St. Clair River

REMEDIAL ACTION PLAN

The St. Clair River Area of Concern

STAGE 1 1997 UPDATE

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EXECUTIVE SUMMARY

The St.Clair River Stage 1 Remedial Action Plan (RAP) was released in 1991. This document served to define the environmental status of the St. Clair River Area of Concern (AOC) by means of summarizing the results of monitoring carried out by government, corporate, academic, and private agencies and stakeholders. The resulting information provided a "snapshot" of environmental conditions which were assessed against benchmarks defined by the Great Lakes Water Quality Agreement.

The second stage of the RAP process defined water use goals, remedial measures, and an implementation strategy for addressing problems identified in the Stage 1 RAP. The *Stage 2--Recommended Plan* document for the St. Clair River RAP was released in 1995, and included the definition of and a schedule for specific remedial goals and actions, the identification of agencies/organizations responsible for specific actions, and the definition of processes for evaluating the effectiveness of remedial measures and monitoring programs.

The periodic assessment of environmental conditions in the St. Clair River AOC, as indicated by measured levels of identified contaminants of concern, provides a means by which changes in environmental conditions can be tracked. This document, entitled *Stage 1 1997 Update*, is the second such update to the original 1991 Stage 1 document--the first update, entitled *St. Clair Remedial Action Plan Addendum*, was released in 1993.

Significant progress has been made towards delisting since the last update and the release of the *Stage 2--Recommended Plan* document. Of the 9 impairments of beneficial uses noted in that document, 2 have changed status to "not impaired", based solely on improving conditions; a third impairment has been reclassified and is no longer considered impaired but requires further site-specific assessment. In addition, the issue of "tainting of fish and wildlife flavour", which had been classed as "requiring further assessment on a site-specific basis", has been reassessed as "not impaired" based on the results of additional study.

These significant improvements are the direct consequence of the reduction in frequency and size of spills from industrial facilities in Ontario and Michigan and have resulted in the achievement of a critical delisting criteria necessary for the removal of the St. Clair River from the list of Great Lakes Areas of Concern. Notable reductions in both the levels of some contaminants as well as in industrial loadings have also been realized, although in the latter case available data does not permit broad sectoral comparisons with the previous update.

Readers of the *Implementation Annex 1997* document released concurrently with this update will note that RAP implementation measures already carried out and committed to amount to tens of millions of dollars expended on the part of the industrial sector, municipal, state, provincial, and federal government agencies, and numerous non-governmental agencies and individual stakeholders.

The focus of this document has shifted in comparison to its predecessors, in that the reporting of ambient environmental conditions is done in comparison with values previously reported in the 1993 addendum document, via the water quality, sediment, and biota "yardstick" parameters and associated values presented in the *Stage 2--Recommended Plan* document. This permits a more direct assessment of conditions with respect to the status of impairments of beneficial uses. The fundamental purpose of the document, however, remains the compilation of data pertaining to the ambient environmental conditions of, and contaminant loadings to, the St. Clair River. This is an essential tool in the evaluation of progress towards the achievement of delisting criteria and the success of remedial measures.

The first section of this document presents individual summaries of the reports, studies, memoranda, and raw data provided to the RAP Implementation Committee by the various agencies/organizations involved in environmental monitoring and remediation efforts, at all levels. The next section summarizes available point source self-monitoring data. The comparison of recent ambient data to data from the previous update is made in the following section, with parameter levels above RAP yardsticks noted. The final section of the document synthesizes the data in light of the impairments of beneficial uses for the St. Clair River AOC.

This progress underscores the challenges that remain. The improvements that have been realized to date provide an indication that the RAP process is working; however, RAP implementation efforts must continue in order to build on the successes that have already been achieved.

St. Clair River Area of Concern
Remedial Action Plan--Stage 1 1997 Update

1.0 INTRODUCTION

The St. Clair River Remedial Action Plan (RAP) Stage 1 report defined problems (ambient conditions and related source loadings) in the Area of Concern (AOC) and was released in December of 1991. The *St. Clair Remedial Action Plan Addendum* report was released in September of 1993, and followed the format of the Stage 1 document. Information contained within the first addendum report was based on ambient and source data collected variously between 1988 and 1992. This is the second addendum/update report developed for the St. Clair RAP.

Information within the Stage 1 report and first addendum report formed the basis for the development of specific delisting criteria and the assignment of impairment status to each of the International Joint Commission's (IJC) impairments of beneficial uses. The *Stage 2--Recommended Plan* document released in March 1995 reported on the criteria and status of impairments of beneficial uses along with monitoring objectives and other aspects of implementing remedial measures.

This 1997 addendum updates information relevant to both the Stage 1 and Stage 2 RAP documents. Reports and papers included cover the period from 1992 through 1997, based on data collected up to 1996, and in some instances to 1997. The format has been changed to allow a clearer focus on information pertaining to the status of use impairments.

The report consists of 4 main sections. Section 2 provides concise summaries of contents and findings contained in each report, document, and memorandum provided to the RAP Implemenation Committee/Coordinator for inclusion in this addendum, organized by media. Section 3 updates point source contaminant loadings based on available self-monitoring data for the period 1991 to 1996. Recent data pertaining to each of the St. Clair River AOC parameter "yardsticks" (as defined in the *Stage 2--Recommended Plan* document) are then presented in Section 4 (see tables 1, 2 and 3). This section is in tabular format highlighting parameter levels above yardstick values (values, location, and date) based on data from the various reports and memoranda summarized in Section 2. All of the information is then synthesized and interpreted in Section 5 in the form of an updated "Summary of Impairments of Beneficial Uses" table (see Table 4).

This report contains recommendations to alter the status of 4 impairments of beneficial uses in the St. Clair River AOC, based on an assessment of conditions against delisting criteria, the results of new study, and the re-evaluation of evidence of previous impairment (see Section 5.2 and Table 4).

The status assigned to each IJC impairment of beneficial use in the St. Clair River AOC is based on a consensus among members of the RAP Implementation Committee (RIC) and the Binational Public Advisory Council (BPAC). The recommendations contained in this addendum must be assessed by members of RIC and BPAC and any changes in impairment of beneficial use status confirmed on the basis of BPAC/RIC consensus.

Information on the implementation of remedial measures at specific facilities is described under separate cover in the *Implementation Annex 1997* document released concurrently with this addendum.

2.0 SUMMARY OF INFORMATION, 1994-1997

2.1 INTRODUCTION

The information in this section is summarized from reports, memos, letters, and other data which has become available since the 1993 addendum report was released. It consists of data on ambient conditions collected principally in the period 1994 to 1997. The nature of the studies reflect the nature of on-going problems in the AOC as defined in the Stage 1 and previous update reports.

Based on the earlier data, the impairments of beneficial uses deemed to be impaired were:

- restrictions on fish and wildlife consumption
  --restrictions on fish consumption
- bird or animal deformities or reproductive problems
  --chironomid mouthpart deformities
- degradation of benthos
  --dynamics of benthic populations/communities
- restrictions on dredging activities
- restrictions on drinking water consumption or taste and odour problems
  --consumption
  --taste and odour problems
- beach closings
- degradation of aesthetics
- added cost to agriculture and industry
- loss of fish and wildlife habitat

As a result, much of the data collected since the Stage 1 and first addendum reports focuses on information required to assess the delisting criteria for these impairments as well as respond to the monitoring requirements defined in the *Stage 2--Recommended Plan* document and inherent to the periodic re-assessments required to achieve delisting. Hence, the data emphasize aspects related to bacterial contamination, sediment quality, benthic community health, fish consumption, and spills.

Section 2.2 is organized according to media: water quality, sediment/benthos, and biota. Each information source is identified and described according to a common format. This includes a listing of title, source of document (in standard reference format), location of reported studies, and the type of studies undertaken. This is then followed with a brief narrative describing the contents of the document and highlighting the key results and conclusions presented in the source document.

Selected tables/figures, presenting significant data on ambient conditions and/or data that indicates contaminant levels above RAP-defined yardstick values, are reproduced in the appendices included with this report.

2.2 DATA SUMMARY

Note: in 1997 the Ontario Ministry of Environment and Energy was redesignated the Ontario Ministry of the Environment. Similarly, in 1995 the Michigan Department of Natural Resources was subdivided--one department remained the Michigan Department of Natural Resources, whose primary jurisdiction is natural resource issues, and the second was designated the Michigan Department of Environmental Quality, whose primary mandate is environmental monitoring, permitting, and inspection. In this report, references to these organizations will be by means of their current designations via the acronyms OMOE, MDNR, and MDEQ, respectively. Readers are cautioned that source materials will refer to these by their former designations.

2.2.1 Water Quality

2.2.1.1 St. Clair River Survey

Source: LHU-OMOE 1994
Where: St. Clair River, Sarnia to southern border of Lambton County
What: bacteriological monitoring 1994

This report summarizes the results of a bacteriological survey of the St. Clair river for the summer of 1994, carried out by the Lambton Health Unit and the Ontario Ministry of the Environment, Sarnia. A total of 16 sites were surveyed on the Canadian side of the river, from Sarnia to the southern boundary of Lambton County. The goal of the survey was to assess general water quality as well as attempt to identify possible sources of bacterial contamination. This was done by selecting sample sites upstream, at the mouth, and downstream of 4 local creeks entering the river. In addition, simple meteorological information for the sampling dates was noted in order to identify any correlations between bacterial counts and weather conditions. Five samples were taken weekly at each site, with sampling carried out from mid May to late August.

The survey confirmed that high levels at a creek mouth generally corresponded to high levels in the St. Clair River downstream of the creek, even if levels upstream were low. It was also observed that the high levels in Talfourd Creek at the beginning of the season tapered off to nearly nil once water temperatures remained consistently above 30°C. It was also noted that light to moderate amounts of rainfall had no appreciable effect on ambient bacterial levels in the river; even when rainfall was heavy the levels did not rise consistently. It should be noted that this report documents the ambient bacteriological and basic meteorological conditions only--no attempt was made to determine the causative sources of the bacterial contamination or analyze the factors impacting levels.

As of 1994, 4 parks along this stretch of the river with beach access had permanent postings of

possible intermittent pollution, intended to remain until subsequent surveys demonstrate river bacterial levels consistently below health guidelines.

All 16 sites sampled reported levels above the 33 organisms/100 ml RAP yardstick level, with high levels concentrated in June and July--out of 1120 samples there were 605 occurrences above yardstick levels (54%), with counts ranging from 10 to 8500 organisms/100 ml. The highest levels (i.e., levels over 1000) took place off Guthrie Park, Baby Creek, Bowen Creek, Clay Creek, Cathcart Park, Lambton Cundick, Reagan Park, Marshy Creek, and Macdonald Park.

Data available: seasonal summaries for each of the 16 sites (including values for each of the samples and geometric means), as well as water temperature, rainfall (2 classes), wind direction, sunlight intensity, and information on bathing activity (see Appendix 1)

2.2.1.2 Analysis of Fecal Coliform Data From the Michigan and Ontario Shorelines of the St. Clair River, 1984-1994

Source: Harris 1994
Where: St. Clair River, numerous sites
What: analysis of fecal coliform bacterial data for Ontario and Michigan

The private study reports on the compilation and analysis of fecal coliform data from the Sarnia-Lambton Health Unit, Ontario, and the St. Clair County Health Department, Michigan. A total of 30 sample sites are reported on, with data spanning the period 1984-94, although it was not until 1993 that data were available for more than half of the sites for a given year (see LHU--OMOE 1994, 1995; MacKenzie 1996). The original sampling was generally weekly through the spring and summer months.

This study focuses on statistical analysis of the data, although it is hampered by the following factors 1) not all sites record supplementary data such as meteorological conditions; and 2) the Michigan data do not include the magnitudes of counts in excess of 200 organisms/100 ml. Results are summarized in terms of percentage of samples exceeding the 100 colonies/100 ml threshold (note: the RAP yardstick is 33 per 100 ml) for Ontario, and the 100 and 200 colony/100 ml thresholds for Michigan. The main result of this study of relevance to the update is the fact that the results above yardstick levels noted on the Ontario side (see LHU--OMOE 1994, 1995; MacKenzie 1996) are matched by results on the Michigan side, indicating that the problem of high bacterial levels is wide-ranging throughout the AOC.

Data available: tables summarizing the percentage of samples exceeding threshold values (Ontario and Michigan); statistical distributions of fecal counts for each site, including correlation coefficients, regression values, etc.; log of counts for each station; map of sites

2.2.1.3 St. Clair River Summary Report

Source: LHU-OMOE 1995
Where: St. Clair river, Sarnia to southern border of Lambton County
What: bacteriological monitoring 1995

This is a continuation of the 1994 study by the Lambton Health Unit and OMOE . From the outset, however, the goal was to establish whether the rural creeks emptying into the river were having a significant impact on the presence and levels of *E. coli* in the river. In addition, the Clifford St. site was selected to evaluate whether the City of Sarnia waste water treatment plant was impacting the levels of organisms in the river.

The trend of higher levels downstream of creek outlets was again confirmed, allowing the conclusion that these creeks were having an adverse effect on river water quality in bacteriological terms. It was therefore recommended that future testing be directed to sampling upstream along the creeks in order to identify the main source(s) of the contamination, thereby providing a focus for remediation efforts.

The 4 beaches remained posted during 1995. Again all 16 sites sampled reported levels above the 33 organism/100 ml RAP yardstick level, with high levels concentrated in June and July (with some August highs)--out of 960 samples there were 607 results above the yardstick level (63%), with counts ranging from 10 to 22,000 organisms/100 ml. The worst levels, from 11,000 to 22,000, were encountered in Clay Creek in mid August; other levels in excess of 1000 were encountered at the Talfourd upstream site, Baby Creek, Bowen Creek, and at Cathcart Park.

The report concluded: "*In general, a creek does have a profound impact upon the water quality of the river seen in the trend that downstream of a creek entrance always had a higher bacterial count than ...the upstream site. Similar analysis of the 1994 dataset indicates that this trend is consistent*". No conclusion was made regarding the Clifford St. site, although the 1994 and 1995 geometric means of bacterial levels were among the lowest of the 16 sites sampled.

Data available: seasonal summaries for each of the 16 sites (including values for each of the samples and annual arithmetic and geometric means), as well as water temperature, rainfall (2 classes), wind direction, sunlight intensity, and bathing activity information; bar graph comparing 1994 and 1995 geometric means at each site (see Appendix 1)

2.2.1.4 Analysis of Fecal Coliform Data From the Michigan and Ontario Shorelines of the St. Clair River, Supplement 1995

Source: Harris 1995a
Where: St. Clair River, numerous sites

What: analysis of fecal coliform bacterial data for Ontario, 1995 update

This private study is a follow-on to Harris (1994), and includes a similar analysis of Ontario data for 1995 and earlier. A key point noted in this study is that information from the 1994-95 period is the first since the 1993 completion of major domestic waste water sewer systems on the Canadian side of the river. The data shows a marked improvement in bacterial levels from 1993 to 1994, and the 1995 data shows that the trend is continuing (although MacKenzie 1996 shows that levels are increasing again in the 1994-96 period). Another point noted is that when data spanning several years is compared, the annual means vary markedly from year to year for a given site, indicating that this contamination is event-driven to a large extent.

Data available: tables summarizing the percentage of samples exceeding 100 organism/100 ml threshold for each sample site, 1984-1995, Ontario only (see Appendix 1)

2.2.1.5 Analysis of Fecal Coliform Data from Combined Sewer Monitoring Program of the Utilities Division, City of Port Huron, Michigan, 1993-95

Source: Harris 1995b
Where: St. Clair and Black rivers
What: analysis of fecal coliform bacterial data for Michigan

This private study of data provided by the Utilities Division, City of Port Huron, and resulting from their monitoring of fecal coliform levels, reports on the effect of sewer overflow on fecal coliform levels first in the Black River and then the St. Clair River. Four sampling sites were chosen, 2 in the Black River and 2 in the St. Clair River - one upstream of the Black River and one downstream. A sample was obtained from each of the sites on each of 32 days between November 5, 1993, and April 27, 1995. The 4 samples were usually taken within a 30 to 60 minute period. The rainfall on the day of sampling and the 24 hrs preceding was recorded. It was also noted whether the sewers were overflowing and the time the overflow began. Samples were usually taken on days of heavy rain but samples were also taken on days of no rain to indicate normal conditions.

Fecal coliform counts were measured using one set of dilutions. This abbreviated technique resulted in more than 50% of the counts being reported as numbers greater or lesser than a given number. These numbers were revised to yield a most probable number.

At the mouth of the Black River, and on the St. Clair River downstream of the Black River, the sewer overflow had a real effect. Levels on the St. Clair River rose from a normal level of about 64 to about 317 organisms/100 ml. The coliform count rose fivefold almost immediately to well beyond the acceptable level of 200 organisms/100 ml (Michigan Water Quality Standards; cf., RAP yardstick level of 33 organisms/100 ml) and remained at that level for at least 20 hours. Levels at the mouth of the Black River rose from a normal level of about 162 to 1300 organisms/100 ml. The coliform count rose eightfold almost immediately and remained steady

for at least twenty hours. At the other site on the Black River, levels rose slightly for about 6 hours and then returned to normal after 20 hours. The levels upstream on the St. Clair River showed no fluctuations.

Rainfall on the day previous to sampling did not exert a significant effect on coliform counts. However, rainfall on the day of sampling did effect the coliform counts at the mouth of the Black River and downstream on the St. Clair River. Rainfall intensity had essentially no effect at the St. Clair River upstream site. The Black River and downstream St. Clair River sites showed that a little over half an inch of rainfall over a 24 or 48 hour period will result in an exceedance of acceptable coliform counts. At the mouth of the Black River almost any rainfall will result in exceedance of acceptable levels.

Data available: means of log coliform counts for each site; log coliform counts versus rainfall in past 48 hours

2.2.1.6 St. Clair River Bacterial Contamination Survey

Source: MacKenzie 1996
Where: St. Clair river, Sarnia to southern border of Lambton County
What: bacteriological monitoring 1996

This is a continuation of the 1994-95 studies reported in LHU-OMOE 1994 and 1995. No mention was made in this report of beach postings. Again all 16 sites sampled reported levels above the RAP yardstick value, concentrated in June and July (with some August highs); out of 192 samples there were 130 results above the yardstick level (63%), with counts ranging from 5 to 22,000 organisms/100 ml. Overall, levels were higher than in previous years, with substantial increases: upstream, at, and downstream of Talfourd Creek and at Centennial Park. The much higher levels at Talfourd Creek may indicate a “hot spot” that requires further study. It was also observed that overall levels were higher than in the previous 2 years.

Data available: seasonal summaries for each of the 16 sites (including values for each of the samples and annual arithmetic and geometric means), as well as water temperature, rainfall (2 classes), wind direction, sunlight intensity, and bathing activity information; bar graph comparing 1994 and 1995 geometric means at each site (see Appendix 1)

2.2.1.7 Analysis of Fecal Coliform Data From the Michigan and Ontario Shorelines of the St. Clair River, Supplement 1996

Source: Harris 1996a
Where: St. Clair River, numerous sites
What: analysis of fecal coliform bacterial data for Ontario, 1996 update

Using MacKenzie's 1996 data, Harris summarizes the data from 1984 to 1996 in the same format for the same stations. Of note is the observation that 1996 levels have generally increased markedly over 1994-95 levels, with half of the stations (from Canatara Park to Baby Creek) showing levels slightly in excess of peak levels in 1993. This is significant as his previous reports attributed the decrease in levels from 1993 to 1994 to the completion of several major Canadian waste water sewer systems in 1993. Additional study is warranted to address the sources of these bacterial levels, which among other areas should involve (as noted in LHU--OMOE 1995) sampling upstream along the tributary creeks emptying into the St. Clair.

Data available: tables summarizing the percentage of samples exceeding 100 organism/100 ml threshold for each sample site, 1984-1996, Ontario only (see Appendix 1)

2.2.1.8 Analysis of Fecal Coliform Data from Combined Sewer Monitoring Program of the Utilities Division, City of Port Huron, Michigan, Supplementary Report, 1996-1997

Source: Harris 1997a
Where: St. Clair and Black rivers
What: analysis of fecal coliform bacterial data, Michigan

This private study is a follow-on to Harris 1995b, and is based on fecal coliform monitoring data provided by the Utilities Division, City of Port Huron, showing coliform counts after the first separation of storm and sanitary sewers was completed. The original 1995 report contained a substantial number of data points approximated by extrapolation. An attempt was made to use the same approximation technique on the 1996 data but the number of dilutions was insufficient. Consequently, many of the data was not included in the analysis and as a result, the analysis is "*open to a considerable degree of doubt*". The report recommends that 6 dilutions are used to estimate fecal coliform levels because of the high variability arising from the ambient conditions at the time of sampling.

An insensitivity to rainfall intensity is suggested at all sites after the first separation. However, this data did not achieve significance at the 95% level. The before-separation results in the previous report did show sensitivity to rainfall intensity. Before the first separation, mean coliform levels at the Black River sites and the downstream St. Clair River site showed a significant difference. The St. Clair River upstream site was not considered in this study. The data for the Black River site showed a significant difference in this study as data was added since the original 1995 report. After the first separation, mean coliform levels at the 2 Black River sites and the downstream St. Clair River site did not show significant differences. This suggested that coliform counts were not sensitive to combined sewer overflows.

Data available: log coliform counts versus rainfall in last 48 hours for all sites in 1993-95 and 1996

2.2.1.9 Analysis of *E. coli* Counts from the Michigan Shoreline of the St. Clair River, Supplement 1997

Source: Harris 1997b
Where: St. Clair River, Blue Water Bridge down river to Algonac
What: analysis of *E. coli* bacterial data, Michigan

In 1994, the following changes were made to Michigan's Water Quality Standards Microorganisms Rule (for total body contact): 1) *E. coli* was established as the test organism, rather than the general group of fecal coliform organisms, 2) the standard for *E. coli* was set at 130 organisms/100 ml (calculated as a 30 geometric mean with a minimum of 5 samples), with a single sample maximum of 300 organisms/100 ml, rather than 200 organisms/100 ml and no single sample maximum.

This private study summarizes *E. coli* counts for 12 sites on the Michigan shoreline of the St. Clair River during 1995 and 1996; this data was provided to the author by the St. Clair County Health Department. The sites are located between the Blue Water Bridge down river to Algonac. Data from these years are compared to data from 1986 to 1994. This comparison is subject to some uncertainty because of the change in standards noted above. To allow for a comparison of the fecal coliform counts to the *E. coli* counts, Dufour's (1991) approximation of "*E. coli* count = 0.80 (fecal coliform count)" was used. This number was determined in areas studied by Dufour and may not be entirely accurate for the St. Clair River.

The Chrysler Park North site showed the highest frequency of levels above 200 organisms/100 ml and the largest variability. The 2 St. Clair sites have shown a marked improvement in recent years following exceptionally poor performances in 1987 to 1989. High levels were seen in 1989 at almost all the sites which many just reflect a change in sampling procedure. Note: the RAP yardstick for bacterial levels is 33 organisms/100 ml.

The Chrysler Park North site showed the most frequent levels above Michigan's acceptable levels.

Data available: percentage of *E. coli* levels over 100 organisms/100 ml and 200 organisms/100 ml for all sites between 1986 and 1996; incidents of exceeding mandatory maximum *E. coli* count; percent of weekly samples exceeding 200 organisms/100 ml at 4 sites (see Appendix 1)

2.2.1.10 Analysis of *E. coli* Counts from the Ontario Shoreline of the St. Clair River, Supplement 1997

Source: Harris 1997c
Where: St. Clair River, 18 sites on the Ontario side
What: analysis of *E. coli* bacterial data for Ontario, 1997 supplement

This private study is a follow-on to previous work (Harris 1994, 1995a) and reports on *E. coli* data collected on the Ontario side of the St. Clair River between 1984 and 1996. The data that was collected before 1986 was based on fecal coliform levels. To allow for a comparison of the fecal coliform counts to the *E. coli* counts, Dufour's (1991) approximation of "*E. coli* count = 0.80 (fecal coliform count)" was used. This number was determined in areas studied by Dufour and may not be entirely accurate for the St. Clair River.

Almost all the sites showed a decrease in the mean levels after the installation of new sewer lines in 1994, including sites upstream of the sewers. The reason for this was unclear. Relatively high levels were noted in the stretch of river from about Bowen Creek to Reagan Park. This area corresponded approximately to the area with the highest levels before the new sewer installation and also included one of the remaining portions of shoreline not serviced by sewers.

Levels at Canatara Park and Centennial Park Sarnia were within the ranges normally experienced for these sites; however, there was a slight decrease in 1994 to 1996. A trend to lower levels was also recorded at Willow Park, Lambton Cundick Park, and Brander Park starting in 1990 through to 1996. The range for the Canatara Park data (0-30%) corresponded to the range for the Lighthouse Park data on the Michigan shoreline suggesting good agreement between Canadian and American data. Also, levels of contamination in the more recent years are similar on both sides of the river.

The report recommends that the stretch of river between Courtright and Sombra be monitored in 1998 to determine the cause of persistently high levels of *E. coli*. If high levels are subsequently observed to persist, then the recommendation is made to undertake a more detailed sampling program in 1999, to determine the source or sources of contamination.

Data available: *E. coli* levels for 18 sites between 1984 to 1996; percent of weekly samples exceeding 200 organisms/100 ml at 5 sites (see Appendix 1)

2.2.1.11 Walpole Island First Nation Bacteria Monitoring Results

Source: Walpole Island First Nation 1997, 1996
Where: unspecified stations on St. Clair, Chematogen, Snye rivers near Walpole Island (i.e., St. Clair delta)
What: bacteria counts, summers of 1994, 1995, and 1996

The 1994 and 1995 results of this monitoring program were published in the May 1996 issue of the *Nin-Da-Waab-Jig News*, in graphical format. The program, intended to monitor recreational/beach areas in and around Walpole Is., is carried out by staff of the Walpole Island Health Centre. The analyses themselves, for each of 1994, 1995, and 1996, were carried out by the Ontario Ministry of Health, Laboratory Services Branch. Levels above the RAP yardstick of

33 organisms/100 ml were noted in all 3 summers, with levels generally lower in 1995 than in 1994, but climbing again in 1996, and generally highest in the St. Clair and Snye rivers. The highest count, of 710 (est.) organisms/100 ml, was recorded in August 21, 1996, in the Snye river.

Data available: weekly counts from late June to early September, for each of the 3 water courses, for each of the 3 years

2.2.1.12 Analysis, Results of 1997 Sampling for Coliform in Lake Huron and the St. Clair River

Source: St. Clair County 1997
Where: St. Clair River, numerous sites
What: analysis of fecal coliform and *E. coli* bacterial data for Michigan, 1997

Water samples were collected by the St. Clair County Health Department and analyzed for *E. coli*, between May and August 1997, for numerous sites along the St. Clair and Black rivers, the Black River Canal, and the creeks draining into and along the beaches of Lake Huron.

There was significant evidence of contamination from heavily polluted streams and drains, combined sewer overflows and surface water runoff. The maximum level in the St. Clair River, 764 organisms/100 ml, was noted offshore of the St. Clair City boardwalk. Levels were highest in the St. Clair River between Marysville and the City of St. Clair, with several samples above the single-sample maximum guideline of 300 organisms/100 ml of the Michigan Water Quality Standards. Although outside the AOC, the results from the Lake Huron creek and beach sampling is significant for the clear correlation between beach contamination and the proximity of that beach to a polluted waterway. There was also a clear correlation between precipitation events and increases in contaminant levels at beaches. This ultimately necessitated the closing of beaches.

The analysis concluded:

> *"1. There is significant evidence of contamination of the water of Lake Huron, Black River, the Black River Canal, and the St. Clair River, based upon the samples collected...*
>
> *2. The path of this contamination is from heavily polluted streams and drains, combined sewer overflows and surface water runoff...*
>
> *3. There is a clear correlation between beach contamination and the proximity of that beach to a polluted waterway.*
>
> *4. There is a clear correlation between precipitation events and increases in*

contamination levels resulting in beach closings.

5. There is a downstream decrease in pathogen indicators ...probably a result of cumulative effects of time, dilution and temperature.

6. If levels of contamination in the St. Clair River rise after decreasing below health advisory levels this is a clear indication of an additional contaminant input from another source...

7. Based upon data available from the samples ...there is no coliform indicated contamination in the St. Clair River on the U.S. side at Marine City or Lake St. Clair.

8. Sewer separation ...will not eliminate health advisories and beach closings, nor meet delisting criteria for the impaired use. "

Data available: geometric mean *E. coli* and fecal coliform counts for numerous sites; includes individual samples, maximum, minimum and median; number of samples exceeding 300 colonies/100 ml for 25 St. Clair River sites; 2 site maps (see Appendix 1)

2.2.1.13 Memorandum, Restrictions on Drinking Water Consumption, St. Clair River

Source: OMOE 1997a
Where: St. Clair River, general, Canadian side
What: water treatment plant shutdowns, 1994 to early 1997

As confirmed in a memorandum by H.O. Wigle, Sarnia District Manager, Ontario Ministry of the Environment, there have been no Ministry-issued drinking water advisories or water treatment plant shutdowns on the Canadian side of the St. Clair River since November of 1994. This information is current to early March of 1997. Also confirmed in this memorandum is the general and dramatic decline in the number of spills reported to the OMOE, from a high of 135 (all sources) in 1986 to just 19 in 1996. This decline was directly attributed to the efforts of industry, regulators, and concerned community organizations in improving spill detection, containment, and remediation measures.

Data available: table summarizing number of OMOE-reported spills for period 1986-96, broken down by industrial, marine, other, and unknown sources (see Appendix 2)

2.2.1.14 Memorandum, St. Clair River Water Quality

Source: MDEQ 1997a

Where: St. Clair River, general, US side
What: mandatory water treatment plant closures

This memorandum is a direct complement to OMOE 1997c, and is from T.A. Benton, Supervising District Engineer, Community Water Supply Section, Michigan Department of Environmental Quality (MDEQ--formerly the Department of Public Health), to F. Kemp, Utilities Superintendent for the City of Port Huron and a BPAC Co-Chair. The letter confirms that for the last few years there have been no mandatory closure notices issued to water treatment plants on the United States side of the river.

The letter points out that this does not include voluntary precautionary closures for some intakes in response to minor spills or other events, as for example during the spring 1996 remediation of the Cole Drain sediments on the part of Dow Chemical Canada. Mr. Benton noted anecdotal reporting by the operators of the 7 area plants that general water quality is improving, with trihalomethane concentrations dropping.

2.2.1.15 Drinking Water Quality Data, St. Clair River Water Treatment Plants, Michigan

Source: MDEQ 1997b
Where: 6 sites along the St. Clair River
What: drinking water quality, post-treatment and pre-distribution

The Drinking Water and Radiological Protection Division (DWRP), Michigan Department of Environmental Quality (MDEQ), monitors the quality of Michigan's drinking water supply. This monitoring is carried out in part by means of periodic sampling at drinking water treatment plants, following treatment and prior to distribution. The parameters subsequently analyzed include inorganic chemicals (including metals), volatile organic compounds, synthetic organic compounds, radionuclides, microbes, and secondary contaminants. For the most problematic contaminants, the references to which results are compared are referred to as maximum contaminant levels (MCLs), which are enforceable. The periodicity of sampling varies with contaminant, and according to the discretion of MDEQ dependent on actual sample results.

The 6 Michigan water treatment plants drawing water from the St. Clair River are located at: Port Huron, Marysville, St. Clair, East China Township, Marine City, Algonac, and Harsens Is (the last in seasonal operation only). Analytical results for specific inorganic, volatile organic, and synthetic organic contaminants at these plants, for the period 1989 to 1996, indicate that there were only 2 occurrences above MCL standards. These were in the levels of thallium at the East China Township and St. Clair plants in August of 1992. Several other occurrences of levels above non-enforceable "secondary maximum contaminant levels" (intended as taste, odour, and/or aesthetic standards) were noted in the levels of aluminum at several plants: East China Township and Harsens Is. in 1990; and Port Huron, Marine City, and Algonac in 1990 and 1991.

Data available: tables containing sample source information, sample and analysis dates,

analytical results, partial MCL standards, and analysis method detection limits for each of the parameters analyzed for

2.2.1.16 Memorandum, Past and Current Activities, Dow Chemical Canada

Source: Dow Chemical Canada 1997a
Where: Dow site, Sarnia
What: summary of Dow implementation initiatives, includes 1996 discharge data

This document presents a summary of Dow's efforts at implementing pollution abatement, control, and remediation measures. Included is a table summarizing 1996 discharge data for 4 outfalls in terms of parameter levels above RAP yardstick values. The report notes that the yardstick values are intended for ambient conditions, not outfalls. Levels above yardstick values were noted for chromium, mercury, zinc, and carbon tetrachloride. Mercury levels were an order of magnitude greater than the yardstick value, zinc levels were consistently 3 orders of magnitude greater, and carbon tetrachloride twice the yardstick level. The latter is due to a known source which will be addressed during remediation efforts.

Data available: analytical data on north pumphouse, 2nd St. outfall, 3rd St. outfall and 4th St. outfall discharges, for most of the RAP yardstick parameters for water (see Appendix 3)

2.2.1.17 Memorandum, Completed Actions for the RAP Implementation Annex

Source: Esso Imperial Oil 1997
Where: Esso refinery site, Sarnia
What: implementation of remediation efforts in response to RAP Stage 2, recommendations to alter RAP yardstick parameter for arsenic, re-examine yardsticks for cadmium, chromium, lead, and total phosphorus, summary of spill incidents

This memorandum confirms: 1) that the Esso Imperial refinery did not have any spills for the 20 month period prior to March 1997, and states 2) that the levels of total phosphorus in Esso's current effluents meet the RAP Stage 2 yardstick; total phosphorus loadings are at a minimum beyond which further reductions are impossible. For further information, see Section 2.1.1 of the *Implementation Annex 1997.*

Data available: NPRI emissions for 1994-95, for both the refinery and chemical plant, with projections for 1996-98 (see Appendix 3)

2.2.1.18 Temporal and Spatial Water Quality Trends in the St. Clair River, Draft Abstract

Source: Chan and Harrison 1997
Where: St. Clair River: Port Lambton (mouth) and Point Edward (head) monitoring stations
What: temporal and spatial water quality trends, 1987 to 1995

The objectives of this Environment Canada (EC) monitoring program are: 1) to establish a reliable database for long-term water quality trend assessment, 2) to assess changes at the head and mouth of the St. Clair River, and 3) to model qualitative loading estimates from Lake Huron and the St. Clair River. This draft abstract presents data on only those contaminants that have exhibited significant temporal and/or spatial changes in level over the monitored period, from 1987 to 1995.

This monitoring program is based on a sampling interval of 2 weeks--the quoted concentrations are means of all the sample results for a given contaminant parameter for a given year. Both water and suspended sediment load were analyzed, although only the water data has been addressed in terms of the RAP yardstick levels.

In a comparison of the water data from the 2 stations at Point Edward and Port Lambton, most major ions and nutrients such as magnesium, potassium, calcium and nutrients (nitrogen and phosphorous) showed no noticeable differences. Sodium concentrations at Point Edward have decreased gradually since 1990 but have decreased substantially at Port Lambton. Prior to 1991, both sodium and chloride concentrations at Port Lambton ranged 30 to 60% higher than at Point Edward, by 1995 levels were essentially identical at both stations, suggesting significant reductions in loadings along the St. Clair River.

Organochlorine pesticide concentrations were similar at both locations and similar to background levels in Lake Huron. Industrial chlorinated chemicals showed definitive differences between Port Lambton and Point Edward water samples. The compounds 1,3,5 tri-chlorobenzene and hexachlorobutadiene were present almost exclusively at Port Lambton. Concentrations of pentachlorobenzene and hexachlorobenzene were higher at Port Lambton. The gradual decline in levels of both of these compounds from 1988 to 1995 was interpreted as arising from government regulations and declining use.

In terms of suspended sediment, many industrial chemicals (i.e., octachlorostyrene, hexachlorobutadiene, 1,3,5 trichlorobenzene, and pentachlorobenzene) were found almost exclusively at Port Lambton or were generally present at higher levels than at Point Edward. Other chemicals such as hexachlorobenzene and polyaromatic hydrocarbons (PAHs) were also higher at Port Lambton. A one-year “spike” in the levels of phenaphthalene, pyrene, and fluoranthene occurred in 1990 at Point Edward, the only case of Point Edward levels far exceeding Port Lambton levels for the contaminants analyzed for; these 3 compounds are the only contaminants whose suspended sediment levels remained higher than at Port Lambton through to 1995.

Seasonal and yearly trends: nitrite + nitrate and reactive silicate concentrations increased slightly between 1987 and 1995, coinciding with values for the Niagara and St. Lawrence rivers. Organochlorine pesticides, hexachlorocyclohexanes (α-HCH and lindane), dieldrin, hexachlorobutadiene and 1,3,5 trichlorobenzene showed an overall decline in concentrations from 1987 to 1995; however, seasonally (summer) higher concentrations were noted. Suspended sediment contaminants showed no obvious trends. The concentrations of octachlorostyrene were generally lower in the 1990s than in the 1980s.

Data available: tables summarizing levels in metals, organics, and toxics for the period 1987-1995 for both water and suspended sediment; graphs showing trends over time for select contaminants (see Appendix 4)

2.2.1.19 1993 Annual Report, Water Quality Assessment Program

Source: Lambton Industrial Society (LIS) 1994
Where: Courtright pumphouse station on the St. Clair River
What: continuous (once per hour) water monitoring for target compounds

The Water Quality Assessment Program is conducted on behalf of the Lambton Industrial Society (LIS) by Ortech Corporation. The goal of this program is to provide a reliable continuous monitor with the capability to detect and allow timely response to elevated levels of target compounds in the St. Clair River. Water temperature and pH are also monitored.

Analytical results are summarized primarily on the basis of numbers of occurrences above threshold values: 1) the method detection limit for the parameter of concern (MDL--the minimum concentration of a substance that can be identified, measured and reported with 99% confidence that the concentration is greater than zero), 2) the "LIS advisory" level, the level at which LIS member companies are notified through the Early Automatic Response System (EARS), and 3) the "OMOE advisory" level, the level at which the OMOE is advised as a courtesy. The OMOE advisory level is set at half the long-term OMOE drinking water guideline or 10 ppb, whichever is lower. None of the OMOE advisory levels are higher than the RAP Stage 2 yardsticks. The LIS advisory level is set between the MDL and the OMOE advisory level.

In 1993, 8,616 samples were analyzed for 20 different compounds (primarily volatile organics) resulting in 172,320 separate results. Only 514 of the results showed values higher than the MDL. Only 8 results, all for benzene, were noted above the OMOE advisory levels. Compared to 1992, there was a slight decrease in occurrences above the MDL (674 to 514) and a notable reduction in OMOE advisory levels (27 to 8). As expected, pH levels did not fluctuate notably during 1993, and the temperature of the river was comparable to that of previous years.

Data available: tables summarizing method detection limits, historical episodes with concentrations greater than 1 ppb for the target compounds (note: the specific

parameters analyzed for changed over the period summarized, as new target compounds were added and others consistently below the MDL and not anticipated to appear in future were removed), monthly summaries of results for 20 contaminants (expressed in terms of numbers of occurrences above threshold guidelines--not absolute values) (see Appendix 5)

2.2.1.20 1994 Annual Report, Water Quality Assessment Program

Source: LIS 1995
Where: Courtright pumphouse station on the St. Clair River
What: continuous (once per hour) water monitoring for target compounds

This report summarizes the Water Quality Assessment Program for 1994, and is a follow-on to the LIS 1994 report. In 1994, 8,639 samples were analyzed for 20 different compounds resulting in 172,780 separate results. Only 261 of the results showed values higher the MDL. Only one episode, consisting of 6 results, equalled or exceeded the LIS-defined "OMOE advisory levels". In this episode, "*ethyl benzene values (maxima 13.5 ppb) exceeded MOEE drinking water guidelines based on aesthetic criteria but remained well below the EPA's short term health criterion...*". Compared to the 1993 results, 1994 showed a notable reduction in the number of occurrences above MDLs and a decline in the number of occurrences above the OMOE advisory level. As expected, pH levels did not fluctuate notably during 1994. The temperature of the river was comparable to that of previous years.

Data available: tables summarizing method detection limits, historical episodes with concentrations greater than 1 ppb for the target compounds (note: the specific parameters analyzed for changed over the period summarized, as new target compounds were added and others consistently below the MDL and not anticipated to appear in future were removed), monthly summaries of results for 20 contaminants (expressed in terms of numbers of occurrences above threshold guidelines--not absolute values) (see Appendix 5)

2.2.1.21 1995 Annual Report, Water Quality Assessment Program

Source: LIS 1997a
Where: Courtright pumphouse station on the St. Clair River
What: continuous (once per hour) water monitoring for target compounds

This report summarizes the Water Quality Assessment Program for 1995, and is a follow-on to the LIS 1995 report summarizing the program for 1994. In 1995, 8,653 samples were analyzed for 20 different compounds resulting in 173,060 separate results; 1030 of the results showed values higher than the MDL. It should be noted, however, that the higher number compared to 1994 is a result of the improvement in analytical techniques and the downward revision of MDLs

in mid 1995. Only 1 result, for perchloroethylene, equalled or exceeded the OMOE advisory levels. This result exceeded the California Department of Health Services' drinking water guideline but remained well below the EPA's short term health criterion. A notable reduction in occurrences above the OMOE advisory levels is evident. As expected, pH levels did not fluctuate notably in 1995, and river water temperature was comparable to that of previous years.

A seasonal variation in the detection of toluene was noted in this study. The presence of toluene in concentrations of greater than or equal to 0.2 ppb was noted. The pattern that emerged was a correlation between numerous toluene detections and the pleasure boat season. Summer levels were higher than winter levels, weekend levels were higher than weekdays and daytime levels were higher than nighttime. The presence of toluene in the gasoline used by the pleasure boats also supports this correlation.

Data available: tables summarizing method detection limits, historical episodes with concentrations greater than 1 ppb for the target compounds (note: the specific parameters analyzed for changed over the period summarized, as new target compounds were added and others consistently below the MDL and not anticipated to appear in future were removed), monthly summaries of results for 20 contaminants (expressed in terms of numbers of occurrences above threshold guidelines--not absolute values) (see Appendix 5)

2.2.1.22 LIS Water Station Summary Report--Preliminary Summary, 1996 Water Quality Assessment Program

Source: LIS 1997b
Where: Courtright pumphouse station on the St. Clair River
What: continuous (once per hour) water monitoring for target compounds

This report summarizes the Water Quality Assessment Program for 1996, and is a follow-on to the previous annual reports (note: at time of writing, only a preliminary version of this report was available). Of the sample results collected for 1996, 3070 showed values higher the MDL, and only 10 of these--for benzene--equalled or exceeded LIS's OMOE advisory levels.

Data available: monthly summaries of results for 20 contaminants (expressed in terms of numbers of occurrences above threshold guidelines--not absolute values) (see Appendix 5)

2.2.1.23 Memorandum, pH Data for the St. Clair River and Industrial Sources

Source: OMOE 1996a
Where: St. Clair River, from Sarnia to the delta

What: pH data for the St. Clair River and industrial sources

Three studies were reevaluated to determine if Warwick's (1996) observation of a decrease in pH levels in the Chenal Ecarte area could be verified through other observations, and if changes to the existing abatement program for pH control were warranted. The first study, from 1986 to 1995, for 3 sites showed no incidences of low pH levels. A summer of 1990 study observed no decreasing trend in pH. No trends were apparent with respect to distance or time in another 1989 to 1994 study.

The reduction in pH observed in the original study was felt to be a result of localized sediment conditions. Delta areas of rivers contain more sediment than the main channels upstream. The low pH in the sediment appears unrelated to the pH in the river water. Reduced pH may be natural in sediment due to biodegradation and local particulate phenomena/chemistry.

Data available: numerous tables reproduced from various sources showing pH levels in the St. Clair River 1988-94

2.2.1.24 Cole Drain (Sarnia) Contaminant Concentrations and Loadings

Source: OMOE 1996b
Where: Cole Drain (Sarnia)
What: Effluent and suspended sediment samples collected in the final effluent loading chamber of the Cole Drain, water samples taken upstream, downstream, and in the Cole Drain discharge plume

This report details effluent and suspended sediment (particulate) samples that were collected in June and August, 1995, from the final effluent mixing chamber of the Cole Drain. These samples were taken to determine the concentrations and loadings of aqueous and particulate-associated contaminants. As these samples were collected from the effluent chamber they do not represent ambient conditions and are therefore not compared to RAP yardstick values.

However, water samples were obtained by divers from 3 locations within the St.Clair River (upstream, downstream, and in the effluent plume of the Cole Drain) for comparison with effluent samples from the Cole Drain and with water samples taken near Port Lambton for an indication of total contribution of the Cole Drain effluent to the water quality entering Lake St. Clair.

The Cole Drain discharge appears to constitute only a small fraction of the total St. Clair River load. Loadings of some contaminants appear to be decreasing over time (Kjedlahl nitrogen, oil

and grease, suspended solids, aluminum, copper, iron, molybdenum, zinc, phenolics, hexachloroethane, hexachlorobutadiene, and 1,2,4,- and 1,3,5-trichlorobenzene).

Water samples exhibited parameter levels above RAP yardstick values from the discharge plume and downstream of outfall locations. There is no indication of where the discharge plume sample was collected (i.e., at the outfall, 2 m from outfall, 10 m from outfall, etc.), however, levels above yardstick values were recorded for hexachloroethane, hexachlorobutadiene, 2,4,5,-trichlorotoluene, pentachlorobenzene, and hexachlorobenzene. The downstream sample had levels of hexachloroethane, hexachlorobutadiene, and hexachlorobenzene above yardstick values.

This report draws the conclusion that the Cole Drain effluent and/or particulates are an important source of aluminum, cobalt, copper, iron, manganese, molybdenum, nickel, vanadium, zinc, hexachloroethane, 1,2,4- and 1,3,5-trichlorobenzene, hexachlorobutadiene, pentachlorobenzene, hexachlorobenzene, octachlorostyrene, and total polychlorinated biphenyls (PCBs) to the river ecosystem. Particular attention should be paid to the more persistent and bioaccumulative chlorinated aliphatic and aromatic compounds (i.e., hexachlorobutadiene, pentachlorobenzene, hexachlorobenzene, and octachlorostyrene).

It was also concluded that with the exceptions of aluminum, chromium, copper, iron, and, tin, particulate-associated contaminants contribute less than 25% of the total effluent loadings from the Cole Drain.

The continued presence of chlorinated aliphatics and aromatics, and of polychlorinated dibenzo-p-dioxin/F congeners and toxic isomers indicate ongoing input to the Cole Drain system from landfill(s) bordering the system upstream and through resuspension of contaminated sediments within the system. It is recommended that the source(s) of these inputs be identified and terminated and the contaminated sediments be removed.

Data available: table summarizing water sample results for chlorinated aromatic and aliphatic compounds (see Appendix 6)

2.2.1.25 Memorandum, St. Clair Sediment, Dow 1st St. Area

Source: Dow Chemical Canada 1997b
Where: Dow 1st St. site, Sarnia
What: Summary of remediation measures addressing chemical pool

The accidental 1985 percholoroethylene spill offshore of the Dow 1st St. site resulted in the discovery of a “chemical pool” atop the river bottom sediments, unrelated to this spill. This pool, which on subsequent analysis was found to consist of an approximately 60:30 mix of undiluted perchloroethylene and carbon tetrachloride, has been the focus of monitoring and remediation efforts on the part of Dow since its discovery, including:

1985-86	initial removal of chemicals via divers and vacuum trucks; monitoring indicates no discharges of these in plant discharges to sewers
1986	one of sewers removed from service; groundwater barrier installed isolating Dow site from shoreline
1990	trench and sump system excavated to divert material to enclosed system for removal
1990-95	small chemical puddles continue to be found; removed by divers/vacuums
1993	all sewers sealed from river
1995	increase in quantity of chemical puddles; sediment cores taken at 230 locations
1996	study indicated that entrenchment system inadequately designed and situated; system redesign and subsequent implementation; as of December 12, 1996, no puddles were observed on the bottom sediment in this area--the first time these puddles have been absent since monitoring began in 1986

Data available: composition of chemical material (weight %); amount of material removed from area in litres 1986--1996

2.2.2 Sediment and Sediment/Benthic Quality

2.2.2.1 1994-95 St. Clair River Sediment Program Defining Spatial Extent and Environmental Conditions

Source: LIS 1997c
Where: 3 priority 1 zones, Sarnia industrial area waterfront
What: integrated sediment, toxicity, benthic invertebrate study

This study was carried out by Pollutech Enviroquatics Limited for the LIS, and was designed to test the hypothesis that "*contaminated sediments are causing deleterious impacts on the aquatic biota of the St. Clair River*". It follows earlier studies that demonstrated a trend of continuing improvement in sediment quality since the early 1970s. The area of sediment degradation, which in 1985 extended in a narrow band along the Canadian shoreline some 12 km downstream of Sarnia (Griffiths 1989), was reduced to 3 areas or zones within 9 km of Sarnia at the time of the Stage 1 document. These zones (identified here as zones 1, 2, and 3) were identified in the St. Clair River RAP as "priority 1" areas due to sediment contamination and impacts on the benthic macroinvertebrate community. These are currently located along the Canadian shoreline between Sarnia and the mid-point of Stag Island, and were the focus of this study.

Three reference stations were also included in this study, representing: 1) sediment conditions upstream of major industrial/municipal inputs, 2) sediment conditions in a healthy area downstream of major industrial/municipal inputs, and 3) an intermediate/unimpaired benthic

community assemblage defined by a benthic macroinvertebrate survey undertaken on behalf of the OMOE (Tarandus Associates Limited 1993). All sampling, for both study samples and reference samples, took place in 1994 except for 3 stations in zone 2 that were sampled in 1995.

An integrated study design was used, incorporating the 3 primary areas of investigation: bulk sediment chemical analysis, laboratory sediment toxicity analysis, and benthic assemblage assessment. With the premise that no one assessment tool provides reliable and complete results, the results from each of these investigations were integrated in a Sediment Quality Triad, to provide a method of defining the quality of St. Clair river sediments by means of relating the impacts of sediment quality on the ecosystem. The integration of results was facilitated by means of an interpretation table, identifying the potential overall outcomes (conclusions) arising from the combination of individual outcomes from each of the 3 areas of study. The results from each of the 3 areas of investigation were statistically analyzed to assess/verify relationships and trends.

The chemical parameters analyzed for in the sediment bulk chemical analysis include: polyaromatic hydrocarbons (PAHs), organochlorine pesticides, polychlorinated biphenyls (PCBs), pentachlorobenzene, hexachlorobenzene (HCB), hexachloroethane, hexachlorobutadiene, 2,3,4-trichlorotoluene, and octachlorostyrene (OCS), metals, and others (loss on ignition, total organic carbon, oil and grease, total Kjeldahl nitrogen, total phosphorus, and sediment physical parameters). The test species selected for mortality testing included fathead minnows, tubifex worms, mayfly larvae, and midge larvae. Benthic invertebrate assessment was carried out by determining the diversity and density of organisms in each sample.

The findings of the study are summarized for each zone, with conclusions based on the interpretation table of the Sediment Quality Triad.

Zone 1 (6 stations)

Results

- Sediment: All stations in this zone reported contaminant levels above RAP yardstick levels in at least one chemical group. Levels above Provincial Sediment Quality Guideline Lower Effect Levels (LELs--below which contaminant levels are deemed to be tolerable by most benthic organisms) were noted for PAHs, HCB, PCBs, cadmium, copper, lead, mercury, nickel, zinc, total organic carbon, and total Kjeldahl nitrogen at one or more stations. Levels above Severe Effect Levels (SELs--above which contaminant levels are deemed to have a pronounced effect on benthic organisms) were noted for HCB and mercury at 6 and 2 stations, respectively.
- Toxicity: Interpreted minnow toxicity was noted for 5 stations, reduced tubifex worm reproduction for 3, and reduced mayfly and midge growth for one station each.
- Benthic Assessment: Benthic alteration was distinguishable from the reference sites at 2 stations.

Conclusions

- toxic chemicals are stressing the system: 5 stations
- strong evidence of pollution-induced degradation from sediments: 2 stations

Zone 2 (10 stations)

Results

- Sediment: All stations in zone 2 reported contaminant levels above RAP yardstick levels in at least one chemical group. Levels above LELs were noted for PAHs, HCB, PCBs, arsenic, cadmium, copper, lead, mercury, nickel, total organic carbon, and total Kjeldahl nitrogen at one or more stations. Levels above SELs were noted for HCB and mercury, at 2 stations each.
- Toxicity: Interpreted minnow toxicity was noted for 3 stations, reduced tubifex worm reproduction for 5, reduced mayfly growth for 3, and reduced midge growth for 1 station.
- Benthic Assessment: Benthic alteration was distinguishable from the reference stations at 2 stations.

Conclusions

- contamination is not bio-available (may not agree with established criteria for biological effect): 1 station
- toxic chemicals are stressing the system: 7 stations
- strong evidence of pollution-induced degradation from sediments: 2 stations

Zone 3 (12 stations)

Results

- Sediment: All stations in zone 3 reported contaminant levels above RAP yardstick levels in at least one chemical group. Levels above LELs were noted for PAHs, HCB, PCBs, cadmium, copper, lead, mercury, nickel, total organic carbon, and total Kjeldahl nitrogen at one or more stations. Levels above SELs were noted for HCB at 1 station and for mercury at 3 stations.
- Toxicity: Reduced tubifex worm reproduction was noted for 8 stations, reduced mayfly growth for 2 stations, mayfly toxicity for 2 stations, reduced midge growth for 1 station, and midge toxicity for 1 station.
- Benthic Assessment: Benthic alteration was distinguishable from the reference stations at 4 stations.

Conclusions

- contamination is not bio-available (may not agree with established criteria for biological effect): 2 stations
- contamination is not bio-available or alteration is not due to toxic chemicals: 1 station
- toxic chemicals are stressing the system: 6 stations

- strong evidence of pollution-induced degradation from sediments: 3 stations

Reference Sites (3 stations)

- toxic chemicals are stressing the system: all 3 stations

The report concluded that sediment contamination is having an effect at all sites, including the reference sites. Further: *"If it is assumed that the reference stations adequately reflect the benthic assemblage that would be present within the 3 study zones had chemical contamination not been a concern, then the stations that differentiate from the reference stations likely do so due to chemical contamination within those sediments or in the water column."*

Data available: tables summarizing sediment chemistry, sediment toxicity for each of the 4 test species, benthic invertebrate density/diversity indices, statistical analyses, and sample collection field observation sheets (see Appendix 7)

2.2.2.2 Memorandum and Appendices, Sarnia Harbour Dredging 1996

Source: Ecologistics Limited 1996
Where: Sarnia Harbour, St. Clair River head (Lake Huron), and southeast bend cutoff channel
What: sediment and contaminant data from proposed dredging sites

Sediment samples were collected from Sarnia Harbour in 1996 (8 cores) within an area identified for maintenance dredging. Samples were analyzed for contaminants to determine the possibility of open lake disposal. An additional 4 samples were collected from the head of the St.Clair River in Lake Huron at the proposed dredge material disposal location.

Six of the harbour samples were analyzed for contaminants in light of Provincial Sediment Quality Guidelines (PSQG). All 6 samples marginally exceeded the PSQG Lowest Effect Levels (LELs) for total organic carbon. The sample from the outfall at the northeast corner of the elevator slip exceeded the PSQG LEL for mercury, cadmium, and lead, in addition to total organic carbon. This sample also showed an levels of grease and oil above the RAP yardstick value.

Two of the river mouth samples had parameter levels above PSQG LELs: one for arsenic and the other for lead.

Fourteen sediment samples were also taken along the southeast bend cutoff channel, for analyses prior to routine maintenance dredging of the navigation route. Five of the samples showed mercury levels above the RAP yardstick level. Dredged materials were to be disposed of in the existing Confined Disposal Facility on Seaway Island.

Data available: tables summarizing results of sample analyses, maps showing areas to be dredged and disposal locations (see Appendix 8)

2.2.2.3 Laboratory Sediment Bioassay Report on Upper St. Clair River Sediments in the Vicinity of Esso, Cole Drain, Polysar and Dow 1994-95

Source: OMOE 1996c
Where: downstream of the Esso intake, around the Cole Drain, along the Polysar property and in the vicinity of the Dow 1st and 2nd St. sewers, Sarnia
What: sediment bioassay analyses

During June 1994, 39 locations were sampled along 13 transects extending from the Canadian shoreline. Repeat collections were made for 6 locations along 2 transects in November 1994 and an additional 4 locations were sampled along different transects in May 1995. The transects started between 10 and 20 m from shore at 10 to 20 m intervals, with 3 samples per transect. In each case the top 5 cm of surficial sediments were collected from a given location. Note: the sediment contaminant data is the same as that cited in Beak International Incorporated (1996).

Analyses of bulk sediment concentrations from the 1994 and 1995 field samples indicated numerous occurrences of parameter levels above both the RAP yardsticks and the PSQG LELs.

This report also outlines the results of laboratory sediment bioassay studies. Sediment contamination levels were replicated in a laboratory and experiments were run on mayflies, midges, and fathead minnows. Toxicity and bioassay results are presented. A series of spatial and temporal trend analyses were run based on the bioassay and toxicity studies. This paper represents one of the few studies that examined the effect of naturally contaminated sediment to benthic organisms in terms of critical body residues for multiple chlorinated organic compounds.

Sediment analyses indicated that concentrations of chlorinated benzenes, octachlorostyrene and mercury were dominant in sediments from the Dow area. Visual and olfactory observations for many of the samples taken in the vicinity of Esso, Polysar, and the Cole Drain also suggested the occurrence of other petroleum or fuel-like substances. Based on the bioassay experiments the report concluded that physical sediment properties did not appear to be a source of any adverse underlying stress to any of the biota tested.

The toxicity tests from the 1994 samples indicated that those sediments with the most deleterious biological responses were found downstream of the Esso intake 30 m offshore, downstream of the Cole Drain 10 and 30 m offshore, and 50 m downstream of Dow's 1st Street sewer 37 m offshore. An additional 6 sites, downstream of industrial and municipal point sources, elicited a moderate to high degree of toxicity (>40% mortality) to mayflies and midges.

Data available: tables summarizing contaminant concentrations in sediments and bioassay/toxicity results (see Appendix 7)

2.2.2.4 Environmental Assessment of Upper St. Clair River Sediments and Benthic Macroinvertebrate Communities 1994

Source: Beak International Incorporated 1996 (Draft)
Where: downstream of the Esso intake, around the Cole Drain, along the Polysar property and in the vicinity of the Dow 1st and 2nd St. sewers
What: sediment contaminant analysis and macroinvertebrate inventory

A complement to OMOE 1996c, the objective of the study was to assess the present environmental condition of the upper St. Clair River by focusing on surficial and sediment quality, sediment toxicity, and benthic macroinvertebrate community structure. A total of 39 stations were sampled in June 1994. Note: the sediment contaminant data is the same as that cited in the OMOE 1996c and LIS 1997c reports.

The report details the results of quantitative cluster analyses run on the benthic macroinvertebrate communities. The 1994 studies noted degraded benthic communities in all areas. The 1994 data supports the sediment quality zones identified in a report by Griffiths (1989) in that the benthic communities from Esso to downstream of Dow are impaired and degraded.

This suggests that there has been little improvement in the health of the benthic invertebrate community in the upper St. Clair River since 1985. This refutes claims made in a 1993 report by Tarandus Associates Limited on behalf of the OMOE in which the Dow waterfront was characterized as no longer “severely degraded-toxic” but as “intermediate” (between unimpaired and impaired) based on 1990 samples. It also suggests a more degraded condition than indicated in the LIS 1997c report based on 1994 sampling (see Section 2.2.2.1).

The report outlines those areas identified as priority 1, 2 and 3, based on RAP Sediment/Habitat Task Team categories.

Priority 1 areas were broken down within this report into Class 1a - those areas characterized by sediments with one or more contaminants exceeding their respective PSQG SEL values, $\geq$80% toxicity to one or more of the test species, and a degraded benthic macroinvertebrate community; and Class 1b for those areas that had degraded benthic macroinvertebrate communities and $\geq$80% toxicity in one of the species tested but no SELs.

Priority 2 areas would then be those areas that are not classified despite having toxic sediments and impaired communities. Priority 3 represents areas characterized by sediments with one or more contaminants exceeding their respective PSQG SEL value.

The main Priority 1 areas are located along the Polysar/Bayer waterfront and downstream of the Dow 1st Street sewer along the Dow waterfront. The Dow sites are characterized by levels of mercury and hexachlorobutadiene above their SEL values, while the Polysar/Bayer sites were characterized by total polyaromatic hydrocarbons (PAHs) or hexachlorobenzene above SEL

levels. Limited Priority 1b sites occur along the Esso waterfront.

Sixteen stations were classed as Priority 2, encompassing all remaining sites along the Dow waterfront, one opposite Esso, 4 located at the upper end of the Polysar/Bayer waterfront and 2 at the lower end.

None of the areas tested were classed as priority 3.

Data available: tables summarizing macroinvertebrate counts from 39 stations; tables comparing 1990 sediment contaminant levels with 1994 levels (Appendix 7)

2.2.3 Fish, Wildlife, and Benthic Communities

2.2.3.1 Preliminary Analysis of the Marsh Monitoring Program's 1995 Amphibian and Marsh Bird Survey Data

Source: Chabot 1996
Where: Great Lakes Basin
What: Marsh Monitoring Program--studies to aid conservation and rehabilitation of wetlands focusing on waterfowl and amphibian population changes and habitat requirements

Note: although a Great Lakes Basin-wide study not specific to the St. Clair River AOC, this report provides part of the basis for establishing baseline habitat and wildlife population data for use in determining impacts and impairments in AOCs, and be of use to qualified researchers in making spatial comparisons. The study focuses on all 43 AOCs and numerous marshes throughout Ontario and the Great Lakes. All of the preliminary results are expressed in terms of "AOC" and "non-AOC" data, without any specific areas mentioned.

The preliminary result of this analysis is that there are no statistically significant differences between AOC and non-AOC sites, in terms of species habitat use, species present, vegetation diversity--except for 2 species of amphibians which were less frequent in AOC marshes (amphibians overall were encountered in lesser numbers in these marshes but not significantly so).

Data available: tables summarizing survey protocols; distance to nearest Great Lake, wetland permanency, marsh size, submergent vegetation, percentage cover of various habitat types, number of live trees, Braun-Blanquet codes, dominant vegetation, marsh bird abundance, aerial forger abundance, marsh visitor abundance, and amphibians present--all on an AOC versus non-AOC basis

2.2.3.2 Memorandum, Contaminants in Waterfowl and Other Wildlife Information

Source: CWS 1997
Where: southwestern Ontario--background
What: national survey of waterfowl contaminants, Health Canada consumption guidelines, summary of wildlife contaminant data for St. Clair AOC from CWS database

This document contains information of relevance to the "restrictions on fish and wildlife consumption" beneficial use. In 2 parts, this material presents 1) the preliminary results of a waterfowl contaminant survey for Ontario and Quebec and 2) a summary of all of the wildlife contaminant data available for the St. Clair AOC. The latter represents a compilation of data from the CWS-Ontario Region contaminants database and from lab reports that have not yet been entered for the St. Clair River--Lake St. Clair area.

Wildfowl Contaminant Survey

In response to growing concerns over contaminants in waterfowl consumed by the general public and native groups, and because of the general paucity of pre 1988 data in this area, the Canadian Wildlife Service designed and implemented a national survey of contaminant levels in commonly harvested game birds. Initiated in 1988, the goals of this survey were to 1) provide a comprehensive database of contaminants in Canadian game birds to help assess the health risks associated with consumption, as well as provide a basis for issuing consumption guidelines, if required (analogous to those issued by the OMOE for sport fish); and 2) provide information on toxic contaminant levels in game to consumers. Canada currently has no consumption guidelines for game birds for any contaminants. This survey is the first step to establishing the background information for guidelines of this type.

Species chosen for sampling are those most frequently shot by hunters, as reported in annual CWS Species Composition Surveys, supplemented by native harvest statistics. Sites were chosen based on information on known migration paths and breeding areas and, where possible, 10 birds per species per site were collected. Collection took place in the fall by volunteers, government staff, or native groups, and storage of samples was in accordance with established protocols. Breast muscle, representing the edible portion of waterfowl, was analyzed after removal of lead shot. Samples were pooled, with the tissue from 5 to 10 birds composited for analysis. The parameters analyzed for included: moisture content, lipid content, organochlorines, polychlorinated biphenyls (PCBs), total mercury, cadmium, lead, arsenic, selenium, and for selected pools, dioxins and furans.

Ontario data for 1985-86, 1990-91, and 1992-93, and Quebec data for 1991-92 have been evaluated by Health Canada and this information was released in April of 1997. Health Canada stated that for the most part, contaminant levels were either non-detectable or very low and would not constitute a health hazard to consumers, and that as a precautionary measure, careful cleaning and inspection should be carried out prior

to consumption to avoid possible exposure to lead. In addition, preparation should be such that fat is minimized, particularly for fish-eating waterfowl. Based on the analytical results, certain contaminants, species, and sites were recommended for further study. Several AOC's were identified for additional sampling; recommended additional work for the St. Clair AOC included: 1) PCBs and mercury in common merganser from the St. Clair River, and 2) mercury in hooded merganser from Lake St. Clair.

Contaminant Levels in Wildlife from the St. Clair River and Lake St. Clair

The data spans the period 1984-95, and is available for snapping turtle, mudpuppy, and 7 species of waterfowl. The parameters analyzed for include: moisture and lipid contents; chlordane and metabolites; DDT and metabolites; tetra-, penta-, and hexachlorobenzene; dieldrin; endrin; heptachlor epoxide; dioxins; furans; alpha, beta, and gamma hexachlorocyclohexane; mirex and photomirex; octachlorostyrene, PCBs (sum of congeners and total); PCB congeners (at least 48). There are no metals data for this area. Note: this summary does not include any information as to how the analysis results are reported, in terms of whether the values are means, the results of composite sampling, etc. In addition, sample locations are only described in broad terms.

This update will focus on the 1991-95 data. Levels significantly above yardstick levels were noted for the following (RAP yardstick values in brackets):

1) Snapping turtle eggs; Walpole Island; 1995; PCBs 490 ppb (2.5 ppb); dieldrin 2.1 ppb (0.37 ppb)

2) Mudpuppy eggs; Mitchell Bay, Lake St. Clair; 1995; PCBs 480 ppb; dieldrin 9.7 ppb

3) Black-crowned night heron; no location given; 1992; PCBs 2400 ppb; dieldrin 41 ppb

4) Forster's Tern; no location given; 1992; PCBs 8310 ppb; dieldrin 64 ppb; octachlorostyrene 46 ppb (20 ppb)

5) Herring gull; no location; 1991; PCBs 36,380 ppb; dieldrin 117 ppb; octachlorostyrene 109 ppb

It is uncertain whether the data for 1985-87 was ever reported; however, some information from the mid 1980s warrants noting here. Sampling results from 1985-86 for Common Mergansers and American Goldeneyes had indicated high levels of PCBs, hexachlorobenzene, dieldrin, and octachlorostyrene. As these species winter in the St. Clair area, this area (at that time) was a source of contaminants. However, no recent data for these species is presented.

In comparing the 1991-95 with the 1985-87 data, it is observed that levels are generally decreasing, except in a few cases where the levels are drastically elevated. In evaluating these data, however, it should be noted that the sample size is generally small. For the waterfowl data, although some of the values are up to 36 ppm, the authors observe that these levels are generally below the point where the reproductive success of the species concerned is affected. The levels are high enough in herring gulls to fall in the range where enzyme induction and immunosuppression occurs; however, the long-term health effects of this on a colony is not understood.

The report also compares the contaminant levels noted with those of other localities, for example, Hamilton Harbour, the Detroit River (both AOCs), and Long Point (not an AOC) and notes that levels are less in the St. Clair AOC. Specific examples include mudpuppy eggs (with levels half those of Long Point samples), and snapping turtle eggs (with levels less than or comparable to Hamilton samples). In the case of snapping turtle eggs, levels for some parameters were comparable to those in samples from Long Point taken in the mid 1980s that, under controlled studies, exhibited excellent egg development.

Data available: tables summarizing recommendations of areas for further study, waterfowl sampled in Ontario 1988-90, species for which data available for St. Clair AOC, contaminant levels/species for 6 parameters (see Appendix 9)

2.2.3.3 Sport Fish Consumption Advisories 1995-98

Source: OMOE 1995a, 1997b
Where: upper, middle, and lower reaches of the St. Clair River
What: fish consumption advisories, sport fish, based on contaminant levels

The consumption advisories in these freely available Government of Ontario guidebooks are those developed by Health Canada. The advisories subdivide the St. Clair River into 3 reaches: the upper--from the river's mouth to just north of Stag Is., the middle--from Stag Is. to just north of the Lambton Generating Station, and the lower--from the Lambton Generating Station to Lake St. Clair.

The advisories are based on testing carried out on the following contaminant groups: 1) mercury, 2) mercury, PCBs, mirex, pesticides, 3) PCBs, mirex, pesticides, 4) mercury, PCBs, mirex, 5) mercury, (± copper, lead, nickel, zinc, cadmium, manganese, chromium, arsenic, selenium), PCBs, mirex, pesticides, 6) mercury, other metals, 7) dioxins, furans, 8) mercury, PCBs, mirex, pesticides, chlorinated phenols and benzenes, benzenes, 9) PAHs. The advisory categories are: up to 8 meals/month, up to 4, up to 2, 1, and none (based on 8 oz servings).

The 1995-96 guide is based on data from surveys undertaken in 1985 and 1991; the 1997-98 guide is based on 1994 data (note: there was no 1996-97 guide). However, the 1985 and 1991 data was used in the 1997-98 guide if no new examples of a given species/size class were caught during the 1994 survey. The 1994 data was analyzed using a different statistical package than that used for the previous edition, which according to staff of the Sportfish Contaminant Group, OMOE, may have caused some size classes to move up (est. 40%) or down (est. 60%) one consumption advisory class.

1995-96 advisories, for 4 meals or less/month (see source for size classes):

UPPER	MIDDLE	LOWER
walleye	yellow perch	walleye
carp	carp	gizzard shad
	freshwater drum	
	white sucker	
	gizzard shad	

1997-98 advisories, for 4 meals or less/month (see source for size classes):

UPPER	MIDDLE	LOWER
walleye	yellow perch	**walleye (5, 8)** *new*
carp	**carp (5, 7, 8)**	**yellow perch (2)** *new*
white sucker (5)	**freshwater drum (5)**	gizzard shad
	white sucker	
	gizzard shad	

Note: for species listed in bold text additional restrictions are advised for consumption levels in comparison to the previous reporting period; the numbers in parentheses indicate the specific contaminant groups analyzed for and on which the advisories are based; the word "new" indicates that no advisories existed in the previous edition for some or all of the size classes of that species.

2.2.3.4 Ontario Sport Fish Monitoring Program

Source: OMOE 1995b
Where: St. Clair River
What: mercury and organic contaminants (data used in preparation of sport fish consumption advisories)

The Ontario Sport Fish Monitoring Program is carried out jointly by the Ontario ministries of Natural Resources and Environment. The data collected by these agencies is summarized in the form of an annual *Guide to Eating Ontario Sport Fish* which presents consumption guidelines for common sport fish (see preceding summary on "Sport Fish Consumption Advisories 1995-

98”).

Data from the 1994 sampling/analysis program is summarized. The data is subdivided into the same 3 reaches of the St. Clair River presented in the consumption advisories (see preceding summary); specific sample sites along the river are not given. Results for individual chemical parameters are presented for several fish species: mercury, other metals, PCBs, chlorinated pesticides, furans, dioxins, benzenes, phenols, and PAHs.

Contaminant levels above the RAP biota yardstick values were noted in all 3 reaches of the St. Clair River in 1994. In the upper St. Clair, tissue samples from white and redhorse sucker contained levels of mercury, PCB, and octachlorostyrene above yardstick values, results from carp samples were above the PCB and octachlorostyrene yardsticks, and walleye results were above the PCB yardstick.

In the middle St. Clair, both carp and brown trout samples returned results above the PCB yardstick, and carp results were also above the octachlorostyrene yardstick. In the lower St. Clair, white and redhorse suckers, carp, walleye, and yellow perch results were above the yardstick for mercury, redhorse sucker and carp results were above the PCB yardstick, and white and redhorse sucker and carp results were above the octachlorostyrene yardstick.

The maximum value of mercury was 1100 ppb, encountered in a walleye in the lower St. Clair, other values from this sample group ranged from 140 to 640 ppb. The maximum values of both PCBs and octachlorostyrene, in the ppm range, were encountered in carp in the middle St. Clair; although values were also high in the upper St. Clair. These contaminants, in addition to DDE, returned the highest values among those analyzed for--other contaminants returned values that were low or below confident detection limits.

Data available: tables summarizing analytical results for chemical parameters by species and by river reach (see Appendix 10)

2.2.3.5 Assessment of the Fish Community of the St. Clair River in 1994

Source: Hyatt and MacLennan 1996
Where: St. Clair River
What: distribution and abundance of fish species

The diversity of the fish community in the St. Clair River was surveyed by the Ontario Ministry of Natural Resources in 1994. This work was done in partial response to the 1987 Protocol amending the Great Lakes Water Quality Agreement, and as a follow-up to assessment of fish communities within all AOCs prior to preparation of individual RAPs; the St.Clair was surveyed as a part of this assessment in September, 1986. The stated objective is to document the status of the St. Clair fish community before and after the implementation of remedial actions.

This survey was designed to measure fish diversity and to use established indices generated from this information as an indicator of the degree of degradation of the aquatic environment. A total of 8 sample sites were used: 1 control site above the main industrial dischargers in Sarnia, 3 sites near these, and 4 sites downstream between Courtright and just above Port Lambton. These sites were chosen with reference to the sites classified by Tarandus Associates Limited (1993) as "unimpaired", "intermediate", "impaired", or "degraded" based on benthic invertebrate composition.

The survey utilized electrofishing methods and took place between August 23 to 26, 1994, between the hours of 1800 and 2400. This time of year and short sampling duration were chosen to avoid the effects of spawning migrations and to avoid the effects of meteorological disturbances (i.e., weather conditions were stable over this period). There were 2 efforts at each station, each of 600 seconds duration. Apart from simple counts, certain species (yellow pickerel, yellow perch, rock bass, white sucker, shorthead redhorse, and carp) were held for detailed measurement and sampling to collect information as to fork length, round weight, age, disease, parasites, tumours, sex, and maturity. Data on local conditions such as water depth, capture depth, air and water temperature, water colour, current flow rate, wind speed/direction, cloud cover, macrophyte classification (i.e., submergent, floating, emergent), shoreline features, and bottom type.

The survey resulted in the capture of 3720 fish belonging to 39 species, with alewife making up 69% of the total, emerald shiner 5%, yellow perch 4%, shorthead redhorse 3%, spottail shiner 3%, and each of the remaining species making up 2% or less of the total. Species diversity was measured by means of the Index of Biotic Integrity (IBI) and Margalef Index (MI). The IBI index, recognized and used by many workers in the Great Lakes, is a means to rate an aquatic environment's health by evaluating species composition, relative abundance, trophic guild abundance, and individual health and abundance.

Overall, no clear associations were noted between derived values of these indices and sites that were unimpaired, intermediate, impaired or degraded. In addition, no consistent differences were noted in the length and weight of Age 1 female perch taken from various sites, with size-at-age seemingly unaffected by conditions at degraded sites. Specific examples highlight this lack of correlation. The numerical IBI scores were subdivided into ranges rated qualitatively as "very poor", "poor", "fair", "good", and "excellent". The sole degraded site returned the highest relative abundance and IBI and MI scores that were higher (i.e., better, although still rated poor) than those from other unimpaired or intermediate sites. The control site, offshore of the CNR rail yards and upstream of the main industrial area, returned the highest IBI score during the 1986 survey, but the lowest during this survey. Four of the sites classed as unimpaired or intermediate had the highest IBI and MI scores for this survey. One site situated between an impaired and degraded had a previous index rating of poor--its IBI and MI scores for this survey indicate that a relatively healthy fish community is present.

Three out of the 4 sites with the highest (i.e., best) IBI and MI values were offshore of breakwalls, local environments which are generally considered unfavourable for fish

communities. The reports suggests breakwalls may not have much of an effect if other factors impacting on community health are favourable.

The authors do not make any general conclusions regarding the health of the fish community, and also do not cite any grounds for changing the "not impaired" status of fish community dynamics in the St. Clair. With regard to the correlation between the fish community health indices and the impaired benthic communities, the report concludes by recommending that any further survey work include one additional degraded and 2 additional impaired sites, and expend 5 times the effort of this survey to increase sample size.

Data available: graphs summarizing relative abundance, MI, and IBI for each of the sites, together with benthic community classification; tables summarizing environmental quality indicators, size/health data for yellow perch, site descriptions, trophic guild classifications, IBI classification scheme, number of fish captured/species

2.2.3.4 St. Clair Remedial Action Plan Fish Tainting Evaluation

Source: Myllyoja and Johnson 1995
Where: above, near, and below main industrial point sources, Sarnia
What: controlled evaluation of fish tainting using walleye samples

Anecdotal reports of tainting have been made by the residents of Walpole Island, as reported in the first St. Clair River RAP Stage 1 report. In response, a controlled study involving a subjective sensory evaluation on the part of a panel was conducted. Panel members consisted of local BPAC members and the public--all of whom were non-smokers and regular fish consumers.

The samples for this study consisted of control and exposed fish. All the samples were of indigenous fish caught via electrofishing methods in August of 1994, from the Bluewater Bridge and/or Sarnia Bay for the control fish, and from the vicinity of the main industrial point sources for the exposed. The study used was a triangle test, wherein 3 samples are compared (with 2 of the 3 identical), and with no abstentions permitted. Each panellist evaluated 6 sample sets in 2 stages. For each set, the panellist had to choose the different sample and evaluate whether it was or was not tainted. With only 35% of the different samples correctly identified, it was concluded that the panel could not distinguish between upstream and downstream fish samples. Of the 12 correctly identified samples, 7 were correctly identified as to source, which in statistical terms does not constitute a reasonable confidence level. It was concluded that even when panellists were able to discern the difference in sample source, noticeable taints could not be distinguished.

Several factors impact the relevance of this study to the impairment of beneficial use *Tainting of Fish and Wildlife Flavour*. The panellists did not have formal training in foodstuff tainting, which ideally should be matched to the specific contaminant group whose effects are being assessed. Study is also required regarding the threshold levels at which various contaminant

groups make their effects known to human sensory evaluations. However, as technologically based analytical means are able to detect contaminants before they pose threats to human and environmental health, this issue is really of public perception. If, after the technological evaluations are able to provide assurances that environmental and human health are in no danger, then a controlled study using untrained evaluators is valid in terms of assessing the impairment of this beneficial use.

Data available: table summarizing evaluation results; original evaluation worksheets

2.2.3.5 Environmental Assessment in the St. Clair River, Biomonitoring and Foodweb Models

Source: Haffner and Morrison 1997
Where: 4 sites along the length of the St. Clair River
What: bioassay results, foodweb modelling

The goal of this biomonitoring study was to define background levels of certain chemical contaminants in the St. Clair River before any major remediation efforts took place, and to assess the toxicological hazards of current levels of these contaminants.

The study involved the deployment of freshwater mussels from a control source (Balsam Lake, Ontario) at 4 sites in the St. Clair River: 1) in Chenal Ecarte, 2) just downstream of Clay Cr., 3) just downstream of Talfourd Cr., and 4) at the border of the Chippewa First Nation property, immediately south of the Suncor docks. The mussels, in batches of 30, were subjected to 18 weeks of field exposure, with batches of 6 removed for analysis at weeks 1, 3, 9, and 18 to determine saturation periods. Sediment samples (3) were also taken at each site to assess local background contaminant levels. The compounds analyzed for were: PCBs, organochlorine pesticides, and PAHs because of their bioaccumulative characteristics. To assess toxicology, a human liver cell culture was exposed to both biological extracts and sediment samples and assessed for chemical stress via cytotoxicity and EROD induction.

The results were as follows:

1) all compounds reached steady state by week 9, with PAHs by week 3
2) reported trends in upstream-downstream gradients: hexachorobenzene--decreased, DDE--increased, dieldrin--increased; however, examination of the data tables shows:
   Biota
   pentachlorobenzene--decreased, hexachlorobenzene--decreased, octachlorostyrene--decreased, DDE--increased, PCBs--decreased
   Sediment
   pentachlorobenzene--decreased, hexachlorobenzen--decreased, octachlorostyrene--decreased, PCBs--decreased (although as high at both ends of the river), PAHs--decreased
3) all levels were quoted as low, with many compounds at Great Lakes background

levels

4) 10 unknown (probably chlorinated) compounds were noted through gas chromatographic analytical techniques, and 1 (compound #2) showed up at high levels (ratio of chromatographic site/area--no absolute units)

The report concluded:

1) that the overall levels were low
2) the only clear upstream-downstream gradients observed were for organochlorine compounds and hexachlorobenzene (see note above)
3) the cytotoxicity and EROD tests revealed that the threat posed by these levels was insignificant, i.e., there were no chemical stresses on the human tissue cultures
4) the sediment hazards are not sufficiently quantified; current levels are such that if remediation measures raised water column concentrations by 5X, biomonitoring should be undertaken to protect downstream water quality
5) more thorough testing is required to better establish risk to benthic community and fish

Occurrences of contaminant parameter levels above RAP yardstick parameters were noted as follows:

Biota	*Sediment*
dieldrin--all stations	PCBs--3 out of 4 stations
PAHs--all stations	hexachlorobenzene--3 out of 4 stations
PCBs--3 out of 4 stations	

The final portion of the report discussed a foodweb model for the St. Clair, to predict contaminant transfer between trophic levels. Result: good predictor for pentachlorobenzene, hexachlorobenzene, octachlorostyrene in fish; satisfactory result for benthic invertebrates (same contaminants).

Data available: tables and figures summarizing contaminant concentrations in mussels, sediment; unidentified compound ratios; foodweb model parameters (see Appendix 11)

2.2.3.6 Zebra Mussel Chlorination Benthic Survey 1990

Source: Ontario Hydro 1997a
Where: 4 hydro generating stations on the Great Lakes including the Lambton Generating Station on the St. Clair River
What: benthic surveys, 4 sites, carried out as a condition of OMOE certificates of approval for discharge of chlorine residues

Benthic organisms were collected at similar reference and discharge sampling sites at the station

prior to (May) and after (December) chlorination. Results: the variations in either reference and discharge benthic density or benthic richness were not significant at the Lambton Generating Station, indicating that the discharge of chlorine residues probably did not affect the discharge benthic community.

Data available: tables summarizing zoobenthic community by taxonomic group, zoobenthos density (1990), zoobenthos richness (1990), zoobenthos composition (1990)

2.2.3.7 Lambton Generating Station Flue Gas Desulphurization Effluent Wastewater, Impact Assessment Report

Source: Ontario Hydro 1997b
Where: Lambton Generating Station, 25 km south of Sarnia, Ontario (and 2 reference sites)
What: assessment of effluent impact on benthic community on start-up of effluent wastewater treatment plant

Benthic samples were collected at a treatment site (immediately downstream of discharge pipe) and at 2 sites upstream of the discharge point. Water quality was similar upstream and downstream before the operation of the plant and this did not change after start-up. The total dissolved solids and sulphite concentrations did not change and chloride actually decreased as a result of ambient conditions. Fluoride, pH, silicon and zinc also declined for the same reason. No changes were detected in the heavy metals. Iron concentrations were above RAP yardstick level on 2 occasions but no reason was given. Mercury levels were almost continuously above the yardstick. Zinc concentrations were above the yardstick on 3 occasions. The water quality results indicated that the variation in water quality of this magnitude between upstream and downstream sites and/or between pre-operational and operational sampling periods would probably have very little influence on benthic community composition and community alterations.

Mean benthic community richness and abundance during the 2 years after start-up remained similar to that found in the pre-operational community. Among major taxa, only bivalves declined from the before-operation values, but this decline showed up in all of the sampling sites. Total abundances of organisms were lower at the discharge site after start-up but this was concluded to result from harsh winter/spring conditions. The macrophyte community at the treatment site declined with the progressive erosion of the treatment site substrate shelf. This decline may have resulted in a natural alteration within the treatment site benthic community. The richness of the benthic community declined over the study period at one site north of the discharge. This low richness was probably the result of the site being scoured by ice. Total abundances of organisms were lower during spring operational surveys at the treatment site than expected and it was concluded that it was a result of harsh winter/spring conditions.

The thermal plume influence affected the treatment site benthic community composition. The warmer water at the treatment site allowed the Asiatic clam to survive the cold water winter period. Also, the advanced growth stages of *Polypedilum* and the advanced hatching of

Phaenopsectra are indicative of thermal plume influence.

The study concluded that the effluent wastewater treatment plant had no detectable effect on the benthic invertebrate community downstream of the station outfall.

Data available: tables summarizing ambient water quality conditions, composition of pre- and post-operation benthic communities (see Appendix 12)

2.2.3.8 Invertebrate Populations in Nearshore Sediments of the St. Clair River 1990-95

Source: Harris 1996b
Where: Ontario and Michigan shorelines of the St. Clair River, from Lake Huron to the delta
What: assessment of benthic invertebrate populations in nearshore sediments

The objectives of the study were to: 1) show current richness and density of invertebrate populations, 2) compare the richness and density of the Ontario shoreline to the Michigan shoreline, 3) identify some of the physical and chemical variables controlling richness and density, and 4) assemble an archive of collected invertebrates.

Sampling procedures consisted of taking 3 grab samples at 18 sample sites along the river. For 1990 to 1992, the sample sites were all along the Ontario shoreline, for 1993 to 1995, 8 of the sample stations were located along the Michigan shoreline. Results of the study showed a range of richness of about plus or minus 10 families (3 families per sample at the head to 18 families at the mouth) and a range of density of about plus or minus 2500 organisms per m^2 (90 organisms per m^2 at the head and 8000 organisms per m^2 at the mouth). Mean richness and mean density rise from low values at the head of the river to a steady state at about 15 to 20 km downstream. Richness showed a decline over the study period. Density remained about constant. *Diptera* was the only predominant order to increase significantly in density.

Populations on the Ontario shoreline are slightly more rich than on the Michigan shoreline but population densities were found to be slightly higher on the Michigan shoreline, at least in the midstream and downstream reaches. Regression analysis shows that the parameters responsible for a large proportion of the variability in richness and density are phosphorous content of the sediment, the time of year the sample was taken, and the sediment particle size. These regressions account for 43% and 41% of the sum of squares observed in richness and density, respectively. The slightly elevated richness and density observed between the 5 and 20 km points downstream may be attributable to nutrients discharged by domestic and industrial sewers in that part of the river. Data from this survey compare well with previously published data (1977 and 1985) and show no consistent trends in richness or density between 1977 and the 1990-1995 period.

Data available: tables summarizing nutrients in nearshore sediments; 1991-1995 invertebrate richness and density for each of the defined reaches and for each of the

Michigan and Ontario shorelines; relative frequency of *diptera*, *trichoptera*, *ephemoptera*, and *hydracarina* families; regressions of total phosphorus against total nitrogen, invertebrate richness and density against physical and chemical variables (see Appendix 7)

2.2.3.9 Review Comments, Warwick 1996 Report on Chironomid Mouthpart Deformities

Source: OMOE 1997c
Where: St. Clair River
What: review of assessment of chemical contamination in the St. Clair River using morphological deformities in chironomid larvae (Warwick 1996)

This memorandum summarizes the comments made by 4 reviewers regarding the Warwick (1996) report. The reviewers raised several points regarding the use of this biotic parameter as a measure of contaminant levels and/or benthic community impairment. Among the points raised was one example wherein the poor survival of one taxa was being related to deformity incidence despite the fact that the same taxa was the most abundant in a given population when its rate of deformity was high; in another comment reviewers noted that independent observations did not support the low pH values (to which deformities were being attributed) quoted for one location. Reviewers also noted that evaluation of the stresses arising from specific contaminants should be a component of follow-on work.

The final recommendation was that chironomid morphological deformities be used to evaluate benthic community health and sediment quality rather than being an exclusive indicator of the presence or absence of bird or animal deformities or reproductive problems.

3.0 AVAILABLE POINT SOURCE LOADINGS DATA

The 1993 *St. Clair Remedial Action Plan Addendum* report updated information on point source contaminant and chemical parameter loading contributions to the AOC. Information available at the time included the 1990 self-monitoring data (originally published annually in OMOE's *Industrial Direct Discharges In Ontario* reports), *Reports on Sewage Treatment Plants in Ontario,* data from the Municipal-Industrial Strategy for Abatement (MISA) 12-month monitoring reports for the organic and inorganic chemical sectors, and Michigan Department of Natural Resources' (MDNR) toxicity/plume studies.

The *Reports on Sewage Treatment Plants in Ontario* and *Industrial Direct Discharges in Ontario* reports are no longer published. The self-monitoring data continue to be collected but are only available in final compiled loadings format for 1991 and 1992; post-1992 data are available as separate files for each discharge outlet, and are not as comprehensive generally in overall coverage as in previous reporting periods.

The point source loadings data summarized here and reproduced in Appendix 6 (Cole Drain contaminant loadings) and appendices 13 and 14 (major Ontario industrial point sources) represent the data available for review at the time of preparation of this *Stage 1 1997 Update* report. Data from Ontario and Michigan municipal point sources as well as Michigan industrial facilities were not available.

The Stage 1 RAP document reviewed industrial self-monitoring data from 1984 through 1989. These data were reported as net discharge data (outfall minus intake). The majority of companies converted to MISA monitoring as of October 1989 using gross loadings (outfall only). Thus it is not possible to directly compare current loadings (gross) to historical (net) as reported in the Stage 1 RAP document. The 1990 data reported in the 1993 addendum report are gross loadings and, thus, can be compared to the available 1991 through 1996 data reported herein.

Appendix 13 provides the monthly gross loadings for parameters monitored at each facility on the Ontario side of the AOC. Data are reported as loadings (kg/day) and, where available, compared to the guideline value each facility is required to meet for any given parameter (calculated to facility flow rates), based on the Certificate of Approval (CofA) issued by OMOE. The data included in Appendix 13 were made available in compiled format for a given facility and/or contained data consistent across certain parameters and for monitored control points that allowed compilation, and for which, subsequently, historical trends or comparisons to earlier reports (1993 Update and Stage 1 RAP document) could be made. These trends are further discussed in sections 3.1, 3.2, and 3.3 immediately following.

Appendix 14 presents all industrial point source data currently available from OMOE, in uncompiled format. This includes some of the data provided in Appendix 13, as well as a wide range of additonal data representing various other control points and parameters which have been monitored for only a short period or only sporadically. Although examined, no broad conclusions based on this data have been made in this update. This data is nonetheless valuable and may

provide a basis for comparisons and trend analyses in a future update.

3.1 PETROLEUM SECTOR

3.1.1 ESSO Petroleum Canada, Sarnia

Compiled MISA monitoring data for Esso Petroleum are shown in Appendix 13, Table A13.1, as gross loadings for 1991, 1993, 1995, and 1996 (principally pH, NH_3, particulates, phenols, and solvent extractables). Following 1993, additional parameters at additional contol points were analyzed for, but gaps in available reported results were noted (see Appendix 14). No contaminant parameter levels above guidelines were noted for NH_3, total phenols, or solvent extractables during 1991.

Total effluent flow decreased in 1993 then increased again in 1995 and 1996; however, particulate residue and solvent extractables were well below their 1991 loadings during the last 2 years. Ammonium loadings are quite variable with no trend evident and total phenol loadings have remained relatively constant.

3.1.2 Sarnia Manufacturing Centre, Shell Canada Products Ltd.

Table A13.2 (Appendix 13) summarizes the MISA monitoring data compiled for Shell Canada Products Ltd for the period 1991 through 1996. No contaminant parameter levels above guidelines occurred in 1991 and the company was in full compliance. Data for the period 1994 through 1996 represent variable combinations of outfalls as shown in the footnotes to the table. Additional data for the period 1994 through 1996 is reproduced in Appendix 14.

Despite higher effluent volumes during the latter 3 years, significant loading reductions are apparent for benzene, ammonium, total phosphorus, residual particulates, solvent extractables, sulfide, and total carbon. Loadings of total phenols are more variable but increased significantly during 1996.

3.1.3 Suncor Inc., Sarnia

MISA monitoring data for Suncor Inc. was compiled for the period 1991 through 1993 and are shown in Table A13.3 (Appendix 13). Guideline parameters are reported for 1991 only and only one monthly parameter level above guidelines occurred (March, NH_3). Additional monitoring data for the facility's process effluent and once-through cooling water is reproduced in Appendix 14.

Over the period of record, most parameters remained relatively constant with no clear trends.

Particulate residues in 1992 and 1993 were about half their 1991 loadings; however, total carbon loadings were higher in the latter 2 years than in 1991.

3.2 ORGANIC CHEMICAL SECTOR

3.2.1 Dow Chemical Canada Inc., Sarnia Division

Table A13.4 (Appendix 13) lists the MISA monitoring data compiled for Dow Chemcial Canada Inc (1991, 1992, and 1994). No contaminant parameter levels above guidelines were noted in 1991 for total phenols (1992 loadings were also well below 1991 guideline values). Additional flow and total organic carbon data, as well as data on the facility's pond and process effluent for the period 1994 through 1996 is reproduced in Appendix 14.

There are not sufficient data available to establish trends, however, total effluent flow decreased by more than one-half in 1994 as compared to 1991 or 1992. This is also reflected in the total loading of dissolved carbon which decreased by almost half in 1994.

3.2.2 DuPont Canada Inc., Corunna

Available MISA monitoring data are provided in Table A13.5 (Appendix 13) for 1991 through 1993 for total effluent flow and total phenolics. No contaminant parameter levels above guidelines were noted for total phenols during 1991.

Although total effluent flows did not change significantly over the period, loadings of total phenolics decreased by 5 times.

3.2.3 Esso Chemical Canada, Sarnia

Table A13.6 (Appendix 13) provides the available MISA monitoring data for Esso Chemical for 1991 through 1993. No contaminant parameter levels above guidelines occurred for total phenols or solvent extractables during 1991.

No trends are evident over the 3 year period with regard to total flow or solvent extractables. However, loadings of total phenolics more than doubled from 1991 to 1993.

3.2.4 Novacor Chemicals (Canada) Ltd., Corunna

Table A13.7 (Appendix 13) provides the compiled MISA monitoring data for Novacor Chemical Ltd in Corunna for the period 1991 through 1993 and 1996. The facility was in full compliance with provincial guidelines for NH_3, total phenols and solvent extractables in 1991. Additional

1995 and 1996 data for the facility's process effluent is reproduced in Appendix 14.

Effluent flows decreased slightly from 1991 to 1996, which is also reflected in the loadings of ammonium, total phenolics, particulate residues and solvent extractables. Total phosphorus was much higher in 1996 than in 1992.

3.2.5 Bayer Rubber Inc (formerly Polysar Rubber Corporation), Sarnia

Available MISA montoring data was compiled and are provided in Table A13.8 (Appendix 13) for the period 1991 through 1994 for Bayer Rubber Inc. No contaminant parameter levels above guidelines were noted and the facility was in full compliance for NH_3, total phenols, and solvent extractables during 1991. Monitoring data for 1996 on the facility's process effluent is reproduced in Appendix 14.

The most significant aspect of the data was the large decrease in effluent flows and corresponding loadings during 1992. Otherwise, most parameters have stayed relatively constant and/or increased slightly. The highest effluent flows and loadings of ammonium, total phenols, and solvent extractables ocurred during the last year of record.

3.3 INORGANIC CHEMICAL SECTOR

Very little data are available for this sector with which historical comparisons/trends can be made. Appendix 14 includes very limited data representing Praxair Canada Ltd, Cabot Canada Ltd, and Chinook Group Ltd for 1994, 1995, and 1996 as well as one year of data (1996 only) for Terra International (Canada) Inc. Terra International, located in Courtright, was formerly known as ICI Nitrogen Products. The Fiberglas Canada Inc. facility in Sarnia ceased production in 1992 and was decommissioned.

3.4 THERMAL GENERATING SECTOR

3.2.6 Ontario Hydro Lambton Thermal Generating Station, Courtright

Table A13.9 (Appendix 13) provides gross loadings of particulate residues as well as effluent temperature and temperature rise (effluent as compared to ambient river temperature) for the Lambton Generating Station for the period 1991 through 1994. No levels above guidelines were noted for monitored parameters including effluent temperature and temperature change (effluent/ambient). Additonal process and event-discharge effluent data for 1995 and 1996, including discontinuous data for iron and aluminum, is reproduced in Appendix 14.

Over the period of record, total effluent flow decreased by about 10%, however, particulate residues decreased by over 80%. Although effluent temperatures remained about the same over

the period, on average, the temperature difference between effluent and the river decreased during 1993 and 1994.

4.0 CURRENT CONTAMINANT LEVELS AND COMPARISON TO YARDSTICK VALUES

During the development of the Stage 1 and first addendum reports, a recurrent problem centred on the plethora of contaminant guidelines issued for water, sediment, and biota quality by various jurisdictions. There was a need to adopt or develop a consistent set of guidelines which would serve as benchmarks against which implementation of remedial measures could be evaluated. As a result, a St. Clair River RAP Subcommittee supported by expert advice was established to develop a set of guidelines referred to as yardsticks.

The purpose of developing agreed-upon quantitative yardsticks was twofold. The yardsticks would serve to:

- assist in measuring progress towards achievement of RAP goals and objectives (long-term)

- assist efforts to measure potential impacts from existing sources and assess the need for additional remediation (short-term)

The rationale utilized in developing these yardstick values was to select the lowest, scientifically valid number from each of the 5 principal jurisdictions (Ontario, Michigan, Canadian and U.S. federal governments, and the IJC). Other jurisdictional numbers within the Great Lakes Basin were used in the absence of a number from the 5 primary jurisdictions. Further, it was generally agreed that the values chosen as yardsticks would be at or above levels occurring in lower Lake Huron. A full explanation of the development of the yardsticks is provided in the *Stage 2--Recommended Plan* document.

Tables 1 through 3 provide the yardstick values for each of water, sediment, and biota, respectively. Each yardstick is evaluated according to the following:

Contaminant Levels to 1994 - This identifies the maximum and/or mean values measured within the river based primarily on data summarized in the Stage 1 and first addendum reports. These were reported in the 1995 *Stage 2--Recommended Plan* (see Table 3.2 in that document) as “Present Level in River”.

Contaminant Levels to 1997 - This summarizes maximum recorded values noted from the sources and studies summarized in Section 2 of this report. If no data for a given parameter are available, the value is left blank in this column.

Occurrences Above Stage 2 Yardstick Level - This highlights the location and date of any parameter maximums above RAP-defined yardstick levels. As in the previous column, this information is derived from the sources summarized in Section 2 of this report.

Due to differences in sample locations and study design, it is not possible to directly correlate the number and magnitude of occurrences in which contaminant levels were found to be above yardsticks from one reporting period to the next. The value in this information is in tracking overall progress through time, particularly as it relates to status of impairments of beneficial uses (see Section 5.0).

Based on the updated information to 1997, occurrences above yardstick values continue to be noted for a variety of parameters in all media:

- levels above water quality yardsticks have been recorded for iron, mercury, zinc, bacteria, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, and pentachlorobenzene

- levels above sediment quality yardsticks have been documented for arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel, zinc, oil and grease, total Kjeldahl nitrogen, total phosphorus, hexachlorobenzene, polyaromatic hydrocarbons, and polychlorinated biphenyls

- biota yardstick exceedences include dieldrin, hexachlorobenzene, octachlorostyrene, polyaromatic hydrocarbons, and polychlorinated biphenyls

The principal water quality occurrences were found in the vicinity of tributary mouths (bacteria) and downstream of the Cole Drain (organochlorines).

Sediment quality occurrences were most frequent in the vicinity of the Sarnia industrial complex (Polysar/Bayer to Stag Island) and in the lower river (Port Lambton, Southeast Bend).

Biota quality occurrences for organochlorines occurred principally in the lower river around Walpole Island and in Mitchell Bay. In addition, fish consumption advisories continue to be in place, with the middle reaches of the river having the greatest number of species listed (Section 2.2.3.3). The number of species under the advisory and the associated contaminant levels have stayed the same or increased in recent collections.

It should be noted that the location of occurrences of high contaminant levels reported here reflects the focus of studies undertaken since the first addendum report. These studies have focused on priority segments of the river, which are by definition those most degraded in environmental terms. The results presented here provide some indication of the problems that remain in the priority areas, but may provide a skewed impression of overall AOC ambient conditions. Using the continuous monitor of the LIS Water Quality Assessment Program as a specific example, the number of occurrences of chemical parameter levels above LIS “advisory” levels in recent years has been on the order of 0.05% of the thousands of samples taken annually. This identifies a requirement for periodic whole-river studies; the last of these was undertaken by the OMOE in 1990.

Table 1. Environmental water quality yardstick values, past and current contaminant levels, and occurrences above Stage 2 yardstick levels, St. Clair River RAP.

Substance	**Water Quality Yardstick** µg/l (ppb)	**Contaminant Levels to 1994** (ppb)	**Contaminant Levels to 1997** (ppb)	**Occurrences Above Stage 2 Yardstick Level** (when, where)
Metals				
Arsenic	1.0			
Cadmium	0.5			
Chromium VI	5	3.5 (1991)		
Copper	5	4 (1990)		
Iron	300	2433 (1989)	369 (1991 max) 780 (1995 max)	Port Edward monitoring station, EC upstream of Lambton Generating Station, 1992-96
Lead	2.9			
Manganese	50			
Mercury	0.011	0.03 (1990)	0.84 (1992 max)	upstream of Lambton Generating Station, 1992-96
Nickel	25			
Zinc	30	14.5 (1991 mean)	80 (1992 max)	upstream of Lambton Generating Station, 1992-96
Conventionals				
Bacteria	33/100ml	8017 (1990)	8500 (1994 max) 22 000 (1995 max) 22 000 (1996 max)	max offshore of Clay Creek, June 21, 1994 max offshore of Clay Creek, August 15, 1995 max offshore of Lambton Cundick Park, July 16, 1996
Chloride	50 000		14 500 (1992 max)	
Oil & Grease	narrative			
Total Phosphorus	20	36 (1991)		
Organics				
Benzene	6.6		> 2.5 (1993) > 2.5 (1996)	
Carbon Tetrachloride	4			
Chlorophenols	7			
1,1-Dichloroethane	50			
1,2-Dichloroethane	904			

Substance	**Water Quality Yardstick** µg/l (ppb)	**Contaminant Levels to 1994** (ppb)	**Contaminant Levels to 1997** (ppb)	**Occurrences Above Stage 2 Yardstick Level** (when, where)
Dieldrin	0.0003		0.000173 (1993) 0.000161 (1994) 0.000137 (1995)	
Hexachlorobenzene	0.001		0.000037 (1993) 0.000036 (1994) 0.007 (1995 max)	upstream and downstream of the Cole drain, November 1995
Hexachlorobutadiene	0.1		0.000212 (1993) 0.000296 (1994) 0.14 (1995 max)	downstream of the Cole drain, November 1995
Hexachloroethane	13		0.027 (1995 max)	upstream and downstream of the Cole drain, November 1995
PAHs (B(a)p)	0.1			
PCBs	0.001	0.0024 (1989 mean)		
Pentachlorobenzene	0.03		0.000027 (1993) 0.000029 (1994) 0.02 (1995 max)	
Tetrachloroethylene	8		> 2 (1995)	
1,1,1-Trichloroethane	120			
1,1,2-Trichloroethane	6			
Trichloroethylene	27			
2,4,5-Trichlorotoluene			0.088 (1995 max)	
Toluene	110		5-10 (1993)	
Xylene-m	2		5-10 (1993) (m+p-xylene)	LIS continuous monitor, Courtright pumphouse station
Xylene	59			

Table 2. Environmental sediment quality yardstick values, past and current contaminant levels, and occurrences above Stage 2 yardstick levels, St. Clair River RAP.

Substance	**Sediment Yardstick** ng/g (ppb)	**Contaminant Levels to 1994** (ppb)	**Contaminant Levels to 1997** (ppb)	**Occurrences Above Stage 2 Yardstick Level** (when, where)
Metals				
Arsenic	4200	9100 (1989 mean)	9200 (1994 max) 7000 (1995 max) 4400 (1996 max)	offshore, Bayer site, Sarnia industrial area, offshore, Polysar-Sunoco Inc. site, Sarnia industrial area head of river (Lake Huron), June 1996
Cadmium	1100	1400 (1990)	1460 (1994 max) 4620 (1995 max) 2700 (1996 max)	offshore, Bayer site, Sarnia industrial area offshore, Sarnia industrial area Sarnia harbour, June 1996
Chromium VI	31 000	36 800 (1989 mean)	23 000 (1994 max)	
Copper	25 000	140 000 (1990)	130 000 (1994 max) 49 000 (1995 max)	offshore, Sarnia industrial area offshore, Sarnia industrial area
Iron	31 200 000	26 600 000 (1991)	67 000 000 (1994 max) 14 749 000 (1995 max)	offshore, Bayer site, Sarnia industrial area, June 1994 offshore, Sarnia industrial area
Lead	31 000	297 300 (1989) mean	85 000 (1994 max) 225 000 (1995 max) 4500 (1996 max)	offshore, Bayer site, Sarnia industrial area, June 1994 offshore, Sarnia industrial area/Stag Island offshore, Sarnia Harbour, April 1996
Manganese	400 000	492 000 (1990)	360 000 (1994 max) 418 000 (1995 max)	 offshore, Sarnia industrial area/Stag Island

Substance	**Sediment Yardstick** ng/g (ppb)	**Contaminant Levels to 1994** (ppb)	**Contaminant Levels to 1997** (ppb)	**Occurrences Above Stage 2 Yardstick Level** (when, where)
Mercury	200	4900 (1990)	163 000 (1994 max) 6290 (1995 max) 970 (1996 max)	offshore, Bayer site, Sarnia industrial area, June 1994 offshore, Bayer site, Sarnia industrial area Southeast Bend Cutoff Channel, March 1996
Nickel	31 000	55 000 (1990)	37 000 (1994 max) 28 420 (1995 max)	offshore, Bayer site, Sarnia industrial area, June 1994
Zinc	90 000	250 000 (1990)	349 000 (1994 max) 208 000 (1995 max)	offshore, Esso Imperial site, Sarnia industrial area offshore, Sarnia industrial area
Conventionals				
Bacteria				
Chloride			186 600 (1994 max)	
Oil & Grease	1 000 µg/g	1772 µg/g (1990)	4928 µg/g (1995 max) 1270 µg/g (1996 max)	offshore, Dow-Sunoco sites, Sarnia industrial area Sarnia Harbour, April 1996
TKN	550 µg/g	1970 µg/g (1989 mean)	2361 µg/g (1994 max) 2218 µg/g (1995 max)	offshore, Port Lambton, and Sarnia industrial area offshore, Sarnia industrial area
Total Phosphorus	420 µg/g	720 µg/g (1989)	537 µg/g (1994 max) 314 µg/g (1995 max)	offshore, Port Lambton, 7 exceedences
Organics				
Benzene				
Carbon Tetrachloride				
Chlorophenols				
1,1-Dichloroethane				
1,2-Dichloroethane				
Dieldrin	1			
Hexachlorobenzene	10	28 930 (1990)	160 000 (1994 max) 20 000 (1995 max)	offshore, Dow site, Sarnia industrial area offshore, Sarnia industrial area

Substance	**Sediment Yardstick** ng/g (ppb)	**Contaminant Levels to 1994** (ppb)	**Contaminant Levels to 1997** (ppb)	**Occurrences Above Stage 2 Yardstick Level** (when, where)
Hexachlorobutadiene		48 786 (1990)	243 000 (1994 max) 65 087 (1995 max)	
Hexachloroethane Octachlorostyrene		1900 (1990)	3100 (1994 max) 851 (1995 max) 13 000 (1994 max) 1000 (1995 max)	
PAHs	2000	54 300 (1990)	436 900 (1994 max) 37 700 (1995 max)	offshore, Bayer site, Sarnia industrial area offshore, Sarnia industrial area
PCBs	20	2020 (1990)	3500 (1994 max) 1800 (1995 max)	offshore, Dow site, Sarnia industrial area offshore, Sarnia industrial area
Pentachlorobenzene		1600 (1990)	6500 (1994 max) 2400 (1995 max)	
Tetrachloroethylene				
1,1,1-Trichloroethane				
1,1,2-Trichloroethane				
Trichloroethylene				
2,4,5-Trichlorotoluene		121 (1990)	88 (1994 max) 110 (1995)	
Toluene				
Xylene				

Table 3. Environmental yardstick values for biota, past and current contaminant levels, and occurrences above Stage 2 yardstick levels, St. Clair River RAP.

Substance	**Biota Yardstick** µg/l (ppb)	**Contaminant Levels to 1994** (ppb)	**Contaminant Levels to 1997** (ppb)	**Occurrences Above Stage 2 Yardstick Level** (when, where)
Metals				
Arsenic	0.097			
Cadmium		690 (1991)	51 (1994)	
Chromium VI				
Copper		1500 (1991)	540 (1994)	
Iron				
Lead	1000	710 (1990)	520 (1994)	
Manganese		1800 (1991)	1200 (1994)	
Mercury	500	1600 (1991)	650 (1994) 650 (1994) 620 (1994) 620 (1994) 1100 (1994)	white sucker, upper and lower St. Clair redhorse sucker, upper and lower St. Clair carp, lower St. Clair yellow perch, lower St. Clair walleye, lower St. Clair
Nickel		840 (1991)	640 (1994)	
Zinc		35 000 (1991)	22000 (1994)	
Conventionals				
Bacteria				
Chloride				
Oil & Grease				
TKN				
Total Phosphorus				
Organics				
Benzene				
Carbon Tetrachloride				
Chlorophenols				
1,1-Dichloroethane				
1,2-Dichloroethane				

Substance	Biota Yardstick µg/l (ppb)	Contaminant Levels to 1994 (ppb)	Contaminant Levels to 1997 (ppb)	Occurrences Above Stage 2 Yardstick Level (when, where)
Dieldrin	0.37		3.13 (1995 max)	freshwater clam, 4 sites spanning length of river, summer 1995
			2.1 (1995)	snapping turtle eggs, Walpole Island
			9.7 (1995)	mudpuppy eggs, Mitchell Bay, Lake St. Clair
			41 (1992)	black-crowned night heron, no location available
			64 (1992)	Forster's tern, no location available
			117 (1991)	herring gull, no location available

Substance	Biota Yardstick µg/l (ppb)	Contaminant Levels to 1994 (ppb)	Contaminant Levels to 1997 (ppb)	Occurrences Above Stage 2 Yardstick Level (when, where)
Hexachlorobenzene	100	88 (1991)	6.3 (1995 max) 1.5 snapping turtle (1995) 7.3 mudpuppy (1995) 7 black-crowned night heron (1992) 21 Forster's tern (1992) 56 herring gull (1991) 33 white sucker (1994 max) 7 redhorse sucker (1994 max) 33 carp (1994 max) 4 brown trout (1994 max) 6 shad (1994 max) 3 yellow perch (1994 max)	freshwater clam, 4 sites spanning length of river, summer 1995
Hexachlorobutadiene	1300	35 (1991)		
Hexachloroethane		2 (1991)		

Substance	**Biota Yardstick** µg/l (ppb)	**Contaminant Levels to 1994** (ppb)	**Contaminant Levels to 1997** (ppb)	**Occurrences Above Stage 2 Yardstick Level** (when, where)
Octachlorostyrene	20	540 (1991)	16.1 freshwater clam (1995 max) 1.9 snapping turtle (1995) 14 mudpuppy (1995) 12 black-crowned night heron (1992) 46 (1992) 109 (1991) 130 (1994 max) 83 (1994 max) 1122 (1994 max) 13 walleye (1994 max) 8 brown trout (1994 max) 5 shad (1994 max) 5 yellow perch (1994 max)	Forster's tern, no location available herring gull, no location available white sucker, upper St. Clair redhorse sucker, lower St. Clair carp, middle St. Clair
PAHs	0.93		278 (1995 max)	freshwater clam, 4 sites spanning length of river, summer 1995

Substance	**Biota Yardstick** µg/l (ppb)	**Contaminant Levels to 1994** (ppb)	**Contaminant Levels to 1997** (ppb)	**Occurrences Above Stage 2 Yardstick Level** (when, where)
PCBs	2.5	2450 (1991)	8.54 (1995 max)	freshwater clam, 4 sites spanning length of river, summer 1995
			490 (1995)	snapping turtle eggs, Walpole Island
			480 (1995)	mudpuppy eggs, Mitchell Bay, Lake St. Clair
			2400 (1992)	black-crowned night heron, no location available
			8310 (1992)	Forster's tern, no location available
			36 380 (1991)	herring gull, no location available
Pentachlorobenzene		3 (1991)	410 (1995 max)	freshwater clam, 4 sites spanning length of river, summer 1995
Tetrachloroethylene				
1,1,1-Trichloroethane				
1,1,2-Trichloroethane				
Trichloroethylene				
2,4,5-Trichlorotoluene				
Toluene				
Xylene				

5.0 IMPAIRMENTS OF BENEFICIAL USES

5.1 CONTAMINANT TRENDS

Many of the studies summarized in this update document are focused on very specific locations and data requirements intended to address the previously identified impairments of beneficial uses. Hence, it is difficult to quantitatively identify trends in contaminant concentrations in the AOC using a direct comparison to data collected earlier from more widespread studies. However, a number of key points regarding contaminant levels in the AOC can be highlighted as follows.

5.1.1 Water Quality

- Fecal coliform levels are event driven and vary markedly from year to year at any site although there is some evidence to suggest an overall improvement from 1993 through 1995.

- Surveys at the head and mouth of the St. Clair River undertaken by Environment Canada indicate that 1) organochlorine pesticide concentrations are similar throughout the river reflecting background concentrations in Lake Huron, but at lower concentrations than occurred in earlier periods, 2) industrial chlorinated organics levels continue to increase in the downstream direction but concentrations are trending downward, and 3) loadings of sodium and chloride to the river have decreased substantially.

- Most volatile organic contaminants monitored at the Courtright pumphouse station continue below MDLs (which are significantly lower than levels set out in drinking water guidelines). In the period 1992-94, individual results greater than MDLs decreased from approximately 7.8% to 3%. In the period 1992-95, levels above LIS's "OMOE advisory" levels (which are set at half the appropriate drinking water guideline level) decreased from approximately 0.3% to zero (i.e., from 27 to 1 result, out of approximately 8600 samples annually). During this period, and during the benzene event in early 1996, only benzene/ethyl benzene were found at concentrations approaching OMOE drinking water guidelines, albeit for a small percentage of the total number of samples taken annually.

- The Cole Drain continues to be a significant source of several metals and organochlorine contaminants including aluminum, copper, zinc, hexachlorobenzene, hexachlorobutadiene, and total PCBs.

- There has been a dramatic decline in the number of spills reported to OMOE between 1986 (135) and 1996 (19) and none have necessitated water treatment plant shutdowns in either Ontario or Michigan since late 1994.

5.1.2 Sediment Quality

- There has been a demonstrated trend of continuing improvement in sediment quality since the early 1970s through the early 1990s with areas of most severe degradation now restricted to 3 zones between Sarnia and Stag Island.

- The most recent sediment surveys in these 3 zones indicate these areas continue to have degraded benthic communities.

- Sediment contaminant and toxicity testing indicates continued moderate to high toxicities to fish and benthic organisms from sediments sampled downstream of major point sources, including the Cole Drain, Esso, Polysar, Dow, and the Sarnia Wastewater Treatment Plant (Beak International Incorporated 1996; LIS 1997c; OMOE 1996c).

5.1.3 Biota Quality

- Contaminant levels in waterfowl consumed by humans are, for the most part, either non-detectable or very low and do not constitute a health hazard to consumers.

- Preliminary indications (based on low sample quantities) are that contaminant levels in snapping turtles, mudpuppys and 7 species of waterfowl are generally decreasing, when comparing 1991-95 data with 1985-87 data, although in a few cases levels were drastically elevated.

- Fish consumption advisories continue for the upper, middle, and lower reaches of the St. Clair River as a result of contamination by metals, dioxins, and furans, and/or PCBs and other organic contaminants.

- Invertebrate populations in nearshore sediments tend to be more rich on the Ontario side than on the Michigan side but densities were higher in Michigan.

- Invertebrate population richness and density show no consistent temporal trend between 1977 and the 1990-95 period.

5.1.4 Point Source Loadings

MISA monitoring data for industrial direct dischargers in the St. Clair River AOC is generally complete for the period 1991 through 1993 and more variable for the period 1994 through 1996. Based on available data the following trends have been observed.

<u>Petroleum Sector</u>

- effluent flows have increased slightly between 1991 and 1996

- significant loading reductions have been achieved in certain parameters, especially, ammonium, particulate residues, total phosphorus, benzene, and solvent extractables

- total phenolics and sulfides have shown little or no change from 1991 through 1996

Organic Chemicals Sector

- in general, effluent flows have remained about the same with the exception of Dow Chemical Canada and Novacor Chemicals (Corunna)

- loadings of most parameters at Esso Imperial Chemical and Bayer Inc. have remained relatively constant or increased slightly

- loadings of certain parameters at Dow Chemical Canada and Novacor Chemicals (Corunna) have decreased along with the decreases in effluent flows

Inorganic Chemicals Sector

- most direct dischargers in this sector are no longer operating

Thermal Generating Sector

- from 1991 through 1994 effluent flows at the Lambton Generating Station have decreased slightly but significant decreases have been achieved in the loadings of particulate residue

- effluent temperatures at the Lambton Generating Station have, on average, not changed much over the 4 years of record but the average temperature differential between discharge and ambient river water has decreased slightly

In summary, there appear to be very positive trends since the release of the 1993 addendum report with regard to the reduction of chemical spills and loadings to the river of ammonium, total phosphorus, solvent extractables, particulate residues, and overall organochlorines.

Continued problems relate to biota and sediment quality and this may, in part, reflect the long time which may be required for the reduction in sediment-adsorbed contaminants derived from historical loadings. Total gross loadings of particulate residue, solvent extractables, and total phenols continued to increase at some organic chemical sector facilities in the AOC.

5.2 CURRENT STATUS OF IMPAIRMENTS OF BENEFICIAL USES

The St.Clair River was first identified by the IJC as an AOC because of degraded environmental conditions resulting in impairments to general or specific objectives of the Great Lakes Water Quality Agreement. The IJC defined 14 impairments of beneficial uses in the GLWQA, of these, 9 were considered “impaired”, 2 were considered to “require additional site-specific study”, one

was considered “not impaired” but also to require “Great Lakes Basin-wide” study, and 2 were considered as “not impaired” in the St. Clair River AOC.

Some of the 9 impairments were qualified in terms of one or more specific subcategories in order to focus on specific remedial actions and the definition of specific delisting criteria in the *Stage 2--Recommended Plan* document (see Table 2.1 in that document). At that time (March 1995), a total of 10 of these subcategories of impairments of beneficial uses were determined to be impaired, 3 to be not impaired, 4 to require basin-wide research prior to rating, and 4 to require site-specific research in the St. Clair River AOC prior to rating.

Table 4 summarizes the status and present conditions of the 14 beneficial uses based on the data collected since the release of the *Stage 2--Recommended Plan* document. The “current conditions” reflect the relevant information summarized in this addendum report (Section 2) and the “status of impairment” is assigned based on a review of the information by the RIC and BPAC.

As a result of the new data and interpretations, changes in the status of impairment for 4 of the beneficial uses are recommended.

These determinations are based on a satisfaction of the delisting criteria presented in Table 1.1 of the *Stage 2--Recommended Plan* document, are the result of a re-assignment of original evidence, or are the result of the implementation (and subsequent evaluation of conditions) of one of the site-specific studes called for in the Stage 2 document.

- tainting of fish and wildlife flavour has changed from “requiring site-specific studies” to “not impaired”

- bird or animal deformities or reproductive problems has changed from “impaired” to “requiring site-specific studies”, based on a re-assignment of evidence of chironomid mouthpart deformities to the impairment “degradation of benthos--dynamics of benthic populations/communities”

- restrictions on drinking water consumption or taste and odour problems has changed from “impaired” to “not impaired”

- added cost to agriculture or industry has changed from “impaired” to “not impaired”

In comparing Table 4 of this report to Table 2.1 in the *Stage 2--Recommended Plan* document, current conditions relating to the impaired uses restrictions on fish and wildlife consumption, degradation of benthos, restrictions on dredging activities, and beach closings, have shown little or no improvement.

Table 4. Summary of impairments of Great Lakes Water Quality Agreement (GLWQA) beneficial uses within the St.Clair River AOC as of June of 1997. Impairment abbreviations: I = impaired, NI = not impaired, A = requires further study on a site-specific basis, B = requires further study on a Great Lakes Basin-wide basis. Abbreviations qualified by asterix (*) are those for which changes in status are recommended based on updated information summarized in this addendum report.

GLWQA IMPAIRMENT OF BENEFICIAL USE	Status of Impairment	CURRENT CONDITIONS IN THE ST.CLAIR
Restrictions on Fish and Wildlife Consumption		
Restrictions on Fish Consumption	I	Fish consumption guidelines are currently in effect for: walleye, freshwater drum, yellow perch, gizzard shad, Blue Gill, carp, and white sucker (OMOE 1995a, 1995b, 1997b).
Consumption of Wildlife	B	Health Canada advises that consumption of commonly hunted Ontario waterfowl (based on an ongoing Canadian Wildlife Service survey) poses no health hazards, although additional study of the common merganser in the St. Clair river and the hooded merganser in Lake St. Clair is recommended (CWS 1997).
Tainting of Fish and Wildlife Flavour	NI*	No identifiable tainting in walleye harvested from St. Clair river near Sarnia, August 1994, as confirmed by controlled study (Myllyoja and Johnson 1995). Note that change in status to be further confirmed by results of extensive angler survey due in late 1997.
Degradation of Fish and Wildlife Populations		
Dynamics of Fish Populations	NI	
Body Burdens of Fish	B	
Dynamics of Wildlife Populations	A	Preliminary study of waterfowl and amphibian populations in wetlands indicates no statistically significant differences between AOC and non-AOC sites (4 AOCs including St. Clair compared) except in the case of 2 amphibian species, which were less frequent in AOCs; significant additional study is required (Chabot 1996). Landowners are releasing non-native species, e.g., pheasant, which are competing with native species. (Kanter 1996).
Body Burdens of Wildlife	B	Contaminants in snapping turtle, mudpuppy, Forster's tern, black-crowned night heron, and herring gull eggs and tissue remain above RAP contaminant yardstick levels for biota (CWS 1997).
Fish Tumours and Other Deformities		

GLWQA IMPAIRMENT OF BENEFICIAL USE	Status of Impairment	CURRENT CONDITIONS IN THE ST.CLAIR
Bird or Animal Deformities or Reproductive Problems	A*	It has been recommended that chironomid mouthpart deformities alone should not be used as basis for impairment status, but should be evaluated as a component of benthic community health (OMOE 1997c). The issue of chironomid deformities has been moved to the impairment of beneficial use "degradation of benthos". Contaminant levels in St. Clair waterfowl, snapping turtle eggs, and mudpuppy eggs, although significantly higher than RAP yardstick values, are not considered to have an adverse impact on reproductive success, based on limited data and comparison with observations/studies in other areas of the Great Lakes (CWS 1997).
Degradation of Benthos	A	
Dynamics of Benthic Populations/ Communities	I	A trend of increasing downstream mean invertebrate diversity and organism density observed, reaching a steady state 15 to 20 km downstream of Sarnia (south of Corunna), with diversity higher in Ontario and densities higher in Michigan. No statistically consistent trends from 1977-1995 (Harris 1996b). A decrease in macrophyte populations near the Lambton waste water treatment plant was noted, with a decrease in benthic species density and diversity and an increase in undesirable species, e.g., asiatic clam, due to altered conditions (i.e., warmer water temperatures (Ontario Hydro 1997a). An increase in the number of taxa was noted in the 3 priority 1 zones offshore of the Sarnia industrial area noted in the Stage 1 report, as compared to previous reports; however, the communities remain moderately to slightly impaired (LIS 1997c). Additional study (Beak International Incorporated 1996) confirms that benthic communities in these zones remain impaired, and does not observe any improvement in these areas since 1985.
Body Burdens of Benthic Organisms	B	The issue of mouthpart deformities in chironomid species requires further study focusing on species and contaminant-specific dose-response (OMOE 1997c). Bioassay and sediment toxicity studies based on 1994 and 1995 sampling report contaminant parameter levels above RAP yardsticks and PSQG lower and severe effect levels in the priority 1 zones downstream of the Sarnia industrial area (LIS 1997c). Test species mortality, growth, and reproduction were adversely impacted during sediment toxicity testing. Additional 1994 studies of sites offshore of the Sarnia industrial area reported sediment contaminant levels above RAP yardstick and PSQG lower effect levels, and moderate to high toxicity to test species (OMOE 1996b).

GLWQA IMPAIRMENT OF BENEFICIAL USE	Status of Impairment	CURRENT CONDITIONS IN THE ST.CLAIR
Restrictions on Dredging Activities	I	Contaminant levels in sediment samples from Sarnia Harbour and the southeast bend cutoff channel in March of 1996 exceed RAP yardstick levels and PSQG lowest effect levels (Ecologistics Limited 1996). Contaminant levels above sediment yardstick values continue to be recorded for arsenic, copper, cadmium, iron, lead, mercury, nickel, zinc, total PCBs, total PAHs, TKN, total phosphorus, and oil and grease.
Eutrophication or Undesirable Algae	NI	
Restrictions on Drinking Water Consumption or Taste and Odour Problems		
Consumption	NI*	There have been no OMOE-issued drinking water advisories or water treatment plant shutdowns on the St. Clair since November of 1994 (OMOE 1997a). Similarly, there have been no mandatory plant closures issued by the Michigan Department of Environmental Quality "*..for the last several years*" (MDEQ 1997a). Ranges of pH in the St. Clair remain consistently in the 7.8 to 8.3 range, and pose no restrictions to consumption (LIS 1995; OMOE 1996a). As there have been no water treatment plant closures in the last 2 years, the delisting criterion for this beneficial use has been met.
Taste and Odour Problems	NI*	The delisting criterion is as that for the consumption impairment; there have been no water treatment plant shutdowns along the river since 1994.

GLWQA IMPAIRMENT OF BENEFICIAL USE	Status of Impairment	CURRENT CONDITIONS IN THE ST.CLAIR
Beach Closings	I	Bacterial levels above the RAP yardstick were noted at several sites in the St. Clair delta, in the vicinity of Walpole Island, in 1994, 1995, and 1996 (Walpole Island First Nation 1997, 1996). Bacterial levels above the yardstick level were also noted in the St. Clair between Sarnia and the southern edge of Lambton County in 1994, 1995, and 1996. Data indicates that the small creeks draining into the St. Clair (e.g., Clay, Talfourd, Bowen, Baby) are a significant source of bacterial contamination, with ambient levels off creek mouths occasionally reaching levels 3 orders of magnitude above yardstick (LHU--OMOE 1994, 1995; MacKenzie 1996). High bacterial levels were also noted on the Michigan side, with levels above the yardstick noted from 1993-97 (Harris 1994, 1995a, 1995b, 1997a, 1997b; St. Clair County 1997). Permanent signs warning of possible intermittent pollution of water are posted at 4 Ontario parks (Willow, Seager, Lambton Cundick and Brander). It has been recommended that postings remain until surveying indicates that water quality has significantly improved to a point where bacterial levels are consistently below Ministry of Health guideline (LHU--OMOE 1994, 1995). It has been recommended that public be made aware of effects of heavy rains on bacterial levels with resulting restrictions on recreational uses.
Degradation of Aesthetics	I	Studies have addressed the issue of foam on the St. Clair river and concluded that some of the foam observed on the St. Clair is a biologically derived phenomena which can be concentrated through a combination of limnological, hydrological, meteorological, and geographic factors (F. Kemp, City of Port Huron, personal communication, 1997). However, objectionable surface films, foams, etc. are still reported that must be attributed to pollution events (e.g., CSO events).
Added Cost to Agriculture or Industry	NI*	There have been no water treatment plant closures or associated interruptions in water supplies to industrial users since 1994 (OMOE 1997a; MDEQ 1997a).
Degradation of Phytoplankton and Zooplankton Populations	NI	
Loss of Fish and Wildlife Habitat	I	Restoration targets have not been fully accomplished. Clearing/draining of marsh and woodland by private landowners is continuing (Kanter 1996).

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