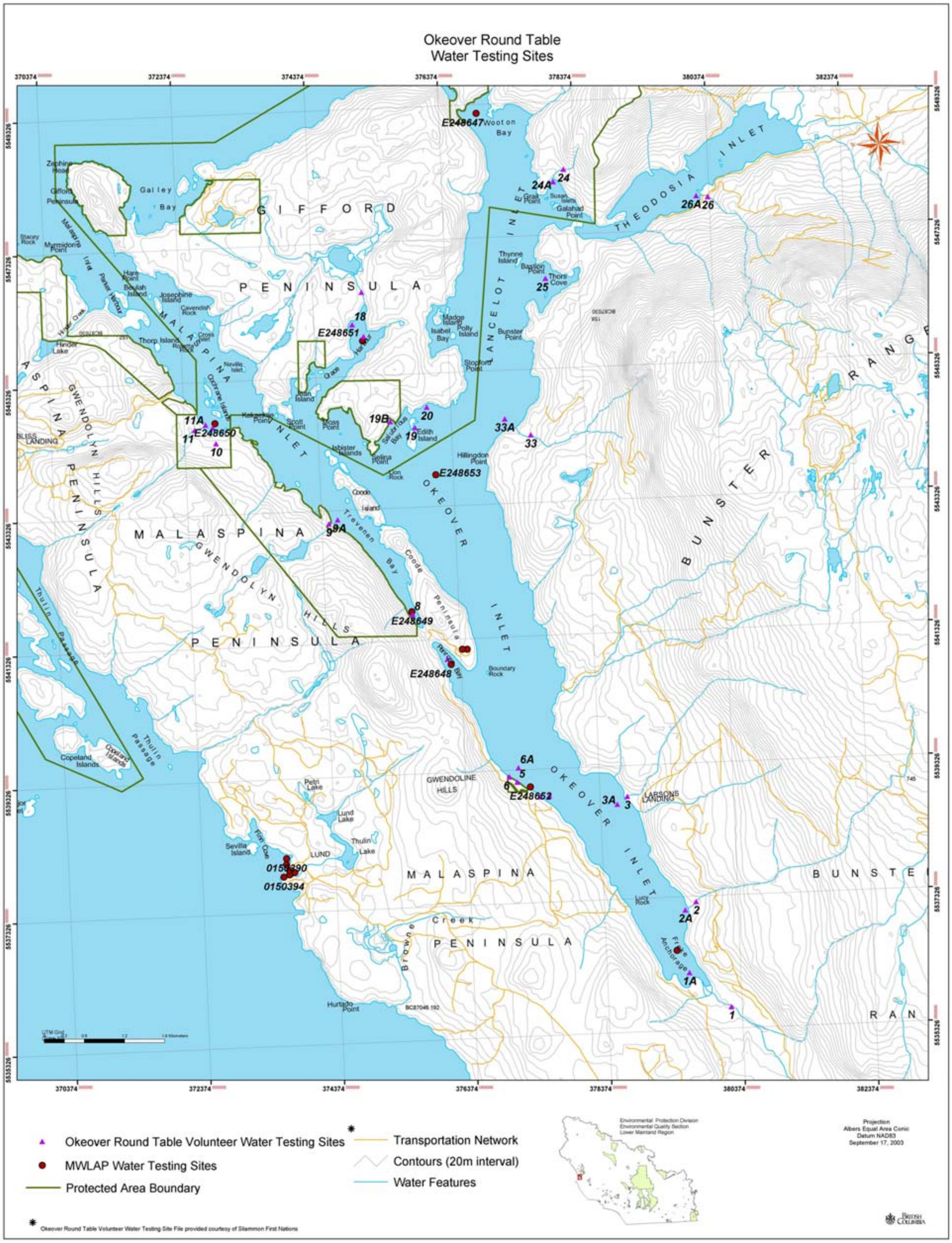
Currently no land use or official community plan exists for the Okeover Inlet area, however, a Malaspina Okeover Coastal Plan has just been completed by the Ministry of Sustainable Resource Management (MSRM) for coastal and foreshore areas (Ministry of Sustainable Resource Management, 2003). In addition, the Regional District of Powell River (RDPR) and the Sliammon First Nations have partnered with community stakeholders and other levels of government to form the Okeover Round Table. The main goals of the Okeover Round Table are to protect, maintain and improve fresh and marine water quality in the Okeover, Malaspina, Lancelot and Theodosia inlets and upland areas.

The Okeover Round Table is a venue for members to identify problems and propose solutions by providing advice to local government, and Provincial and Federal agencies. The Round Table is also a venue to encourage local stewardship activities.

The Ministry of Water, Land and Air Protection's role within the Round Table is to support stewardship activities and to monitor and report on water quality. MWLAP also has a mandate to set site-specific water quality objectives for certain water uses and plans to set Water Quality Objectives for Okeover Inlet in the near future. These Objectives would provide local decision makers with local water quality target levels.

One of the Round Table stewardship projects was water quality monitoring of marine and fresh waters in the Okeover Inlet area watershed in 2001, 2002 and 2003. Water quality information is intended to guide future efforts to prevent contamination of Okeover Inlet area waters. This report summarizes the data collected from 2001 to 2003.

FIGURE 1: OKEOVER INLET MONITORING LOCATIONS



1.2 Objectives

The goals of water quality monitoring in Okeover Inlet are:

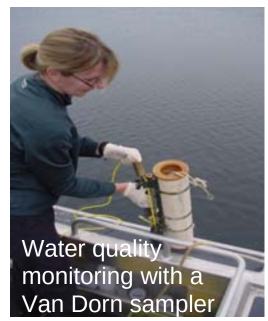
- To determine the present environmental conditions in Okeover Inlet utilizing marine water and sediment quality as indicators,
- To determine the quality of surface fresh water runoff from upland areas in order to understand the potential sources of non-point source pollution to marine water,
- To provide environmental information to the RDPR, Sliammon First Nations, Coast Garibaldi Health Authority, community groups and residents with a long-term goal of providing water quality objectives as target levels for local water and land use decision makers.

Ultimately, the Ministry would like to see land and water use planning used as a tool to prevent environmental degradation of local natural resources.

2.0 METHODOLOGY

2.1 Monitoring Program

Marine water quality monitoring was conducted to characterize the current conditions in Okeover Inlet. The monitoring parameters chosen are typical indicators of non-point sources of pollution. The majority of non-point source pollution to Okeover Inlet is from numerous, small sources of sewage-related discharges and land run-off. These could come from boaters or from upland sources such as sub-surface flows from on-site sewage systems. Fecal coliform and E.Coli are known water quality indicators of sewage pollution as they are found primarily in the intestinal tract of warm blooded animals. Marine water nutrients and metals are also indicators of non-point source pollution from anthropogenic upland and marine use activities.



Water quality monitoring with a Van Dorn sampler

Marine water quality monitoring locations were chosen in areas where some pollution may be expected and in reference control areas where pollution would not be expected.

Sediments are also a good monitoring media since many contaminants adsorb to particulates and deposit with bottom sediment. Sediment metals and polycyclic aromatic hydrocarbon (PAHs) are indicators of combustion engine use and can provide an indication of whether the level of anthropogenic activities is causing these contaminants to accumulate in bottom sediments. Potential sources of PAHs into Okeover Inlet are boats, generators or vehicle parking lot run-off. Sediments were also sampled for phthalate esters in locations where plastic drums were used as floats. Phthalate esters are compounds found in plastic and have recently been found to have potential environmental impacts at higher levels.

The six sediment sites were chosen to generally characterize the various water uses in Okeover Inlet: pleasure boat anchorage (Grace Harbour), mariculture operations (Trevenen Bay and Freke Anchorage), residential development (Penrose Bay) and a relatively pristine location (Wootton Bay). The Okeover Central sediment sampling station was the deepest site at approximately 80 metres. This inner basin within Malaspina and Okeover Inlet can be a sediment depositional area and therefore, may be a potential contaminant sink.

2.2 Field Methodology

Marine water and sediment sampling was conducted by WLAP in July 2002 and 2003. In 2001 and 2002, however, community volunteers coordinated by the Sliammon Treaty Society, collected fresh and marine water bacteriology samples from the Inlet area. Data collection in 2001 was limited and therefore, this report will focus more heavily on the 2002 and 2003 data. Water quality monitoring locations conducted by all parties are shown in Figure 1: *Okeover Roundtable Water Testing Sites.*

2.2.1 Marine Water

Limited marine water sampling in 2001 was conducted on May 10, 2001. Community volunteer samplers collected marine water samples for bacteriological analysis at 19 different sites on four dates. (see Figure 1 map showing volunteer water testing sites).

In 2002 and 2003 the MWLAP collected marine water samples five times in 14 days at eight locations. The monitoring sites include: Penrose Bay, Wootton Bay, Freke Anchorage, Grace Harbour, Okeover Central (near Lions Rock), at the Government Wharf, Cochrane Bay and Trevenen Bay. Field measurements included water temperature, dissolved oxygen and salinity. Samples were collected and sent to the lab for analyses for total metals (low level ICP-MS), nutrients and bacteriological indicators.

2.2.2 Marine Sediments

Marine sediments were collected in 2002 and 2003 at six stations: Trevenen Bay, Wootton Bay, Okeover Central (near Lion Rock), Grace Harbour, Penrose Bay and Freke Anchorage. Three replicate samples per sediment station were collected. Monitoring parameters included: particle size, organic/inorganic carbon, metals and bacteriology. Phthalate esters were collected at Trevenen and Wootton Bays as well as at the Okeover Central site. Polycyclic Aromatic Hydrocarbons (PAHs) were collected at Grace Harbour and Wootton Bay.

2.2.3 Fresh water

Volunteer samplers collected fresh water samples for bacteriological analyses from streams which discharge into Okeover Inlet (see Figure 1 Map). Samples were collected four times in 2001, six times in 2002 and 10 times in 2003/2004.

2.3 Quality Assurance/ Quality Control

Blind field replicates were collected to ensure field collection reproducibility and precision. Field blanks were used to ensure no contamination of sample bottles occurred during sampling. All water samples were collected directly into sample containers. All samples were kept on ice during sampling and shipping to analytical laboratories

Trevenen Bay sediment with a sculpin by-catch

A volunteer coordinator was given sampling procedures by WLAP who then organized community volunteers and provided basic sampling instructions.

Laboratory QA/QC included duplicates, spiked summaries and blanks.

Grab sampling in general, provides a 'snapshot' of water quality information at a certain time. While inferences can be made from repeated grab sampling over a designated time period, it is important to note that localized water quality changes, especially to freshwater drainages, can be short-lived and therefore not represented in the sample data set. For example, storm events can have significant but short-lived impacts to a local stream and those impacts would not be detected with a grab sample regime unless timed perfectly.

2.4 Data assessment

Wootton Bay Sediment

Bacteriological data results are inherently variable and several sample results per monitoring station are needed in order to make the data meaningful. Water quality guidleines for bacteriological parameters require the geometric mean and the median of the data for comparison to standards. Thus it is important to rely on several samples from each monitoring station for interpretation. Two standards exist for bacteriology: one for shellfish harvesting (for the protection of humans consuming shellfish) and the second for primary-contact recreation. Primary-contact recreation is defined as activities where a person would have direct contact with water over most of the body's surface or where there is substantial risk of ingestion or intimate contact with eyes, ears, nose, mouth or groin. The guidelines are shown in Table 1 below.

Table 1: Summary of Water Quality Guidelines for Microbial Indicators (MWLAP 2001)

Microbial Indicator	**Aquatic Life – Shellfish harvesting**	**Primary-contact Recreation**
Enterococci	*4/100mL median*	*20/100mL geometric mean*
Fecal Coliforms	*14/100mL median and <10% of samples should not exceed 43/100mL*	*200/100mL geometric mean*

Shellfish classification is a federal responsibility and more detailed information can be obtained from http://www.inspection.gc.ca/english/anima/fispoi/manman/cssppccsm/toctdme.shtml. Shellfish closure information can be viewed at: http://www.pac.dfo-mpo.gc.ca/ops/fm/shellfish/biotoxins/closures/sanitary_e.htm.

The international (Canada/U.S.) standard for shellfish growing areas may be designated as *Approved* when the following conditions set forth in the Canadian Shellfish Program (CSSP) Manual of Operations are met:

- The area is not contaminated with fecal material, poisonous or deleterious substances or marine biotoxins to the extent that consumption of the shellfish might be hazardous; and
- the median or geometric mean fecal coliform MPN (most probable number) of the water does not exceed 14/100mL, and not more than 10% of the samples exceed a fecal coliform MPN of 43/100mL.

Sediment quality was determined by comparing sediment chemistry to the Canadian Environmental Quality Guidelines set by the Canadian Council for Ministers of the Environment (CCME). These guidelines use two tiers for sediment chemistry assessment. The interim marine sediment quality guideline (ISQG) is the highest contaminant concentration at which impacts to sediment dwelling organisms are unlikely to occur. The probable effects level (PEL) is the contaminant guideline concentration at which impacts to sediment dwelling organisms are probably or likely to occur.

Shellfish harvesting in Freke Anchorage

3.0 RESULTS AND DISCUSSION

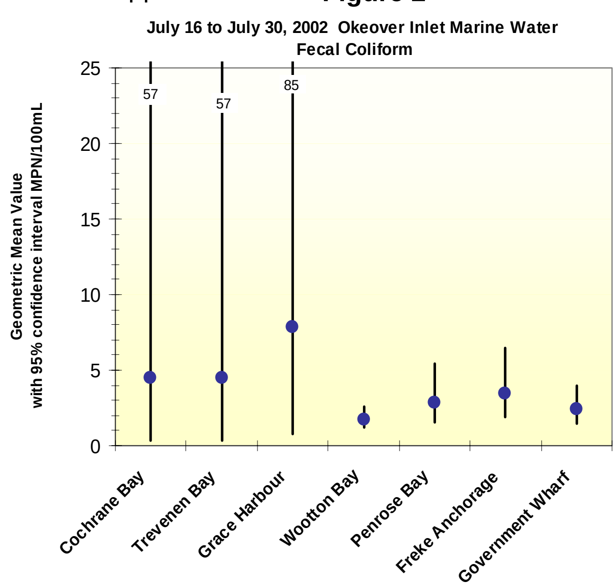
Water quality and rainfall data are depicted in the figures, tables and Appendix.

3.1 Marine Water and Sediment

In Okeover Inlet, where the extent of land development within the watershed as a whole is relatively minimal, bacteriological levels in marine waters and sediment are expected to be relatively low. In addition, marine waters are not a good environment for pathogen survival. Within hours of exposure to the saline marine environment, there is significant microbial die-off. The majority of data was collected during the summer months when bacteriological levels are expected to be highest due to the increased number of people present at that time of year.

Microbial indicator results for Okeover Inlet in 2002, 2003 and 2004 were similar among years, showing generally good marine water quality at most monitoring sites. Note that 2004 marine water quality bacteriological data only is included in this report. Data

Figure 2



from 2001 are very limited and this report relies mainly on the two subsequent years of data results (see Tables 2 – 7 and Volunteer data in the Appendix and Figures 2 - 6 showing the geometric means and confidence intervals).

Freke Anchorage enterococci levels were generally at or below detection limits for both 2001 and 2002. Marine water fecal coliforms had a geometric mean of 23 MPN/100mL in 2002; well below the primary-contact recreation guideline of 200 MPN/100mL. Median fecal coliform levels in 2002 were 26 MPN/100mL and exceeded the shellfish harvesting guideline of 14 MPN/100mL. Fecal coliform data in July 2003 and August 2004 showed few detectable levels. Data in 2004 appeared more variable but not significantly different from previous years (see Figures 2, 4 & 5). Freke Anchorage is currently the only area of Okeover Inlet with a shellfish harvesting closure. Potential sources of bacteriological contamination to Freke Anchorage are currently unknown.

Marine water and sediment chemistry data were also collected in Freke Anchorage. Marine water nutrients and metals and sediment metals concentrations are all below Provincial guideline levels for metals or expected ambient levels for nutrients, indicating very little to no impacts from related anthropogenic activities in Freke Anchorage. Sediment chemistry results show slight exceedences of arsenic and cadmium guidelines in 2002 but not in 2003.

Penrose Bay bacteriological data for 2002, 2003 and 2004 were below shellfish harvesting and recreational water quality guidelines. Marine water and sediment chemistry data were also collected in Penrose Bay. Marine water nutrients and metals and sediment metals are all below guideline levels for metals and expected ambient levels for nutrients, indicating very little to no evidence of anthropogenic influence. Penrose Bay is one of the "busier" areas of Okeover Inlet with relatively higher levels of upland development than other parts of the Inlet.

Marine waters adjacent to the **Government Wharf** were sampled. The Wharf is at the end of the main access road to Okeover Inlet and as a result has the highest amount of recreational and commercial traffic. Marine water bacteriological levels for 2002, 2003 and 2004 were below the shellfish harvesting and recreational guidelines. Fecal coliform data in 2004, however, were highly variable with a slightly higher geometric mean of 9 MPN/100mL. Marine water nutrients and metals are all below Provincial guideline levels for metals or expected ambient levels for nutrients except for cadmium which had a mean concentration of 0.2 µg/L which slightly exceeds the Provincial water quality guideline for cadmium of 0.1 µg/L.

Grace Harbour is a popular marine anchorage and kayak campsite in the summer. Potential sources of contaminants to Grace Harbour are wastes from boating and camping activities. Marine water bacteriology data showed fecal coliform levels slightly above detection limits but no exceedences of either the shellfish harvesting or the primary-contact recreation guidelines. Occasional individual high counts result in higher variability in the data confidence intervals (see Figures 2 & 4). Due to summer

Figure 3

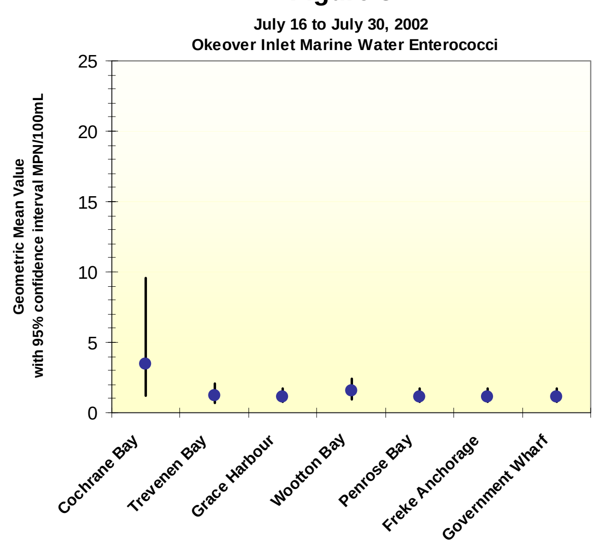
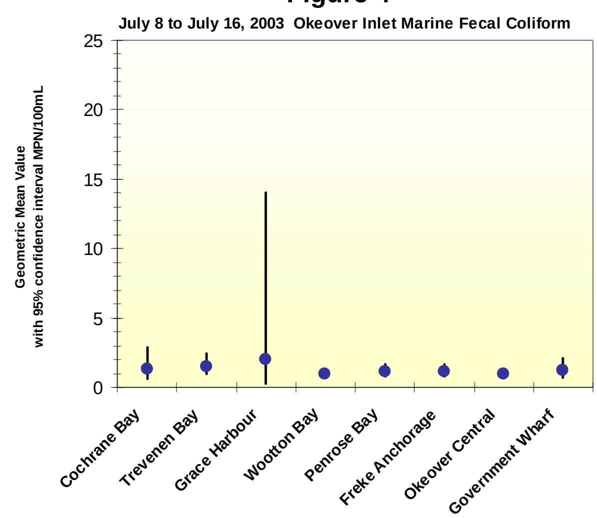


Figure 4

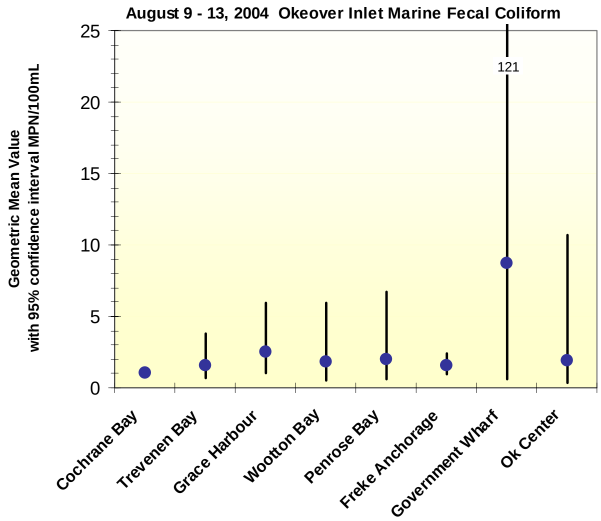


boating traffic, Grace Harbour has a seasonal shellfish harvesting closure (May 31 – Sept.30).

Marine water nutrients and metals, and metals in sediments are all below Provincial water quality guideline levels for metals or expected ambient levels for nutrients. Sediment phthalate esters and PAHs were all below laboratory detection limits. All sediment metals were below guideline levels except for cadmium at 0.96 µg/g in 2002 and 0.99 µg/g in 2003 which are above the ISQG of 0.68 µg/g. It has been suggested that higher levels of cadmium may be naturally occurring in the Strait of Georgia due to local mineral geology and sediment transport (Kruzynski, 2000).

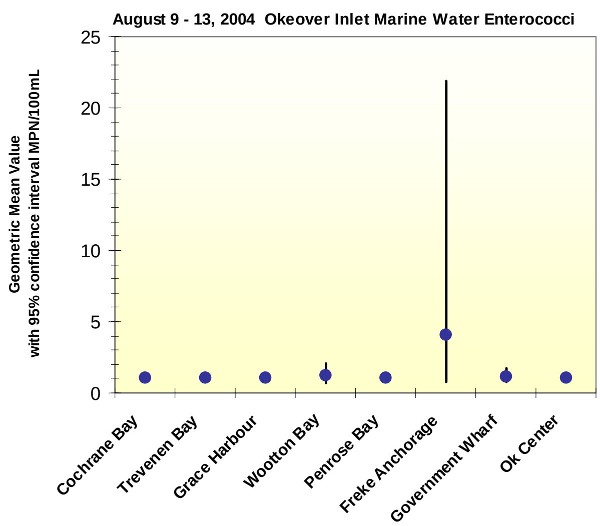
A deep water station (**Okeover Central**) was located south from Lion Rock to examine whether this area could be a sediment contaminant sink for the overall Inlet. This monitoring site is relatively far from upland influences compared to the other monitoring stations. Marine water bacteriology at Okeover Central was mainly at or below detection limits. Sediment metals levels exceeded the ISQG guidelines for arsenic, cadmium and copper for both 2002 and 2003. The sediment cadmium level in 2003, in fact, slightly exceeded the PEL guideline level. One sediment PAH (Napthalene) exceeded the ISQG guideline in 2003. The sediment at Okeover Central had a fine-textured particle size which can be associated with higher contaminant concentrations due to larger sediment particle surface area for contaminant adsorption. This sediment also had a significantly higher total organic carbon content than the other sediment stations which contributes to contaminant absorption.

Figure 5



Most of the other monitoring locations had very low marine water bacteriology levels overall. Possible exceptions to this trend are **Grail Point** and **Theodosia Inlet** which both had slightly elevated fecal coliform and to a lesser extent, enterococci levels. No bacteriology results from either site exceeds the shellfish harvesting or recreational guidelines. Neither Grail Point nor Theodosia Inlet have residential development or high volume recreational traffic so these elevated bacteriology levels may be due to wildlife. For the remaining data, see Tables 2 & 3 and Volunteer Data in the Appendix.

Figure 6



In summary, most Okeover area marine water monitoring sites had relatively low marine bacteriological levels indicating good water quality. The data appears to suggest that heavier recreational use of Grace Harbour during the summer season may be resulting in slightly higher water column bacteriology levels. The volunteer data which spans a longer time frame indicates that Freke Anchorage marine fecal coliform levels can periodically exceed the shellfish harvesting guideline.

Sediment chemistry results for 2002 and 2003, indicate generally low levels of contaminants of concern at most stations, and do not exceed guideline levels at which impacts to sediment dwelling organisms are probably or likely to occur. A few locations, however, had sediment metals concentrations that exceeded the Interim marine sediment quality guideline (ISQG) in both years. Higher levels of cadmium may be naturally occurring in the Strait of Georgia due to local mineral geology and sediment transport (Kruzynski, 2000).

With increased recreational use, mariculture and upland development, marine sediments can be used to track many contaminant inputs into Okeover Inlet over time.

3.2 Fresh Water Quality

Microorganisms can be discharged to marine waters from a variety of pollution sources along three main pathways: i) direct discharges from sewage outfalls, boaters and other sources, ii) subsurface flows from such sources as on-site sewage systems, and iii) overland flows such as stormwater runoff and stream flows. Bacteriological loadings to marine waters tend to correlate with the level of land uses (Glasoe and Christy, 2004). Fresh water bacteriological monitoring can therefore provide an early indication of potential upland contaminant sources to marine waters.

Freshwater bacteriology monitoring was conducted by community volunteers from 2001 to 2004. Data in 2001 was limited to four sampling occasions and therefore difficult to assess due to the small sample size. A large sample size is needed due to the inherent variability of bacteriological data and to calculate geometric means for comparison to guidelines. The sample size was increased to six in 2002 and to eleven sampling occasions in 2003 and 2004. While freshwater streams do not themselves support shellfish habitat, stream flows often discharge into shellfish habitat. Most freshwater monitoring stations had very low levels of fecal coliforms and enterococci. The monitoring sites with the highest bacteriological concentrations found are discussed below.

The **Freke Anchorage** freshwater drainage bacteriological levels were found to be relatively low in 2001 with enterococci levels between 6 – 81 CFU/100mL and fecal coliform levels between 9 – 35 CFU/100mL from four sampling occasions during the summer. In 2002, the freshwater drainage into Freke Anchorage was found to have a fecal coliform geometric mean of 79.5 CFU/100mL and an enterococci geometric mean of 70.9 CFU/100mL based on six sampling days between May and December. In 2003, bacteriological sampling was conducted between November 2003 and February 2004. The fecal coliform and enterococci concentrations were very low

Figure 7

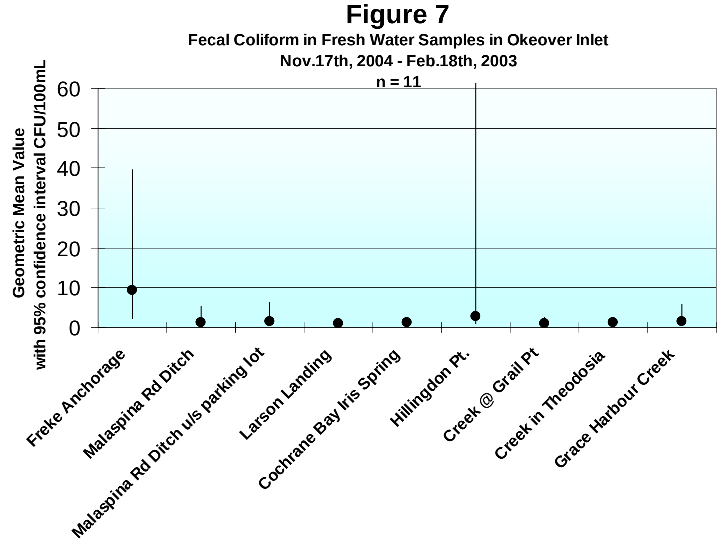
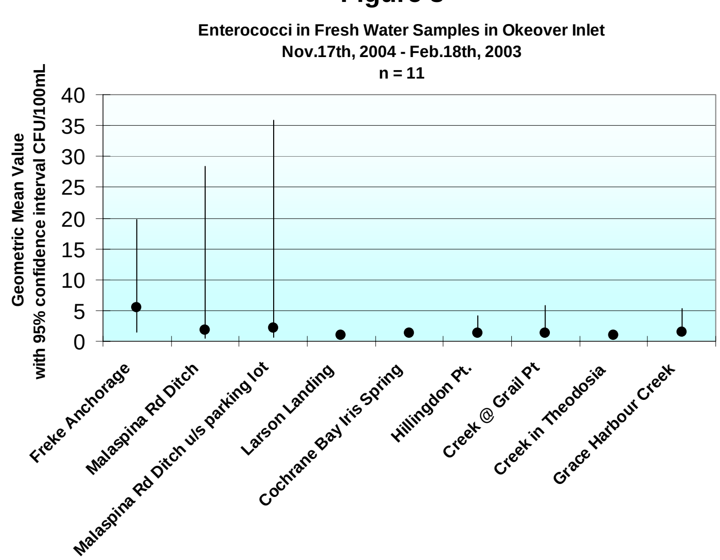


Figure 8



with a geometric mean of 9.3 CFU/100mL and 5.4 CFU/100mL respectively. Data from 2003/04 were collected during late fall and winter and had overall lower bacteriological levels than data collected during the summer in 2002. This could be due to higher rainfall in the fall and winter contributing to a dilution effect and less recreational activities. Freshwater monitoring conducted in 2004 shows consistently at all sites that enterococci and fecal coliform levels are lower in November/December than August/September (see the last table in the Appendix: Volunteer Monitoring 2004). As a result the geometric mean for enterococci in 2004 was 34.0 cfu/100mL and 78.7 cfu/100mL for fecal coliforms (see Figures 9 &10).

The creek discharging adjacent to the Government Wharf (also called **Malaspina Road ditch**) tended to have slightly elevated bacteriological levels. The 2002 fecal coliform and enterococci geometric means were 175.6 CFU/100mL and 157.4 CFU/100mL respectively. The 2003/04 fecal coliform and enterococci geometric means were 1.3 CFU/100mL and 1.9 CFU/100mL respectively and significantly lower than the previous year. An additional new monitoring station was added in 2003 further upstream (approximately 200m upstream) in the same drainage and showed no significant differences in bacteriological concentrations from the downstream site. A new sampling site added in September 2004, located adjacent to the Malaspina Road Ditch immediately downstream a restaurant facility, showed elevated freshwater bacteriological levels especially in September and October. The bacteriological concentrations at this site mirrored the other monitoring sites where the concentrations decreased with time between September to December, 2004. Flow volumes would be needed to fully characterize the significance of any bacteriological loadings from this site.

Figure 9

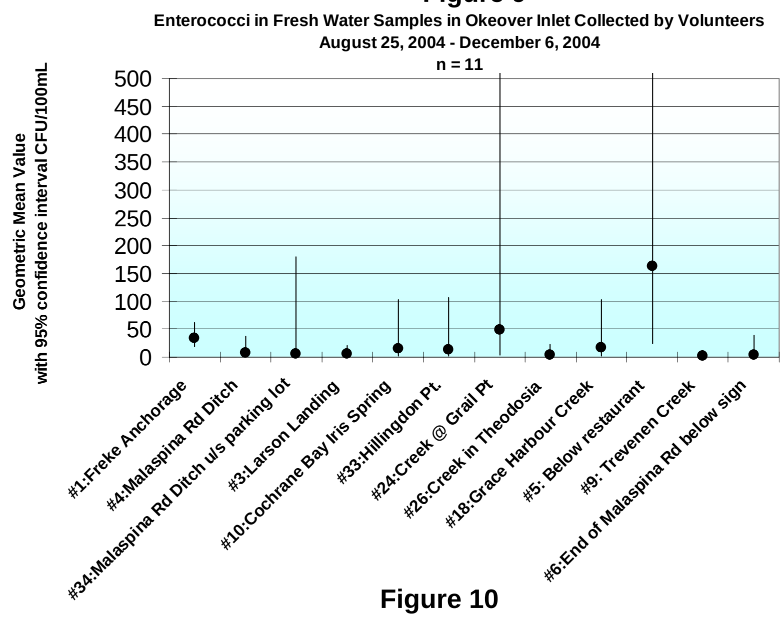
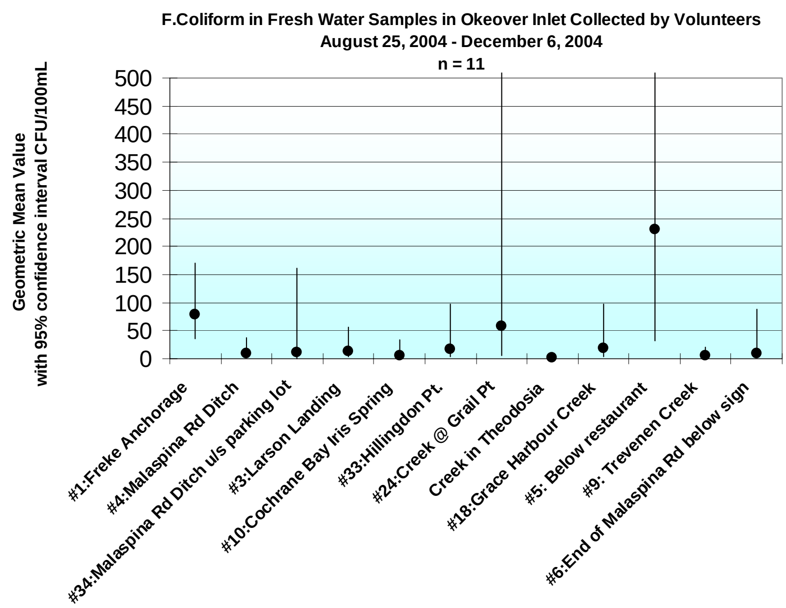


Figure 10



The creek discharging into **Grace Harbour** had 2002 fecal coliform and enterococci geometric mean levels that were relatively low at 43.1 CFU/100mL and 45.4 CFU/100/mL respectively with the majority of the samples collected during the summer. Samples in 2003 were collected during the late fall and winter and had significantly lower geometric means at less than 2 CFU/100mL for both bacteriological parameters. Since the majority of bacteriological sources of contamination to Grace Harbour are likely from marine vessels anchored during the summer months, it is expected that freshwater bacterial contamination sources to Grace Harbour are minimal during other times of the year. In August, 2004, this site had one elevated enterococci and fecal coliform result but the geometric means were

16.0 cfu/100mL and 19.1 cfu/100mL respectively. This data shows how seasonally variable the freshwater bacteriological concentrations can be.

Freshwater bacteriological data from **Grail Point** was found to be relatively elevated in 2002 and 2004. The fecal coliform geometric mean was 128.7 CFU/100mL and enterococci geometric mean was 91.9 CFU/100mL. There are no identifiable bacteriological sources in the immediate area. The presence of wildlife, such as deer, river otter or bear can contribute to positive microbial indicator results.

While freshwater bacteriological data between 2001 and 2004 are very limited, the results indicate that slightly higher bacteriological concentrations are expected during dry (summer) periods than during the wetter winter periods. This is probably due to heavier summer traffic and anthropogenic activities coinciding with lower rainfall and thus, lower dilution rates.

Typical bacteriological levels from urban stormwater can reach much higher levels than those found in Okeover Inlet. For comparison, typical stormwater from urbanized watersheds can have mean fecal coliform concentrations ranging from 5,000 to 22,000 MPN/100mL with large variability at individual sampling sites (Glasoe and Christy, 2004). In addition, freshwater bacteriological loadings data are needed to fully characterize the degree of contamination risk from the various freshwater drainages to Okeover Inlet.

Overall, the fresh water drainages with higher microbial indicator levels coincide with areas of higher anthropogenic activity such as recreational marine anchorages (Grace Harbour) and residential/commercial development along Malaspina Road. While it is difficult to determine the specific sources without investigating further upstream, data from other jurisdictions has shown strong correlations between bacterial levels in receiving waters, on-site septic densities and run-off from impervious surfaces such as parking lots and roads (Duda and Cromartie, 1982). Once land has been built upon it is prohibitively difficult and costly to reverse. It is, therefore, extremely important to proactively plan land use in order to protect marine and freshwater resources.

4.0 SUMMARY

In general, Okeover Inlet marine water quality is good. The marine water quality data suggest occasional elevated bacteriological indicator levels occur in Freke Anchorage, near the government wharf and, at times, in Grace Harbour. Freshwater quality monitoring conducted by volunteers has shown similar observations at these same locations. These data are consistent with the shellfish harvesting closure areas for Okeover Inlet. Additional data on bacterial loadings from freshwater creeks and drainages would help quantify where the largest sources of contamination to Okeover Inlet are occurring and therefore, help target preventative solutions to further degradation. Many other jurisdictions, however, have abundant information on the effects of land use/development and how to avoid impacts to water quality (Glasoe and Christy, 2004 and EPA 2004). Therefore, effective preventative measures could be initiated immediately to protect the integrity of Okeover Inlet water quality.

Research in other jurisdictions has shown the importance of limited impervious surface area and intact vegetation for mitigating microbial contamination of coastal waters (Glasoe and Christy, 2004). Shellfish growing areas can be degraded at very low levels of upland development, especially if there is high connectivity between pollution sources and receiving waters through surface water channeling and ditching to reduce rainfall retention times. Therefore the best preventative step would be land use planning by local jurisdictions (Regional District of Powell River and the Sliammon Nation). Other efforts that can be effective at reducing contaminants into waterways are raising awareness through local landowner contact or distributing information to visitors such as the clean boating guide.

The environmental effects of increased upland development are irreversible. Degraded water quality is extremely difficult to reverse as experienced in various Puget Sound locations and in Baynes Sound, B.C., where a significant effort and resources were expended to mitigate degraded shellfish growing waters.

5.0 CONCLUSIONS

- Sampling in 2001, 2002 and 2003 indicates that Okeover Inlet marine water quality is generally good. The areas with some elevated bacteriological indicator levels are Freke Anchorage, near the government wharf and, at times, Grace Harbour.
- Fresh water samples collected at various drainages flowing into the Okeover watershed show the presence of microbiological indicators at the end of Malaspina Road and the drainage into Freke Anchorage.

6.0 RECOMMENDATIONS

That the community and the Okeover Round Table work together on preventative solutions to minimize discharges from non-point sources of pollution into marine and fresh waters of Okeover Inlet in order to maintain good water quality. Some specific recommended action items are:

Short-Term:

- Landowner contact to encourage best management practices for septic systems and other land use activities.
- More obvious and larger signage prohibiting sewage discharges from boats especially in Grace Harbour.
- Continue to distribute clean boating guide to visiting boaters.
- Obtain “no discharge” status for the entire Malaspina Inlet under the *Pleasure and Non-pleasure Craft Pollution Prevention Regulation* under Transport Canada.
- Enforcement of the *Pleasure and Non-pleasure Craft Pollution Prevention Regulation* is needed to properly address the potential impacts of vessels to marine water quality.

Long-Term:

- Land use planning in the entire Okeover Inlet watershed as recommended in the *Malaspina Okeover Coastal Plan,* needs to be initiated. Solid and liquid waste plans need to be included in any land use planning process.
- Delineation of riparian zones around freshwater drainages into Malaspina/Okeover inlets and sensitive marine foreshore areas should be designated and protected to retain the integrity and function of freshwater discharges to marine water in Okeover Inlet.

“*There is no replacement for sound land use planning and personal stewardship that recognize and preserve the inherent qualities of natural systems for buffering impacts and preserving clean water and healthy aquatic habitats*”

from: *Coastal Urbanization and Microbial Contamination of Shellfish Growing Areas* by Glasoe and Christy, 2004 unpublished, Puget Sound Action Team, Washington.

6.0 REFERENCES

Canadian Council of Ministers of the Environment, 1998. *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life*. Guidelines and Standards Division, Environment Canada, Ottawa.

Duda, A.M. and K.D. Cromartie. 1982. Coastal Pollution from Septic Tank Drainfields. *Journal of the Environmental Engineering Division, American Society of Civil Engineers.* 108(6):1265-1279.

Environmental Protection Agency, May 2004. *Protecting Water Resources with Smart Growth*. EPA 231-R-04-002. www.epa.gov/smartgrowth.

Environment Canada, 2002. *Phthalate Esters in Harbour Areas of South Coastal British Columbia.* Regional Program Report 02-04. Environmental Protection Branch, Pacific and Yukon Region.

Fisheries and Oceans Canada, 2004. Shellfish Contamination – Pacific Region. http://www.pac.dfo-mpo.gc.ca/ops/fm/shellfish/Biotoxins/closures/area15/area_15_e.htm

Glasoe. S. and A. Christy. 2004 unpublished. *Coastal Urbanization and Microbial Contamination of Shellfish Growing Areas.* Puget Sound Action Team, Olympia, WA.

Kruzynski, G. 2000. *Cadmium in BC farmed oysters: A review of available data, potential sources, research needs and possible mitigation strategies.* Fisheries and Oceans Canada, Marine Environment and Habitat Science Division, Sydney.

Mallin, M.A., S.H. Ensign, M.R. McIver, G.C. Shank, and P.K. Fowler. 2001. Demographic, Landscape and Meteorological Factors Controlling the Microbial Pollution of Coastal Waters. *Hydrobiologia*. 460:185-193.

Mallin, M.A., K.E. Williams, E.C. Esham and R.P. Lowe. 200a. Effect of Human Development on Bacteriological Water Quality in Coastal Watersheds. *Ecological Applications*.10(4):1047-1056.

Ministry of Water, Land and Air Protection Home Page, "Protecting BC Waters from Boat Sewage Discharge - An Update".

Ministry of Environment, Lands and Parks, 1998. *Water Quality Criteria and Technical Appendix for Microbiological Indicators*. Resource Quality Section, Water Management Branch, Victoria

Ministry of Sustainable Resource Management, 2003. *The Malaspina Okeover Coastal Plan.* Coast and Marine Planning Branch, Victoria.

FIGURES AND TABLES

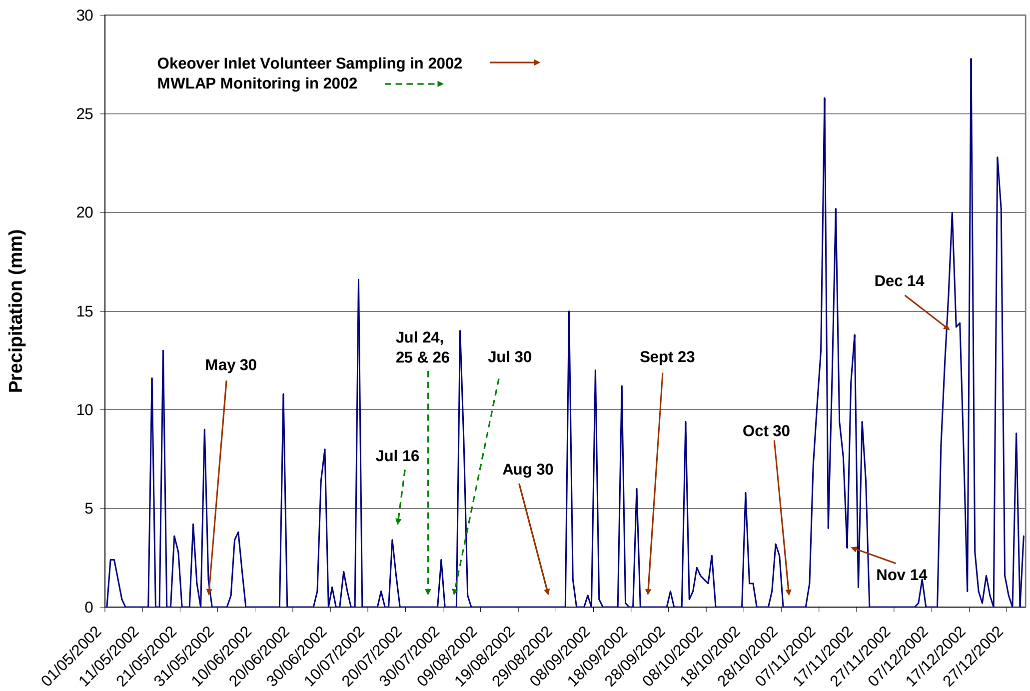


Figure 11: Precipitation and Sampling Schedule for 2002

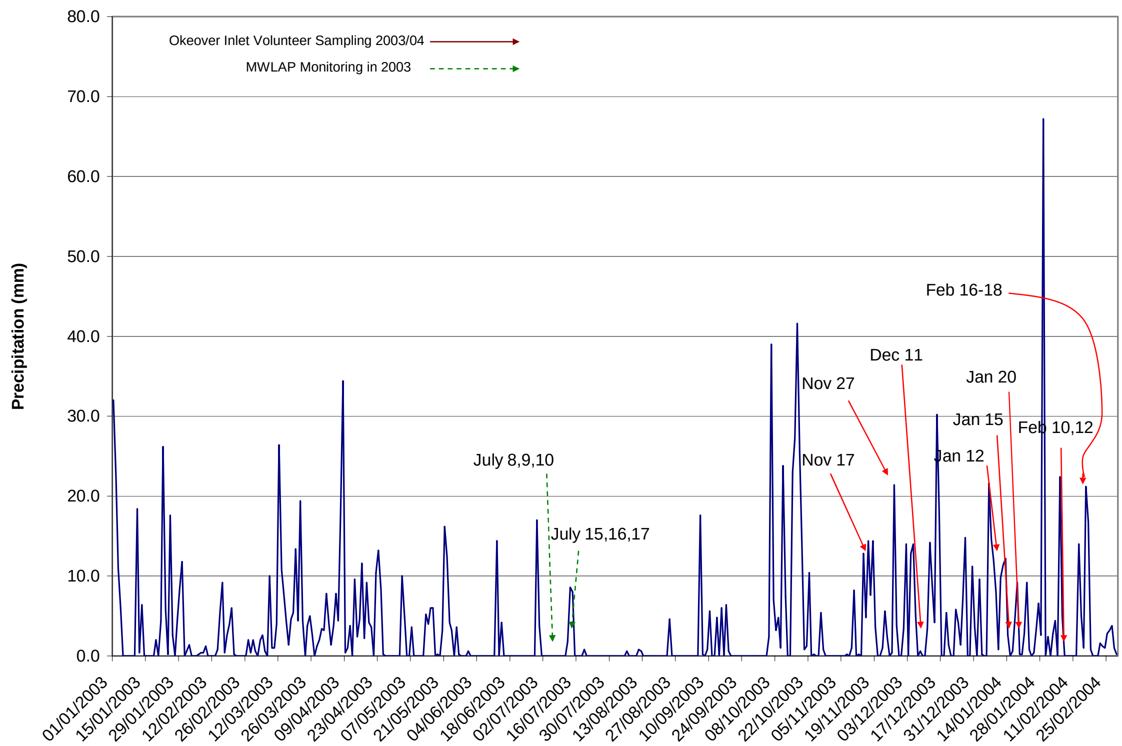


Figure 12: Precipitation and Sampling Schedule for 2003 (note different time and precipitation scales than 2002).

TABLE 2:

2002 Okeover Inlet Marine Water Quality: Means and Standard Deviations

July 16 -30, 2002	Trevenen Bay		Cochrane Bay		Grace Harbour		Wootton Bay		Penrose Bay		Freke Anchorage		Govt. Wharf		Okeover Central	
	Mean	St.Dev.	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Temperature (*C)	17.76	1.40	14.20	5.69	9.76	7.53	19.64	1.31	20.15	1.32	20.70	1.80	21.45	2.71	19.29	1.12
Salinity (ppt)	23.62	1.83	24.22	1.11	12.70	12.97	25.12	0.24	24.61	0.51	24.18	0.53	20.28	8.43	24.89	0.44
DO (mg/L)	9.68	0.98	9.02	0.97	5.16	4.84	9.56	0.38	9.22	0.82	8.78	0.32	8.82	1.31	9.71	0.93
Nitrogen (mg/L)																
Total Kjeldahl N	0.155	0.021	0.183	0.050	0.102	0.079	0.150	0.020	0.150	0.000	0.153	0.021	0.155	0.017	0.225	0.134
Total N	0.160	0.029	0.200	0.054	0.111	0.082	0.150	0.020	0.144	0.005	0.153	0.021	0.155	0.017	0.220	0.141
Total Organic N	0.155	0.021	0.183	0.050	0.102	0.079	0.150	0.020	0.150	0.000	0.153	0.021	0.155	0.017	0.225	0.134
Ammonia N	<0.005		<0.005		<0.005		<0.005		<0.005		<0.005		<0.005		<0.005	
Nitrate N Dissolved	<0.002		<0.0225		<0.02		<0.02		<0.02		<0.02		<0.02		<0.02	
Nitrate + Nitrite	<0.0078		<0.018		<0.002		<0.002		<0.002		<0.002		<0.002		<0.002	
Nitrite N	<0.002		<0.002		<0.002		<0.002		<0.002		<0.002		<0.002		<0.002	
Bacteriological																
Enterococci (MPN/100g)**	2.0	0.0	3.4	2.4	<2	0.0	2.0	0.0	2.0	0.0	2.0	0.0	<2	0.0	<2	0.0
Fecal Coliform (MPN/100mL)**	4.4	23.5	4.4	23.5	10.2	11.0	2.0	0.0	2.9	1.8	4.0	1.5	2.4	1.3	<2	0.0

* '<' assumed 1/2 MDL for means

** geometric means used for bacteriology with <MDL's = to the MDL

TABLE 3:

2003 Okeover Inlet Marine Water Quality: Means and Standard Deviations

July 8 - 17, 2003	Trevenen Bay		Cochrane Bay		Grace Harbour		Wootton Bay		Penrose Bay		Freke Anchorage		Govt. Wharf		Okeover Central	
	Mean	St.Dev.	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Temperature (*C)	16.44	0.33	15.39	1.25	18.20	0.35	16.00	2.01	16.18	0.66	17.14	1.59	16.59	0.76	16.70	1.24
Salinity (ppt)	24.78	0.59	25.34	1.10	25.86	0.18	26.03	0.22	26.19	0.37	26.55	0.19	26.26	0.18	26.17	0.21
DO (mg/L)	10.32	0.88	9.46	0.27	12.47	0.43	11.16	0.75	10.97	0.72	11.92	1.13	10.80	1.23	11.32	1.04
Nitrogen (mg/L)																
Total Kjeldahl N	0.182	0.018	0.162	0.019	0.178	0.019235	0.17	0.07	0.226	0.083	0.194	0.029	0.220	0.035	0.188	0.077
Total N	0.190	0.016	0.206	0.048	0.178	0.018	0.17	0.068	0.234	0.086	0.198	0.036	0.225	0.034	0.192	0.077
Total Organic N	0.174	0.017	0.158	0.019	0.170	0.024	0.164	0.066	0.214	0.084	0.184	0.025	0.210	0.034	0.182	0.074
Ammonia N	0.0084	0.0050	0.0066	0.0023	0.0094	0.0070	0.0076	0.0036	0.0120	0.0069	0.0130	0.0057	0.0120	0.0044	0.0100	0.0045
Nitrate N Dissolved	0.0220	0.0045	0.0500	0.0346	0.0200	0.0000	0.0200	0.0000	0.0200	0.0000	0.0200	0.0000	0.0233	0.0082	0.0200	0.0000
Nitrate + Nitrite	0.0162	0.0119	0.0492	0.0419	0.0034	0.0022	0.0020	0.0000	0.0072	0.0069	0.0040	0.0039	0.0087	0.0163	0.0054	0.0050
Nitrite N	0.0020	0.0000	0.0026	0.0013	0.0022	0.0004	0.0020	0.0000	0.0032	0.0013	0.0025	0.0010	0.0020	0.0000	0.0024	0.0009
Bacteriological																
Fecal Coliform (MPN/100mL)**	2.0	0.0	2.3	0.9	4.0	14.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0	1.0	2.0	0.0

* '<' assumed 1/2 MDL for means

** geometric means used for bacteriology with <MDL's = to the MDL

TABLE 4:

2003 Okeover Inlet Marine Water Metal Concentrations: Means and Standard Deviations

	Grace Harbour		Wootton*	Okeover Central		Penrose Bay		Freke		Govt. Wharf		B.C. Aquatic Life Criteria	
Metals (µg/L)	Mean	St.Dev.		Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.	Maximum	30-day mean
Arsenic	0.267	0.06	0.3	0.333	0.06	0.367	0.12	0.300	0.00	0.400	0.10	12.5**	
Cadmium	0.100	0.00	0.1	0.100	0.00	0.100	0.00	0.100	0.00	0.167	0.06	0.1***	
Chromium	0.500	0.00	<0.5	0.500	0.00	0.567	0.06	0.500	0.00	0.500	0.00		
Cobalt	0.100	0.00	<0.1	0.100	0.00	0.100	0.00	0.100	0.00	0.100	0.00		
Copper	0.333	0.06	0.2	0.267	0.15	0.233	0.12	0.400	0.14	0.267	0.21	3	2
Iron	2.333	0.58	5	4.000	1.73	3.500	0.71	5.000	1.41	3.667	1.15		
Lead	0.100	0.00	<0.1	0.100	0.00	0.100	0.00	2.050	2.76	0.100	0.00	140	2
Manganese	1.000	0.00	2	1.000	0.00	1.000	0.00	1.000	0.00	1.000	0.00		
Nickel	0.500	0.00	<0.5	0.500	0.00	0.500	0.00	0.500	0.00	0.500	0.00		
Zinc	1.333	0.58	1	1.000	0.00	1.000	0.00	1.000	0.00	1.000	0.00	10	

* One sample

Exceeds Provincial Criteria

** Interim Guideline

*** Under Review

TABLE 5:

2002 OKEOEVER INLET SEDIMENT ANALYSIS
July 2002

	Trevenen Bay	Grace Harbour	Wootton Bay	Okeover Central	Penrose Bay	Freke Anchorage	Canadian Sediment Quality Guidelines ISQG	PEL
	E248649	E248651	E248647	E248653	E248648	E248646		
Physical (% w/w)								
Moisture	28.1	35.8	33.4	87				
Gravel 2.0 mm	5.1	<0.1	<0.1	<0.1	<0.1	<0.1		
Coarse Sand 0.59 mm	8.1	1.9	9.7	1.7	0.7	1.1		
Medium Sand 0.297 mm	6.9	3.8	20.8	12.3	3.4	7.1		
Fine Sand 0.149 mm	12.4	10.9	27.6	33.5	17.2	29		
Very Fine Sand 0.053 mm	66.1	69.1	37.2	44.3	72.9	48.3		
Silt 0.037 mm	0.9	7.3	2.3	7.1	3.1	8.1		
Clay <0.037 mm	0.5	7.1	2.5	1.1	2.8	6.3		
Carbon (µg/g)								
Inorganic Carbon-Total	770	1100	<500	960	3300	<500		
Organic Carbon-Total	3800	8300	16000	53000	3300	27000		
Carbon-Total	4600	9400	16000	54000	6600	27000		
Phosphorus Total (P, µg/g)	529	718	545	1030	389	609		
Metals (µg/g)								
Aluminum	5760	5610	6060	12900	4170	7120		
Antimony	0.2	<0.1	0.2	0.4	0.1	0.4		
Arsenic	2.3	2	3.4	12.7	2.4	9.8	7.2	42
Barium	10.4	13.4	15.4	48.7	7.9	15.9		
Beryllium	<0.1	<0.1	<0.1	0.2	<0.1	0.1		
Bismuth	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		
Cadmium	0.21	0.96	0.56	4.13	0.67	2.02	0.68	4.2
Calcium	7030	4590	3870	7240	3230	4460		
Chromium	3.9	4.5	4.4	18.2	3.2	9.8	52	160
Cobalt	2	1.9	2.3	3.4	1.1	2.2		
Copper	4.4	8.9	7.4	44.6	5	18.5	19	108
Iron	6790	7100	7640	12600	4020	8340		
Lead	1.3	1.8	1.5	10.5	1.3	3.6	30	112
Magnesium	2960	3130	3990	12500	2200	6280		
Manganese	84.5	80.7	129	136	48.2	88.7		
Molybdenum	0.2	0.5	0.6	17.2	0.3	6.2		
Nickel	2.7	3.8	3.1	14.7	2.6	7.6	30	50
Potassium	558	586	737	2970	420	1110		
Selenium	<0.5	<0.5	<0.5	2.8	<0.5	1.1		
Silver	<0.05	0.07	<0.05	0.54	<0.05	0.15	1	2.2
Sodium	2590	5000	5290	64200	3610	21300		
Strontium	42.9	29.3	30	78.4	22.4	41.9		
Tellurium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		
Thallium	0.13	0.23	0.23	0.4	0.2	0.26		
Tin	<0.1	0.1	<0.1	0.6	<0.1	0.4		
Titanium	169	224	238	318	113	235		
Vanadium	16	15	19	36	9	21		
Zinc	16.4	20.3	25.9	89.2	13.4	43.4	124	271
Zirconium	<0.5	<0.5	<0.5	1.3	<0.5	<0.5		
Phthalates (µg/g)								
bis(2-Ethylhexyl) phthalate	0.2		0.5	<1			0.47	0.78
Butyl benzyl phthalate	<0.1		<0.1	<1			0.049	0.64
Diethyl phthalate	<0.09		<0.09	<0.9			0.61	1.10
Dimethyl phthalate	<0.07		<0.07	<0.7			0.53	
Dibutyl phthalate	<0.07		<0.07	<0.7			2.2	17
Di-n-octyl-phthalate	<0.1		<0.1	<1			0.58	45
Polycyclic Aromatic Hydrocarbons (µg/g)								
Acenaphthene		<0.01	<0.07				0.007	0.089
Acenapthylene		<0.01	<0.07				0.006	0.128
Anthracene		<0.01	<0.1				0.047	0.245
Benzo(a)anthracene		<0.01	<0.01				0.075	0.693
Benzo(b)fluoranthene		<0.01	<0.01				2.3	4.5
Benzo(k)fluoranthene		<0.01	<0.01				2.3	4.5
Benzo(g,h,i)perylene		<0.02	<0.02				0.31	0.78
Benzo(a)pyrene		<0.01	<0.01				0.089	0.763
Chrysene		<0.01	<0.01				0.108	0.846
Dibenz(a,h)anthracene		<0.02	<0.02				0.006	0.135
Fluoranthene		<0.01	<0.01				0.113	1.494
Fluorene		<0.01	<0.01				0.021	0.144
Indeno(1,2,3-c,d)pyrene		<0.02	<0.02				0.34	0.88
Naphthalene		<0.01	<0.01				0.035	0.391
Phenanthrene		<0.01	<0.01				0.087	0.544
Pyrene		<0.01	<0.01				0.153	1.398
Total PAH's		<0.01	<0.01					
Total Low MW PAH's		<0.01	<0.01				3.7	7.8
Total High MW PAH's		<0.01	<0.01				9.6	53
Bacteriological (MPN/100g)								
Fecal coliform	<20	<20	<20	<20	<20	<20		
Depth	25m & 10m	12m	20m	80m	12m	15m		
Observations	Fine sand, uniform, lots of shells, worms & brittle stars	Brown mud, some lighter brown mud in thin surface layer	Fine sand, many brittle stars	Black, uniform mud, not smelly	Fine sand, fine layer of lighter brown mud on top	Dark brown mud, large clam		

TABLE 6:

2003 OKEOVER INLET SEDIMENT ANALYSIS MEANS

July 2003 3 replicates per site	Wootton Bay	Okeover Central	Grace Harbour	Trevenen Bay	Penrose Bay	Freke Anchorage	Canadian Sediment Quality Guidelines	
	E248647	E248653	E248651	E248649	E248648	E248646	ISQG	PEL
Physical								
Moisture (%W/W)	30.9	85.4	29.8	23.9	25.3	21.2		
% Gravel >2.00 mm	0.08	0.09	0.03	7.20	0.05	0.06		
% Sand < 2.00mm > 0.063mm	87.91	1.31	76.42	88.31	81.63	93.37		
% Silt < 0.063mm > 0.004mm	8.92	16.53	17.85	2.70	11.95	4.59		
% Clay <0.004 mm	3.09	82.08	5.70	1.78	6.37	1.99		
Carbon (µg/g)								
Inorganic Carbon-Total	877	2633	940	2457	877	930		
Organic Carbon-Total	6200	52333	9933	8167	5033	7100		
Carbon-Total	7100	55000	11000	10733	5867	7700		
Phosphorus Total (P, µg/g)	584	820	646	554	408	329		
Metals (µg/g)								
Aluminum	4910	11700	6347	6373	4447	4230		
Antimony	0.1	0.2	0.1	0.2	0.1	0.2		
Arsenic	4.2	9.3	2.9	3.9	2.3	2.9	7.2	42
Barium	9.8	41.6	16.4	16.1	8.3	8.5		
Beryllium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		
Bismuth	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		
Cadmium	1.59	4.80	0.99	0.31	0.51	0.48	0.68	4.2
Calcium	3800	10150	4850	16973	3363	2777		
Chromium	4.5	17.9	5.0	4.9	4.0	4.0	52	160
Cobalt	1.5	3.2	2.4	3.0	1.3	1.7		
Copper	8.5	42.8	10.9	6.6	6.0	5.6	19	108
Iron	4060	11423	6310	8693	3883	6090		
Lead	1.5	8.1	2.4	1.8	1.5	1.1	30	112
Magnesium	2287	9960	2873	3417	1760	2127		
Manganese	70.5	124	95.9	121.3	54.9	72.0		
Molybdenum	1.0	17.4	0.7	0.5	0.3	0.5		
Nickel	3.7	15.9	4.9	3.9	3.0	2.7	30	50
Potassium	759	4120	1104	998	636	613		
Selenium	0.6	3.1	<0.5	0.6	0.7	0.5		
Silver	<0.05	0.47	<0.05	<0.05	<0.05	<0.05	1.0	2.2
Sodium	5680	57233	5367	4343	3850	3083		
Strontium	27.4	94.6	33.3	96.7	25.0	18.8		
Tellurium	<0.1	0.1	<0.1	<0.1	<0.1	<0.1		
Thallium	0.27	0.39	0.28	0.18	0.21	0.14		
Tin	<0.1	0.65	<0.1	<0.1	<0.1	<0.1		
Titanium	144	291	221	192	123	152		
Vanadium	10	34	16	21	10	16		
Zinc	20.0	78.4	26.9	25.3	14.1	16.4	124	271
Zirconium	<0.5	1.3	<0.5	<0.5	0.6	<0.5		
Bacteriological (MPN/g)								
Fecal coliform	<2	<2	<2	<2	<2	<2		
Phthalates (µg/g)								
bis(2-Ethylhexyl) phthalate (DEHP)	<4	<4	<4	<4			0.47	0.78
Butyl benzyl phthalate (BBP)	<0.2	<0.2	<0.2	<0.2			0.049	0.64
Diethyl phthalate (DEP)	<0.18	<0.18	<0.18	<0.18			0.61	1.10
Dimethyl phthalate (DMP)	<0.14	<0.14	<0.14	<0.14			0.53	
Dibutyl phthalate (DBP)	<0.14	<0.14	<0.14	<0.14			2.2	17
Di-n-octyl-phthalate (DnOP)	<0.2	<0.2	<0.2	<0.2			0.58	45
Polycyclic Aromatic Hydrocarbons (µg/g)								
Acenaphthene	<0.01	<0.01	<0.01				0.007	0.089
Acenaphthylene	<0.01	<0.01	<0.01				0.006	0.128
Anthracene	<0.01	<0.01	<0.01				0.047	0.245
Benzo(a)anthracene	<0.01	<0.01	<0.01				0.075	0.693
Benzo(b+j)fluoranthene	<0.01	<0.01	<0.01				2.3	4.5
Benzo(k)fluoranthene	<0.01	<0.01	<0.01				2.3	4.5
Benzo(g,h,i)perylene	<0.02	<0.02	<0.02				0.31	0.78
Benzo(a)pyrene	<0.01	<0.01	<0.01				0.089	0.763
Chrysene	<0.01	<0.01	<0.01				0.108	0.846
Dibenz(a,h)anthracene	<0.02	<0.02	<0.02				0.006	0.135
Fluoranthene	<0.01	<0.01	<0.01				0.113	1.494
Fluorene	<0.01	<0.01	<0.01				0.021	0.144
Indeno(1,2,3-c,d)pyrene	<0.02	<0.02	<0.02				0.34	0.88
Naphthalene	0.013	0.063	0.02				0.035	0.391
Phenanthrene	<0.01	<0.01	<0.01				0.087	0.544
Pyrene	<0.01	<0.01	<0.01				0.153	1.398
Total PAH's	0.013	0.063	0.02					
Total Low MW PAH's	0.013	0.063	0.02				3.7	7.8
Total High MW PAH's	<0.01	<0.01	<0.01				9.6	53

TABLE 7:

2003 OKEOVER INLET FRESHWATER BACTERIOLOGY: GEOMETRIC MEANS AND MEDIANS Collected by Volunteers							
	November 2003 - February 2004	*Enterococci (CFU/100mL)*	*Enterococci (CFU/100mL)*		*Fecal Coliform (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	
Site #	*Fresh Water Site*	geomean	median	standard dev	geomean	median	standard dev
1	Freke Anchorage	5.4	3	35.4	9.3	3	90.1
4	Malaspina Rd Ditch	1.9	1	24.3	1.3	1	3.6
34	Malaspina Rd Ditch U/S of Parking Lots	2.2	1	32.6	1.5	1	3.0
3	Larson Landing	1.1	1	0.3	1.2	1	0.6
10	Cochrane Bay Iris Spring	1.3	1	0.7	1.4	1	1.6
33	Hillingdon Point	1.3	1	2.4	2.9	1	29.6
24	Creek at Grail Point	1.4	1	3.0	1.1	1	0.9
26	Creek in Theodosia	1.0	1	0.0	1.3	1	2.8
18	Grace Harbour Creek	1.5	1	1.4	1.6	1	1.5

APPENDIX

VOLUNTEER MONITORING DATA 2001

VOLUNTEER MONITORING - OKEOVER INLET 2001

Date:		May 10, 2001				June 14, 2001				July 13, 2001				August 31, 2001			
Site #	Site Name	*Enterococci (cfu/100mL)*	*Fecal Coliform (cfu/100mL)*	*Enterococci (MPN/100mL)*	*Fecal Coliform (MPN/100mL)*	*Enterococci (cfu/100mL)*	*Fecal Coliform (cfu/100mL)*	*Enterococci (MPN/100mL)*	*Fecal Coliform (MPN/100mL)*	*Enterococci (cfu/100mL)*	*Fecal Coliform (cfu/100mL)*	*Enterococci (MPN/100mL)*	*Fecal Coliform (MPN/100mL)*	*Enterococci (cfu/100mL)*	*Fecal Coliform (cfu/100mL)*	*Enterococci (MPN/100mL)*	*Fecal Coliform (MPN/100mL)*
		Freshwater		Marine Water		Freshwater		Marine Water		Freshwater		Marine Water		Freshwater		Marine Water	
1	Okeover Head	6	9			9	24			81	13	<2	2	21	35	<2	<2
2	Sliammon Lease	5	1	2	<2	1	114	<2	2	39	38	<2	2	37	47	<2	4
3	Log Dump	19	<1	<2	<2	1	4	<2	<1	1	1	<2	<2	28	19	<2	<2
4	Govt Wharf Ditch	69	252			40	114			2580	750			6	140		
5	D/S Park South					45	5			30	4			37	300	<2	2
6	D/S Park North			<2	2	3000	C			30	12			31	241		
7	Penrose Bay			<2	2			<2	<1			<2	<2			<2	2
8	Trevenen Bay Head			<2	<2			<2	<1			<2	<2			<2	<2
9	Trevenen Bay	3	1	<2	2	3	38	<2	1	17	5	4	2	40	111	<2	11
10	Cochrane Bay south of Iris spring	29	IC	<2	2	1	4			290	3000	<2	2	121	9	<2	130
11	Cochrane creek	355	16	2	<2	1	77	<2	<1	25	1	<2	<2	20	250	<2	2
12	Cochrane Bay north			<2	<2			<2	<1			<2	<2			<2	<2
13	Thorp Is.			<2	2			<2	<1			<2	<2			<2	<2
14	Parker Bay	27	5	<2	<2	4	24	<2	<1	7	1					<2	<2
15	Cavendish Bay							<2	<1			<2	<2			<2	2
16	Jean Island West			<2	<2			<2	<1			<2	<2			<2	<2
17	Jean Island East			<2	2			<2	1			<2	2			<2	22
18	Grace Harbour at head	64	11	<2	2	2	56	<2	1	53	29	<2	2	34	55	<2	13
19	Edith Island north			<2	<2			<2	<1			<2	<2			<2	<2
20	Edith Island south			2	2							2	2			5	2
21	Isabel Bay			<2	<2			<2	<1			<2	<2			<2	<2
22	Madge Is.			<2	2			<2	1			<2	2			<2	4
23	Wooton Bay			<2	<2							<2	<2			<2	2
24	Grail Point	137	2	<2	14					212	225	<2	2	147	300	<2	2
25	Thors Cove											<2	2			<2	8
26	Theodosia Inlet									14	2	<2	12	28	10	<2	49
27	Grace Harbour centre							<2	1			<2	2			<2	13
28	Moss Point							<2	1			<2	2			<2	5
29	Moss Point Bay							<2	<1			2	<2			2	4

IC = Incomplete results, flooded waterbath
C = Incomplete results, too much sediment

VOLUNTEER MONITORING DATA 2002

VOLUNTEER MONITORING - OKEOVER INLET 2002

Date:		May 30, 2002				August 30, 2002				September 23, 2002				October 30, 2002				November 14, 2002			December 14, 2002				January 20, 2003	
Site #	Site Name	*Enterococci (CFU/100mL)*	*Fecal coliform (CFU/100mL)*	*Enterococci (MPN/100mL)*	*Fecal coliform (MPN/100mL)*	*Enterococci (CFU/100mL)*	*Fecal coliform (CFU/100mL)*	*Enterococci (MPN/100mL)*	*Fecal coliform (MPN/100mL)*	*Enterococci (CFU/100mL)*	*Fecal coliform (CFU/100mL)*	*Enterococci (MPN/100mL)*	*Fecal coliform (MPN/100mL)*	*Enterococci (CFU/100mL)*	*Fecal coliform (CFU/100mL)*	*Enterococci (MPN/100mL)*	*Fecal coliform (MPN/100mL)*	*Fecal coliform (CFU/100mL)*	*Enterococci (MPN/100mL)*	*Fecal coliform (MPN/100mL)*	*Enterococci (CFU/100mL)*	*Fecal coliform (CFU/100mL)*	*Enterococci (MPN/100mL)*	*Fecal coliform (MPN/100mL)*	*Enterococci (MPN/100mL)*	*Fecal coliform (MPN/100mL)*
		Freshwater		Marine Water		Freshwater		Marine Water		Freshwater		Marine Water		Freshwater		Marine Water		Freshwater	Marine Water		Freshwater		Marine Water		Marine Water	
1	Okeover Head	40	55	<2	2	77	45	5	>1600	39	7	4	13	339	>300	<2	<2	73	22	26	44	82	17	33	<2	49
2	Sliammon Lease	40	<1	<2	2	97	11	2	<2	<1	8	13	5	5	1	<2	<2	3	2	<2	2	1	2	<2	<2	7
3	Log Dump	<1	<1	2	5	510	1400			68	81	<2	<2	46	55	<2	<2	1	8	<2	4	1		2	<2	2
4	Govt Wharf Ditch	91	8	<2	<2	1140	410			>300	>300			124	320			79	33	<2	25	>300				
5	D/S Park South	52	10			4	<25							<1	<2			29			1	10				
6	D/S Park North	26	81			16	13	<2	<2	8	2	<2	<2	103	45	<2	<2	93			36	15	<2	2	<2	5
7	Penrose Bay							<2	<2	22	233	<2	2			<2	<2		8	2			<2	<2	<2	<2
8	Trevenen Bay Head			<2	<2			2	<2			<2	2			<2	<2		<2	<2				2	<2	<2
9	Trevenen Bay	23	<1	<2	<2	7	8	<2	<2	4	<1	<2	4	<1	3	<2	<2	2	2	<2	3	3		5	2	5
9B		<1	1																							
10	Cochrane Bay	16	<1	<2	<2	37	2	<2	2	45	12	<2	<2	32	2	<2	<2	35	2	<2	<1	3		<2	<2	<2
11	Cochrane Ck	14	<1	<2	2	11	<1			1	<1	<2	<2	2	<1	<2	<2	2	5	<2	17	25		2	<2	2
14	Parker Bay	1	<1	<2	<2																					
15	Cavendish Bay			<2	<2																					
16	Jean Island W			<2	<2																					
17	Jean Is East			<2	<2																					
18	Grace Harbour Hd	59	6	<2	<2	174	93	<2	4	44	31	<2	<2	107	23	<2	<2	9	2	<2	4	5		8	2	13
19	Edith Is. North							<2	<2			<2	<2			<2	<2		2	<2				2	<2	<2
20	Edith Is. South							<2	<2										13	2				<2	<2	<2
24	Grail Point	17	18	2	7	1760	>3000	<2	13	>300	>300			243	>3000	<2	<2	28	8	9	3	3	2	9	<2	<2
25	Thors Cove			<2	<2			<2	<2			<2	<2			<2	<2		2	<2				<2	<2	2
26	Theodosia Inlet	18	<1	8	13	30	14	<2	23	20	12	4	17			<2	<2	6	5	4	1	3	5	8	<2	2
27	Grace Harbour Ctr			<2	<2			<2	2			2	<2			<2	<2		5	<2			<2	2	<2	<2
28	Moss Point			2	<2																					
29	Moss Point Bay			<2	<2							<2	4													
33	Hillingdon Point					31	13	<2	5	424	264	<2	8			<2	<2	11	23	<2	3	<1	<2	<2	<2	7
	Precipitation																									
24 hour			0.00				0.00				0.00				0.00			3.00				2.80				
48 hour			Trace				0.00				0.00				0.00			10.60				30.60				
72 hour			10.40				Trace				0.00				0.00			20.00				31.40				

VOLUNTEER MONITORING DATA 2003

Volunteer Monitoring - Okeover Inlet 2003

Date:		November 17, 2003		November 27, 2003		December 11, 2003		January 12, 2004		January 15, 2004		January 20, 2004		February 10, 2004		February 12, 2004		February 16, 2004		February 17, 2004		February 18, 2004	
Site #	*Fresh Water Site*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*
1	Freke Anchorage	*69(42)	*120 (110)	85	290	81	110	11	26	8	3	3	25	1	<1	1	<1	1	3	<1	1	<1	2
4	Malaspina Rd Ditch	82	13	*11(8)	*1(3)	1	1	1	<1	<1	2	<1	1	*1(<1)	*<1(<1)	*<1(<1)	*<1(<1)	1	<1	<1	1	<1	<1
34	Malaspina Rd Ditch U/S of Parking Lots	110	11	10	3	3	2	2	1	1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1
3	Larson Landing	<1	3	<1	2	<1	1	2	1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
10	Cochrane Bay Iris Spring	1	<1	<1	<1	<1	<1	1	6	2	2	*3(1)	*3(4)	<1	<1	<1	<1	2	<1	*<1(1)	*<1(<1)	2	<1
33	Hillingdon Point	9	99	1	29	*<1(1)	*12(2)	<1	<1	<1	3	<1	<1	<1	<1	<1	<1	2	1	<1	<1	<1	1
24	Creek at Grail Point	11	4	3	<1	<1	<1	*<1(<1)	*<1(<1)	<1	<1	<1	1	<1	<1	<1	<1	<1	1	<1	1	<1	1
26	Creek in Theodosia			<1	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	*<1(<1)	*1(<1)	<1	2	<1	<1
18	Grace Harbour Creek			<1	2	3	4	5	5	*3(5)	*3(4)	<1	1	<1	<1	<1	<1	<1	1	<1	1	*1(1)	*<1(1)

(blind duplicate)

VOLUNTEER MONITORING DATA 2004

Okeover Inlet Volunteer Freshwater Monitoring August - December 2004

2004	August 25		September 2		September 15		September 23		October 4		October 14	
24 hour rainfall	heavy rain		none (last week heavy rain)		light rain		drizzle to heavy rain		none		none	
Fresh Water Site	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*
Freke Anchorage	120	150	34	180	53	160	87	150	28	50	57	410
Malaspina Rd Ditch	940(920)	270(990)	6	17	89	49	26(32)	53 (72)	6	17	1	5
below Laughing Oyster					2500	3700	1000	1500	4000	4700	1200	2000
Malaspina Rd Ditch U/S of Parking Lots	1800	710	23	22	8	24						
Larson landing:Creek thru residence					51	22			7(4)	6(24)		
Larson Landing	190	560	12	89	5	25	22	11			7	10
Cochrane Bay Iris Spring	260	2400	450 (410)	3 (3)	360	6	230	<1	2	23	21	22
Hillingdon Point	760	2100	3000	750	60	51	25	37	<1	2	58	2
Creek at Grail Point	1300	1200	310	750	1700	2400	310	1400	3500	110	42	420
Creek in Theodosia	110	78	53	8	19	1	8	4	<1	<1		
Grace Harbour Creek	3000	2200	130	250	24	120	160	86	21	4	4 (2)	4 (4)
Trevenen Creek (from Wednesday Lake)	860	890	1	1	6(3)	2(1)	4	9	<1	10	2	4
End of Malaspina Rd below Sign			86	360	430	370	14	50	<1	670	<1	4

2004	October 25		November 8		November 22		December 1		December 6	
24 hour rainfall	heavy rains		heavy rain		none (last week heavy rain)		light rain		drizzle to heavy rain	
Fresh Water Site	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*	*Enterococci (CFU/100mL)*	*Fecal Coliform (CFU/100mL)*
Freke Anchorage			35	24	18	68	11	35	10	12
Malaspina Rd Ditch	60	38	3	3	<1	<1	<1	<1	<1	2
below Laughing Oyster	200	120	24	20	17	84	17	42	5	4
Malaspina Rd Ditch U/S of Parking Lots					<1(<1)	2 (<1)	<1	7	<1	<1
Larson landing:Creek thru residence										
Larson Landing	34	38	1	<1	<1	5	<1	10	<1	1
Cochrane Bay Iris Spring	76	49	<1(1)	1(4)	<1	3	<1(3)	<1(<1)	2	<1
Hillingdon Point	70	44	<1	2	1	4	1	14	<1	<1
Creek at Grail Point	2800000 (22500)*	4300000(45000)	4	7	2	2	<1	<1	<1	<1
Creek in Theodosia	62	56	1	<1	<1	<1	<1	1	<1(<1)	<1(<1)
Grace Harbour Creek	49	7	23	15	<1	2	<1	13	<1	<1
Trevenen Creek (from Wednesday Lake)	12	33	2	5	<1	1	<1	<1	<1	<1
End of Malaspina Rd below Sign	1	1	<1	2	<1	<1	<1	<1	<1	<1
Ahola Creek			<1	11	3	2	<1	4		
D'Angio Creek			<1	<1	<1	<1				

*high levels of suspended matter
(blind duplicates in brackets)