2018

RE-DESIGNATION REPORT

NIAGARA RIVER
Remedial Action Plan

Eutrophication or Undesirable Algae in the Niagara River (Ontario) Area of Concern

Beneficial Use Impairment #8

Re-designation Report:
Eutrophication or Undesirable Algae
in the Niagara River (Ontario) Area of Concern
Beneficial Use Impairment #8

FINAL
February 2018

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NIAGARA RIVER
Remedial Action Plan

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Correct citation for the technical BUI Assessment:
Long T, Green N, Vieira C, and V Cromie. 2017. Assessment of Eutrophication and Undesirable Algae Beneficial Use Impairment in the Niagara River (Ontario) Area of Concern. Niagara River (Ontario) Remedial Action Plan. Welland, ON. 53 pages.

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Overview

Algae are tiny plant-like organisms that are an important part of the food web as they are the main source of food for planktivorous fishes and zooplankton. However, when algae are overabundant due to nutrient pollution (often referred to as an algal bloom) they can cause disruptions to the aquatic ecosystem, result in fish kills, pose a risk to human health and/or impair recreational enjoyment of the waterbody (boating, swimming). Pollution from human sources such as municipal and industrial wastewaters, agricultural runoff, fertilizers on lawns and golf courses, and poorly maintained septic systems are sources of nutrients that can contribute to eutrophication, a term that describes the enrichment of nutrients within a waterbody. *Eutrophication or Undesirable Algae* is currently listed as one of the 14 potential beneficial use impairments (BUIs) in the Niagara River Area of Concern (AOC).

According to the International Joint Commission (IJC), the *Eutrophication or Undesirable Algae* BUI applies "w*hen there are persistent water quality problems attributed to excessive nutrient discharges from point (end-of-pipe) or nonpoint (diffuse land uses) sources. Typically, the impairment manifests itself as nuisance or harmful algal blooms, dissolved oxygen depletion in bottom waters, and decreased water clarity"* (IJC 2018). Although a 1985 IJC assessment indicated that the Niagara River <u>did not</u> indicate an impairment related to eutrophication (NRRAP 1993), the status of the *Eutrophication or Undesirable Algae* BUI has undergone several status changes since the inception of the Remedial Action Plan (RAP) (details are in the technical assessment).

On the Canadian side of the AOC, the 'Impaired' status suggested from 1993-2009 was generally due to eutrophication issues in the Welland River (a Niagara River tributary) and other small tributaries in the Welland River watershed. Conditions in the Niagara River itself or potential impacts from the tributaries on the Niagara River were not specifically investigated, and no evidence was presented in historic reports that might suggest an impairment issue in the Niagara River proper. Nevertheless, the Niagara River RAP Stage 2 Update (NRRAP 2009) maintained the 'Impaired' status pending further investigation. On the U.S. side of the AOC, the decline in phosphorus and chlorophyll *a* levels in Lake Erie between 1968 and 1985 and high levels of dissolved oxygen and absence of nuisance algal blooms measured in the Niagara River was evidence of no impairment; therefore, the *Eutrophication or Undesirable Algae* BUI is designated 'Not Impaired' for the U.S. side of the AOC (NYSDEC 2012).

Locally-developed delisting criteria were never developed for this BUI (NRAP, 2009). Also, the Great Lakes Water Quality Agreement (GLWQA) Protocol of 2012 specified that BUIs are to apply to Waters of the Great Lakes, meaning "the waters of Lakes Superior, Huron, Michigan, Erie, and Ontario and the connecting river systems of St. Mary's, St. Clair, Detroit, Niagara and St. Lawrence" […] (GLWQA 2012). In keeping with the intent of the focus of the GLWQA and due to absence of key evidence to confirm the status of the BUI in the Niagara River proper or the potential water quality impacts from the tributaries to the Niagara River, the RAP Team pursued a science-based, weight-of-evidence approach to assess the BUI, which has been done in other AOCs. The assessment, initiated

in 2014, examined all recent data (2003-2013) from multiple sources collected in the Niagara River (and Chippawa Creek/Niagara power canal) from multiple agencies for five key eutrophication metrics: total phosphorus (TP), phosphate/soluble reactive phosphorus (SRP), chlorophyll *a*, dissolved oxygen (DO) and Secchi disc depth (refer to Appendix 6 for details of the technical assessment). Key findings of the assessment were:

- The 90th percentiles of TP concentrations did not unequivocally meet the criterion of 30 ug/L; however, this was attributed to TP sources upstream from the Niagara River and out of scope of the RAP;
- Phosphate and chlorophyll *a* concentrations were generally equivalent to or less than those measured in unimpaired reference areas (SRP data were inconclusive);
- Dissolved oxygen (DO) concentrations were generally above the screening criterion of 6.5 mg/L. Of the two DO observations below 6.5 mg/L, impact to biota was not expected;
- Historical Secchi disc depth values in the Niagara River were generally on par with or better than current day values in unimpaired reference areas;
- The BUI is listed as Not Impaired on the New York side of the AOC (Niagara River New York RAP, 2012).

Taken together, the **results of the assessment indicate that there is no eutrophication or undesirable algae impairment in the Niagara River** and that the status of the BUI should be changed to 'Not Impaired'. Therefore, the RAP Team initiated the re-designation process (Figure 1), beginning with a technical peer review and a public review.

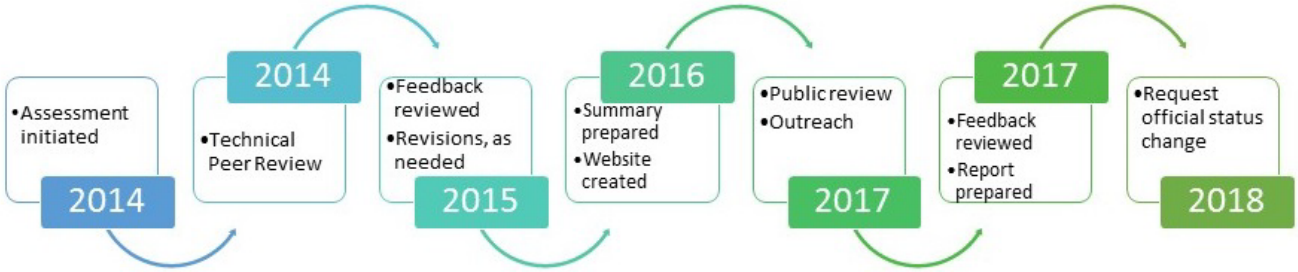

Figure 1. A diagram showing the steps taken for the BUI Assessment/re-designation process from 2014-2018.

The technical peer-review was conducted from October 6, 2014 to November 15, 2014 by eight different experts from various agencies including the New York State Department of Environmental Conservation (NYSDEC), Ontario Ministry of the Environment and Climate Change, Environment and Climate Change Canada, and the Niagara Peninsula Conservation Authority to evaluate the scientific evidence and rationale for changing the status of the BUI. The main comments provided in the technical review were requests for additional details on the data used for the assessment and the inclusion of Environment and Climate Change Canada's dataset on total phosphorus (TP), collected through the Upstream/Downstream Monitoring Program as part of monitoring completed for the binational Niagara River Toxics Management Plan. In February 2015, the RAP Team discussed the comments and necessary changes required. A summary of major reviewer comments and how they were addressed is provided in Appendix 1. Overall, the reviewers agreed with the results of the

assessment and the tiered (weight-of-evidence) approach taken to assess the BUI. No additional monitoring or follow-up studies were recommended by the reviewers. The final technical report provided in Appendix 6 of this re-designation report reflects the most recent changes and addresses the concerns from the reviewers. Once the edits were complete, the RAP Team proceeded with the next step in the re-designation process: a public review.

Due to the lack of an active Public Advisory Committee (PAC) participating in the Niagara River (Ontario) RAP at the time re-designation was proposed and based on recommendations and feedback from an externally-conducted stakeholder survey regarding public outreach for the RAP (LURA 2014), the RAP Team undertook an extensive approach to community outreach and engagement. These efforts sought to re-connect the public to the RAP process, invite stakeholder participation in the progress of the RAP, update the public with current information on the status of the RAP activities, as well as provide an opportunity to participate in the review of two BUI assessments (*Eutrophication or Undesirable Algae* and *Degradation of Phytoplankton and Zooplankton Populations*). The RAP Team also hoped that the various outreach opportunities would spark a renewed interest in the RAP process and encourage interest in re-establishing the PAC. The public review period for the two aforementioned BUIs was conducted concurrently from October to November 2017. An overview of public outreach and engagement opportunities are outlined in Table 1 with a detailed account provided in Appendix 2.

Table 1. Summary of various public outreach and engagement activities that directly supported the public review of two BUI assessments.

Description of the outreach activity	Timeline
Public-friendly summary document prepared (revised for accuracy and brevity in 2017)	2016/2017
Documents posted online with built-in commenting feature enabled and details of related events included.	Oct. 20 – Nov. 25/17
Hosted an informative bus tour of the Niagara River AOC to highlight recent projects and progress, including the BUI assessments and opportunities for guests to have their say.	Oct. 25/17
Developed a short video to communicate the purpose of the RAP and to inform the public about current activities and projects, as well as the proposed status change for the two BUI assessments.	Oct. 2017
Implemented a public service announcement campaign at various local venues (movie theaters, coffee shops, malls, bus terminals).	Oct. 20 – Nov. 25/17
Hosted a Public Information Open House to share results of two BUI assessments and provide an opportunity for the public to ask questions and have a say on the proposed status change.	Nov. 15/17
Prepared/sent a media release and an advisory to inform the local media and general public on ways to have their say on the proposed status change.	Oct. 23 & Nov. 13/17
Social media campaign to inform public and encourage them to have their say on the status change.	Ongoing

Overall, results from the outreach efforts (event attendance, website analytics and social media engagements) show that many people were aware of the recommendation to change the status of the BUI but did not submit their comments (Appendix 2). A significant effort was made toward public outreach. Many people were reached/engaged through social media and in-person participation at the bus tour and public open house. Four feedback forms were formally submitted. It is unclear if the low number of written responses was due to lack of interest in the RAP process, concurrence or disagreement. The RAP Team carefully considered the feedback that was provided, summarized it and addressed and responded to the key issues submitted, as needed (Appendix 3). Of the four people that provided their feedback, two agreed with the recommendation but noted that there is other work to be done in the AOC to further progress and prevent backsliding (e.g., water quality studies at Queen's Royal Beach and coastal wetland fish habitat restoration). The key concerns submitted by respondents were related to the geographic scope of the AOC, the RAP process, and water quality concerns in the Welland River and Black Creek (tributaries of the Niagara River). Following the completion of the re-designation reports, the RAP Project Manager contacted each of the respondents to provide them with a copy of the reports to ensure their comments were adequately addressed and to give them an opportunity for further discussion, if required. A copy of the blank feedback form as well as other supporting outreach documents are attached as Appendix 4.

The RAP is in the process of preparing a delisting plan which will identify remaining actions to restore and assess BUIs and outline long-term monitoring needs and/or programs that will continue to monitor water quality in the Niagara River and tributaries that may impact the Niagara River (e.g., ECCC's Upstream/Downstream Program, NPCA's watershed water quality monitoring program, etc.) to ensure the conditions of the Niagara River related to this BUI remain healthy.

Conclusion

The results of the assessment indicate there is no evidence of eutrophication or undesirable algae impairment in the Niagara River (Ontario) AOC. The technical review indicated experts agree with the recommendation to change the BUI status to 'Not Impaired' and no further studies/remedial actions were suggested. The public was provided with many opportunities to review the assessment and the results. While many people were aware of the recommendation to change the BUI, as indicated through web-site and social media analytics, a small number (four people) formally submitted written feedback. Comments were mainly related to the boundaries of the AOC, the RAP process, and the condition of the Welland River and Black Creek (tributaries of the Niagara River). Taken together, the information in this report supports the RAP Team's decision to move forward with officially re-designating the status of the *Eutrophication or Undesirable Algae* BUI from 'Impaired' to Not Impaired'.

The Niagara River (Ontario) RAP Team requests that the Parties (Canada and Ontario) officially change the status of the *Eutrophication or Undesirable Algae* BUI from 'Impaired' to 'Not Impaired'.

Literature Cited

The list of references in this section applies only to the text in the Overview. Individual appendices have their own literature cited sections, if applicable.

Canada-U.S. Great Lakes Water Quality Agreement (GLWQA). Sept. 7, 2012. Retrieved from http://ijc.org/files/tinymce/uploaded/GLWQA%202012.pdf

International Joint Commission (IJC). 2018. Great Lakes Areas of Concern Impairments. Retrieved from http://ijc.org/en_/aoc/Desc_Impairments

LURA Consulting. 2014. Outreach and Engagement Strategy for the Niagara River Area of Concern 2014-2019 Appendix A: Stakeholder Feedback and Key Ideas Report.

New York State Department of Environmental Conservation (NYSDEC). 2012. Remedial Action Plan Stage 2 Addendum for the Niagara River Area of Concern.

Niagara River Remedial Action Plan (NRRAP). 1993. The Niagara River (Ontario) Area of Concern: Environmental Conditions and Problem Definitions, Remedial Action Plan Stage 1.

Niagara River Remedial Action Plan (NRRAP). 2009. Niagara River Remedial Action Plan Stage 2 Update.

APPENDIX 1:
Results of Technical Peer Review Process

Results of Technical Peer Review Process

Topic or Comment/Concern from Reviewer	Response
Exclusion of Environment and Climate Change Canada's Upstream/Downstream (US/DS) TP data	Data collected 2003 – 2013 through ECCC's Upstream/Downstream Program were added to the weight-of-evidence in the assessment. The report acknowledges and explains the reasons for higher concentrations of TP collected through this program compared to other monitoring programs in the Niagara River. For example, the US/DS program captures year-round conditions and has a higher sampling frequency than other programs. Although the 90th percentiles of the US/DS data did not meet the 30 µg/L criterion, the BUI was not considered impaired. The TP concentration was higher at Fort Erie relative to Niagara on the Lake, and there was no statistically significant difference in TP concentration between the Niagara on the Lake and Fort Erie stations, suggesting no strong input of TP from the Niagara River's tributaries. The other metrics used in the weight of evidence assessment also point to a 'Not Impaired' status.
Concern was noted about the use of the 90th percentile in the evaluation rather than a mean or median.	Many of the reviewers were not familiar with the methodology used for evaluating water quality by RAPs. The concern was addressed in the introduction of the report which explains that use of the 90th percentile is an approach used by other RAP teams consistent with use of an allowable 10% exceedance frequency of the evaluation guideline (i.e., PWQO).
Variability of analytical methods/comparability of phosphate/SRP data	The report explains that there is variability in analytical methods for measuring phosphate and SRP data. Phosphate/SRP datasets which did not include enough background information on the analytical method used to determine the reported concentrations were excluded from this assessment. Phosphate/SRP data are not used as a Eutrophication evaluation metric by other AOCs likely for this reason, and issues stemming from comparing data analyzed by different labs using different methods.
Trend analysis of phosphate and SRP data	The 2003-2013 time period was selected to represented "current day" conditions and, as noted above, there are uncertainties in these datasets. No further changes were made.
Chlorophyll *a* not a good metric for the Niagara River and benthic algae data should be investigated.	Caveats are included about the use of chlorophyll *a* data as a metric for the assessment. Benthic algae data is not available for the Niagara River and was therefore not included. Given the results for the other metrics corroborate each other, the need for an additional evaluation of benthic algae was determined to not be necessary.

Topic or Comment/Concern from Reviewer	Response
Concern regarding potential cross-sectional variability in the Niagara River data and what it meant for the assessment	A caveat was added to the report addressing the concern and it is also explained that all available data were being used to support a 'Tiered' weight-of-evidence approach for the assessment.
Locations of data used for assessment	A map showing the geographical scope of data collection was added to the report.
Concern that screening criteria for DO was not adequate	The concern was addressed in the revised report explaining that the 6.5 mg/L value is a screening tool, and not a guideline in and of itself. The report also explains that using DO as a screening tool is more stringent than what is used at other AOCs, and that there are inconsistencies between provincial and federal guidelines, making it difficult to apply both guidelines to a single data point.
Request for more background information on the Niagara River	The information was added in the introduction section of the report.
Reference sites	The RAP Team discussed appropriate references sites. It was agreed upon that lakes and other rivers are not suitable reference sites as the Niagara River is a connecting channel. It was decided that the other Great Lakes connecting channels (despite being AOCs themselves) were the best surrogate for an appropriate reference site for comparison as the *Eutrophication or Undesirable Algae* BUI is 'Not Impaired' at those locations. The report addresses the selection of reference sites.

APPENDIX 2:
Public Review and Engagement Opportunities

Introduction

Engaging and obtaining input from the broad range of partners involved in the RAP initiative (public, Indigenous Peoples, municipalities, industry, etc.) is vital to the success of restoring the Niagara River AOC. There was significant involvement and engagement from the community through a Public Advisory Committee (PAC) since the Niagara River RAP's inception in 1987 until 2009. The PAC was involved in the development and review of all major RAP documents (e.g., Stage 1, Stage 2, and Stage 2 Update Reports) as well as important decisions regarding the review of BUI status and delisting criteria. However, the PAC did not exist at the time of these BUI reviews and had not been actively engaged since 2009.

In 2014, the RAP's Coordinating Committee (which oversees Governance) hired an external consultant to develop a strategic outreach and engagement framework to support the delisting process by reviewing existing outreach mechanisms and interviewing past and present RAP participants, including six representatives from government agencies and twelve from the local community (LURA, 2014). The report found that many stakeholders expressed disappointment that the Public Advisory Committee no longer existed and offered advice and potential tools for successful and engaging opportunities in the RAP process. Some of the principles and ideas from the LURA (2014) report were used to guide the outreach and engagement process for the RAP with stakeholders, as well as the BUI assessment review.

The RAP Team is presently working diligently to re-establish the PAC to better engage with the community and provide a forum through which the public and stakeholders can share concerns, views and opinions on Niagara River issues, and become involved in the activities and studies of the RAP initiative. The RAP Team undertook an extensive approach to community outreach and engagement. Part of these efforts included facilitating the review of the two BUI assessments (*Eutrophication and Undesirable Algae* & *Degradation of Phytoplankton and Zooplankton Populations*). The public review period for these two BUIs was conducted concurrently from October 20 to November 25, 2017. One of the main goals of the outreach and engagement activities was to provide ample opportunity for review, discussion, and comment on the proposed status change for the two BUIs. The RAP Team also hoped that the outreach events would spark a renewed interest in the RAP process and help to re-establish the PAC and Implementation Committee, as well as enhance the information exchange and involvement with RAP activities.

Starting October 2, 2017, the RAP Coordinator contacted over 50 past and new stakeholder organizations/participants to invite them to attend an informative bus tour event and to get involved in the RAP (to re-establish the Implementation and Public Advisory Committee) (see pg. 16). In addition to contacting people individually, the RAP Team put out a general call for participation in the RAP initiative and/or the Bus Tour on the RAP's social media accounts, which resulted in views but no active engagement. Responses from those contacted personally were received from 24 individuals spanning various sectors (municipalities, government, environmental groups, Indigenous Peoples, industry, scientists, and citizens) that expressed an interest in re-engaging in the RAP process. These

representatives will be contacted in early 2018 to begin re-establishing the Implementation and/or Public Advisory Committees.

Outreach Event: Bus Tour

The "Rolling by the River" Bus Tour event was hosted on October 25, 2017 and was attended by 32 people, including past and present RAP participants, academic researchers, students, and interested citizens. The tour was the Niagara River RAP's first outreach event since a public information meeting hosted in May 2015. Participants met at the Niagara-on-the-Lake Community Centre and boarded a coach bus to learn about recent progress and work in the Niagara River in a unique and interactive way. There were six stops and three additional topics along the tour route that were designed to tell the Niagara River story. Invited experts from various partnering organizations spoke about their work and provided hands-on experiences for participants along the tour.

The group learned about the purpose of the RAP initiative, the revisions to the Niagara River AOC boundary as a result of the 2012 Great Lakes Water Quality Agreement, historical sediment contamination in the watershed, ongoing watershed water quality monitoring, assessment and condition of plankton populations, monitoring of fish populations, coastal wetland habitat and prairie habitat restoration projects, binational water quality monitoring, and recent beach contamination investigations. At various stops, attendees had the opportunity to get off the bus and interact with researchers, examine water samples containing live plankton, witness electrofishing sampling efforts, get up close with live Niagara River fish, view habitat restoration sites, and ask a lot of questions (Figure 1). Each participant received a summary of the BUI assessment, Open House Poster, a feedback form, and other relevant, informative materials. Participants were informed about the review process and ways to provide input. Overall, the bus tour was a great success! A lot of positive feedback was received from those in attendance and several participants expressed their renewed interest in the RAP initiative and were encouraged by the recent progress. Thanks are owed to Ontario Ministry of Environment and Climate Change, Environment and Climate Change Canada, Fisheries and Oceans Canada, Niagara Peninsula Conservation Authority, Ontario Ministry of Natural Resources and Forest, Niagara Parks Commission, and the Town of Niagara-on-the-Lake for their involvement in delivering the event.

Digital Engagement: Website

A page on the RAP's website (ourniagarariver.ca/bui-review-2017) dedicated to the proposed BUI status changes was enabled on October 20, 2017 to allow the public to easily access relevant information and provide their feedback on the changes. The page was linked to various places on the website so that it could be found easily by the end-user (under 'Track Our Progress', 'Latest News' and through its own link). The webpage included a brief overview of the two BUIs undergoing review and provided easy access to the relevant technical and summary documents (Appendix 4). A "Have Your Say" section outlined the ways in which individuals could learn about the research and BUI assessments and submit their comments on the proposed status changes. There were several ways to submit written comments to accommodate as many people as possible: online (RAP website), by mail,

in-person at the bus tour or open house events, and email. A copy of the feedback form is provided in Appendix 3. Despite receiving only 4 feedback forms (2 online, one by email, one by mail), there was a lot of activity on the website during the review period. Three days prior to the review period (when the analytics tool was enabled), there were 61 users that visited the website with a total of 167 total page visits. During the review period (Oct. 20 – Nov. 25), there were 295 users to the website and 724 total page visits, including 97 unique to the BUI Review page. The reach of our digital engagement was multi-national with 67% of users accessing the site from Canada, 23% from the United States and 10% from other countries.

Figure 1. An assortment of photos from the "Rolling by the River" Bus Tour hosted by the RAP Team on October 25, 2017.

Part of the growth to website visits can be attributed to our other outreach efforts including connecting with past RAP partners over the phone and email, hosting events, video ad campaign, and connecting to people through social media and an E-newsletter. A short video was created and released on the same day as the other BUI documents to inform the public about the Niagara River RAP and the recent research on the two indicators. The 36-second video was used in several ways through different media outlets during the review period. It was broadcast in its entirety at the Cineplex movie theaters in Welland, Ontario and Niagara Falls, Ontario. A shorter 15 second version was shown at Landmark Cinemas in St. Catharine's and that truncated version with captions (and no sound) was also broadcast on television monitors at over 90 different Tim Horton's locations in the Niagara Region, at the Seaway Mall in Welland, and two bus stations in St. Catharine's and Niagara

Falls. The video was also shared on the Niagara River RAP's social media channels and in the monthly E-newsletter. There were 44 views of the video on YouTube, and over 5000 on Facebook and Twitter (Table 1). Although the RAP does not have quantitative data on the number of views or the reach resulting from the ad campaigns at the local theaters, mall and bus stops, it's reasonably to presume that many people saw the ads which resulted in more visits to the website and more people learning about the RAP.

Digital Engagement: Social Media

In April 2017, the RAP Team created its own social media accounts (i.e., Facebook, Twitter, YouTube), managed by the RAP Coordinator, to communicate relevant information about the Niagara River and to share related Great Lakes news, science, and issues. During the review period, the RAP gained 23 followers on Twitter and 7 followers on Facebook. Many posts/tweets about the proposed status was shared on both platforms—some relating directly to the BUI review and others were more general (Figure 2). Existing analytics information collected by each social media platform and extracted data related to three key metrics (plus one specific to the video) were used to gauge the overall reach during the review period. The total followers, number of users that saw two key posts/tweets (referred to as an impression), and the number of interactions with the post/tweet (e.g., click, like, share/retweet) (referred to as engagement) as well as the number of 3 sec. video views are summarized in Table 1. The results indicate that while many people were aware of the information and the proposed BUI status change, they chose not to provide written feedback. Commenting directly on a post/tweet is an easy way for an end-user to share their opinion about a given topic. During the review period, there were no comments provided on any of the posts and tweets shared on the RAP social media pages.

Table 1. Summary of social media metrics to gauge the interaction or reach during the review period. The asterisk indicates a result that was paid to be "boosted" to reach a larger number of people in a given area.

Post or Tweet Topic	Metric	Facebook	Twitter	YouTube
N/A	Total page followers (as of Dec. 1)	19	55	N/A
Video	Video Views (number of times it was watched at least 3 sec.)	5,517*	160	48
	Number of people that saw the post/tweet with video at least once	1,922*	1,070	N/A
	Number of interactions (clicks, likes, shares, retweets)	8*	22	N/A
There's still time to have your say	Number of people that saw the post/tweet at least once	662*	83	N/A
	Number of interactions (clicks, likes, shares, retweets)	34*	5	N/A

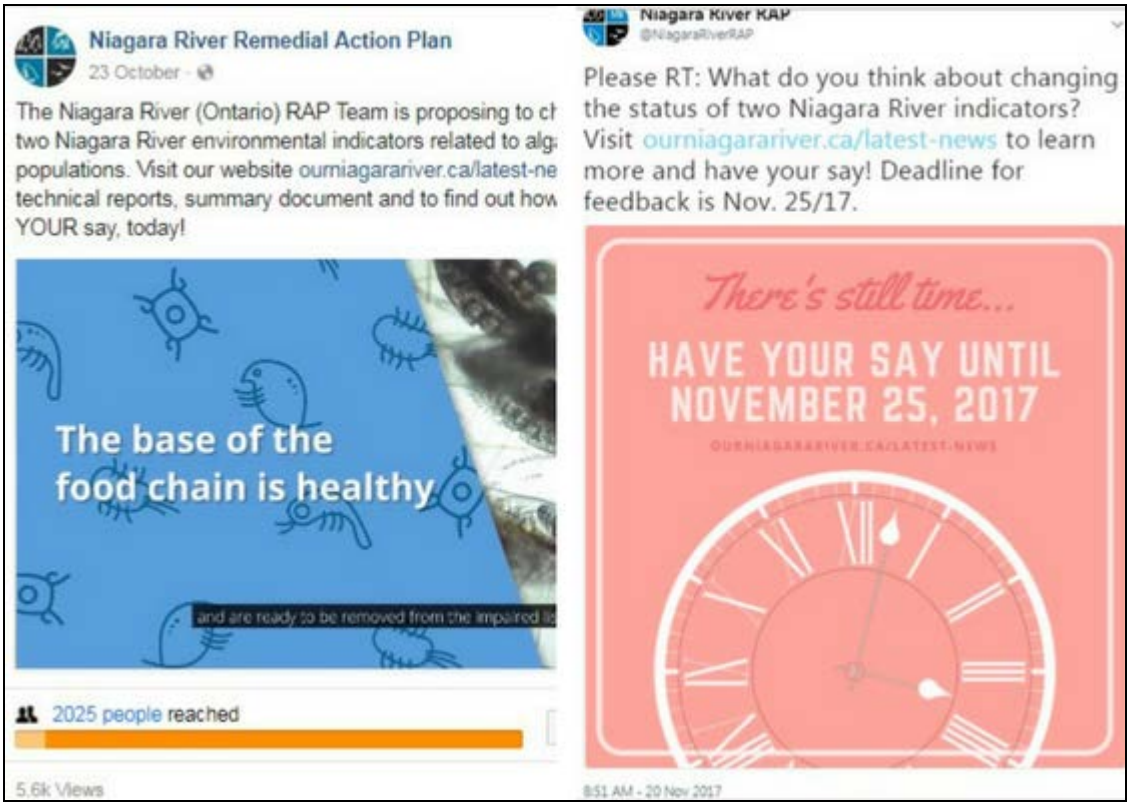

Figure 2. Two sample posts shared on the Niagara River RAP's social media accounts to support the BUI review from Oct. 20 to Nov. 25, 2017. A Facebook post with the video is shown on the left and a Tweet to encourage people to have their say is on the right.

Outreach Event: Public Information Open House

Twenty people attended the Public Information Open House on November 15, 2017 (6:30 pm to 8:30 pm) at the Niagara Parks School of Horticulture in Niagara Falls—centrally located within a short drive for most residents in the Niagara River area. The Open House was an opportunity for interested citizens to learn about the recent research and to provide feedback in-person. Attendees were provided with supporting documents (hard copy and electronic copies on a USB stick), feedback forms with a comment submission box, a RAP overview brochure, E-newsletter sign-up, and some promotional items. There was a meet-and-greet with light refreshments before the presentations were set to begin so that guests could mingle, peruse the supporting documents, read the poster boards (AOC boundary, BUI status, habitat restoration), and ask questions.

The two lead scientists that were involved in leading the technical assessments (Dr. Warren Currie and Tanya Long) provided short presentations summarizing the results and proposed recommendation to change the status of each BUI) (Appendix 6). There was ample opportunity after the presentations to ask questions about the research (Figure 3). Overall, the event went very well. The group was engaged and interested in the research. Most of the questions were directed toward Lake Erie (e.g., algal blooms, fisheries), one related to flow of the Upper Niagara River and secchi depth sampling in plankton assessment, and one question about the geographic scope of the AOC and

the importance of efforts in the Welland River watershed (which ultimately drains in to the Niagara River). All of the questions were addressed by the scientists and the RAP Team, as appropriate.

Figure 3. Photos of the Public Information Open House event on Nov. 15, 2017: (Top) Dr. Warren Currie takes questions from the group; (bottom left) information table with supporting documents; (bottom right) Tanya Long begins her presentation on the *Eutrophication or Undesirable Algae* BUI assessment.

While no media representatives attended the event, the information was highlighted in the local newspaper and three attendees noted that they heard about the event through the newspaper. The invitation to the open house was shared as broadly as possible using the social media platforms noted previously, advertised on our website, E-newsletter, shared directly with RAP partners (via email), and during the bus tour. In addition, the RAP Coordinator posted the event details on the community event section of each local newspaper (St. Catharine's Standard, Niagara Falls Review, Welland Tribune, Fort Erie Times) and the local TV channel. Furthermore, a media release was sent to local media outlets on October 23, 2017 and a media advisory on November 13, 2017. Refer to Appendix 4 for a copy of the Open House poster, agenda, media release and advisory, and news article.

List of groups/organizations that participated in related outreach opportunities (i.e., bus tour or public information open house)

Brock University
Buffalo-Niagara Waterkeepers
Citizens-at-large
Environment and Climate Change Canada
Fisheries and Oceans Canada
Friends of One Mile Creek
Hamilton Harbour Remedial Action Plan
Lorraine Bay Water Quality Group
Ministry of Natural Resources and Forestry
Ministry of the Environment and Climate Change
Mississaugas of the New Credit First Nation
Niagara College
Niagara River (ON) Remedial Action Plan
Niagara River (NY) Remedial Advisory Committee
Niagara Parks Commission
Niagara Peninsula Conservation Authority
Niagara Regional Native Centre
Ontario Federation of Anglers and Hunters
Town of Niagara-on-the-Lake
Welland Riverkeepers

List of groups/organizations contacted to participate in the RAP or related outreach opportunities

Atlas Steels
Bert Miller Nature Club
Brock University
Buffalo-Niagara Waterkeeper
Citizens-at-large
City of Niagara Falls
City of Welland
Cytec
Ducks Unlimited Canada
Environment and Climate Change Canada
Fort Erie Conservation Club
Fort Erie Friendship Centre
Friend of One Mile Creek
Friends of Fort Erie's Creeks
Greening Niagara
Hamilton Regional Native Centre
Land Care Niagara
Lubrizol Canada Ltd.
Metis Council
Mississaugas of the New Credit First Nation
Ministry of Natural Resources and Forestry
Ministry of the Environment and Climate Change
Niagara College
Niagara Community Awareness & Emergency Response Group
Niagara Falls Nature Club
Niagara Parks Commission
Niagara Regional Native Centre
Niagara Restoration Council
Niagara River (NY) Remedial Advisory Committee
Niagara Sustainability Initiative
Niagara Peninsula Conservation Authority
OMAFRA / Environmental Farm Plan
Ontario Federation of Anglers and Hunters
Ontario Power Generation
Oxy Vinyls Canada
Peninsula Field Naturalists Club
Region of Niagara
Town of Fort Erie
Town of Niagara-on-the-Lake
Welland Riverkeepers

APPENDIX 3:
Results of Written Feedback

Results of Written Feedback

Four feedback forms were submitted. Two people expressed concerns with the recommendation to re-designate the BUI. Feedback that included one or more concerns and were grouped into specific topics or issues (summarized below). The main concerns noted were related to water quality issues in the Welland River and to the boundaries of the Niagara River AOC. Those that submitted written feedback indicated they had read the supporting documents (i.e., the technical report or the summary) and had attended either the Bus Tour and/or the Public Information Open House. To maintain privacy, names and other identifying text are not included (e.g., organization, contact information).

Summary of Feedback	Response
Submission #1	
Concern over the change of the AOC boundary from encompassing the entire watershed to a focus on the Niagara River proper. The watershed was the true (original) focus of the International Joint Commission and those that framed the AOC concept.	Prior to 2012, the Niagara River Remedial Action Plan included the Welland River as part of the Area of Concern, as requested by the Public Advisory Committee in 1989. The 2012 Canada-U.S. Great Lakes Water Quality Agreement (http://ijc.org/files/tinymce/uploaded/GLWQA%202012.pdf), clarified that the **Waters of the Great Lakes** as the waters of "Lakes Superior, Huron, Michigan, Erie and Ontario and the connecting river systems of St. Marys, St. Clair including Lake St. Clair, Detroit, Niagara and St. Lawrence at the international boundary or upstream from the point at which this river becomes the international boundary between Canada and the United States, including all open and nearshore waters". The International Joint Commission provides advice and input to Canada and the United States on Great Lakes issues and continues to assess progress on restoring Areas of Concern. Taking into account this clarification, the Niagara River (Ontario) Area of Concern is now defined as the waters of the connecting channel flowing from the mouth of Lake Erie to Lake Ontario from the international boundary to the Canadian shoreline. Where issues within the watershed contribute to beneficial use impairments in the Niagara River, actions will be undertaken as appropriate.

Summary of Feedback	Response
Submission #1 (continued)	
Concern about uncoupling the Niagara River AOC from its watershed in determining delisting criteria. Would be disappointed if instead of remediating excess nutrients in the Welland River, the RAP Coordinating Team simply redefined the delisting criteria so that Niagara River watershed rivers would fall under the delisting radar as long as some agency agreed to monitor them.	This concern relates to the Area of Concern boundary (see response above), the delisting criteria process as well as addressing nutrient issues in the Welland River. Delisting criteria were never specifically developed for the *Eutrophication or Undesirable Algae* Beneficial Use Impairment. This prompted the use of a transparent, science-based assessment framework for examining Beneficial Use Impairments established by the Toronto Region Area of Concern and used by other Areas of Concern. While it is recognized that the condition of the Welland River continues to be a local community concern, sources or issues which occur outside the geographic scope of the Remedial Action Plan program and do not contribute to issues in the Niagara River are captured through other local, provincial/state, federal processes, and legislated programs. Where it affects the waters of the Great Lakes, the issue of excessive nutrients is being addressed through a dedicated annex under the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health. Both the federal and provincial governments have committed to developing programs and tools for the agri-food sector to raise awareness and increase adoption of environmental farm planning and beneficial management practices through education, technical advice and funding.
The Welland River, which drains a large area into the Niagara River, suffers from high nutrient loads. Most of the NPCA's Welland River monitoring sites are classified as "impaired". Cleaning up the Welland River so that the majority of the NPCA sample sites were no longer "impaired" would mean that the entire Niagara River watershed had been improved. The RAP's rationale that the Welland River would not negatively impact the Niagara River because the nutrients are diluted to harmless levels suggests that "dilution is the answer to pollution". Disagree that impairments in the Welland River should not impede the goal of delisting the Niagara River as an AOC.	The Welland River is the Niagara River's largest tributary. Improvements within the watershed would certainly contribute to better conditions in the Welland River. There are many other factors (not just the condition of tributaries or incoming waters of eastern Lake Erie) to consider when examining potential algal blooms or eutrophication in the Niagara River. For this reason, this comprehensive assessment was undertaken using five different water quality metrics at key locations along the Niagara River. The assessment indicates that nutrients in the Welland River do not result in eutrophication or undesirable algae impairments in the Niagara River. Specifically, the assessment examined the potential impact of the Chippawa Creek/Niagara Power Canal where the flow of the Welland River mixes with Niagara River water (the Welland River does not discharge directly into the Niagara River due the flow reversal for power generation).

Summary of Feedback	Response
Submission #2 (continued)	
Agree with the recommendation to change the status of eutrophication to not impaired. Understand that further remediation along the Fort Erie shorefront, Niagara-on-the-Lake *E. coli*, is part and parcel of this recommendation.	The comment refers to elevated levels of *E. coli* at Queen's Royal Beach in Niagara-on-the-Lake. The matter is being addressed by Remedial Action Plan partners through efforts related to the *Beach Closings* Beneficial Use Impairment. Other work through the Lake Erie LAMP and the Nearshore framework addresses issues along the Lake Erie shoreline (including Fort Erie). These issues are the focus of the Niagara Coastal Community Collaborative.
Appreciate the reasons for recommending changing the Plankton Population BUI to unimpaired given the fresh monitoring evidence and DFO's scientific evaluation. The predation on this reportedly normal /expected forage downstream (fast flowing mixing) is reassuring to the higher level forage species (emerald shiners in the upper section and gizzard shad in the lower). More assessment of the Hydro reservoirs was also mentioned. The effects of the increased plankton from these reservoirs seem to replenish the forage for lower river fish.	No response required.
At a past RAP Update meeting, some attendees were disappointed in the lack of progress compared to the impressive habitat enhancement projects that NY State had accomplished in the upper Niagara. It's refreshing and reassuring to see interagency cooperation and dedicated efforts being put into [the Niagara River] RAP and the Hamilton Harbour RAP. Enthusiastic about the targeted vegetative aquatic and terrestrial habitat enhancements by Niagara Parks Commission	In the last two years, additional habitat projects have been implemented in the Niagara River Area of Concern by RAP partners, including environmental agencies in the United States. There are additional Niagara River coastal wetland restoration projects planned in 2018 and 2019. Monitoring will be completed to assess these improvements and/or identify next steps. There is a plan for continued interagency cooperation and community engagement in the implementation of the Niagara River (Ontario) Remedial Action Plan.
Concern about the $3 million Welland River remediation dollars that were granted to the NPCA (accountability and transparency) given that tight natural resources based funding is repeatedly raised.	This comment was forwarded to the Niagara Peninsula Conservation Authority given it does not pertain to the Niagara River Remedial Action Plan. Please contact the Conservation Authority for details.

Summary of Feedback	Response
Submission #3	
Respondent concurs with changing the status as long as conditions are such that we are confident that neither of these two scenarios [Beneficial Use Impairments] are likely to return.	Given that the long-term water quality trends do not indicate issues related to eutrophication or undesirable algae, future impairments are not anticipated. Environment and Climate Change Canada continues to monitor water quality through its Upstream/Downstream Program. No further monitoring of plankton is recommended or required.
Submission #4	
Black Creek [a tributary of the Niagara River] has been used to dump human excrement, thus causing huge blooms of algae. Many other creeks are choked up with algae.	General water chemistry, nutrients, metals and bacterial levels are monitored by the Niagara Peninsula Conservation Authority at two monitoring stations on Black Creek. The data do not indicate any recent (i.e., past 5 years) issues related to human sewage pollution. The Conservation Authority continues to monitor water quality parameters in the region and reports on results annually. The Ontario Ministry of Environment and Climate Change also reviewed their files and found no reports related to water quality problems in Black Creek. Any pollution incidents can be reported to the local ministry district office (905-704-3900) or Ontario's Spills Action Centre (1-866-663-8477).

Feedback Form

Your comments are important! We want to know what you think about the recommendation to change the status related to these two ecological indicators: *Eutrophication or Undesirable Algae* and *Phytoplankton and Zooplankton Populations*. Please fill out the following feedback form and drop into the comment box or mail to: Niagara River Remedial Action Plan, 3rd Floor, 250 Thorold Road West, Welland, Ontario, L3C 1W2.

Comments will be reviewed and addressed by the RAP Team. If you wish to be contacted in follow-up to your submission, please be sure to provide your contact information. Comments will be compiled and shared in the form of a summary report after the deadline; however, personal information (name, email, phone number) will remain confidential. To obtain a copy of the technical and summary reports visit our website: ourniagarariver.ca or contact Natalie Green at info@ourniagarariver.ca or 905-788-3135 x243. **The comment period closes November 25, 2017.** Thank you for your feedback.

Name

Email

If you wish to be contacted by someone to follow-up on your comments, please provide an email address. It will not be shared publicly.

Phone

If you wish to be contacted by someone to follow-up on your comments, please provide a phone number. It will not be shared publicly.

1. **How did you hear about the recommendation to change the status of these two BUIs?**
   - Attended the Nov. 15 Open House
   - Social Media (Facebook, Twitter)
   - Website
   - E-newsletter
   - Colleague
   -

2. **Have you read the supporting documents?**
   - Yes
   - No
   - I don't know

If you answered 'Yes' to the question 2 above, please indicate which documents you read.

- ☐ Eutrophication/Undesirable Algae Summary
- ☐ Plankton Populations Summary
- ☐ Technical Report on Eutrophication/Undesirable Algae
- ☐ Technical Report on Plankton Populations
- ☐ All of the above
- ☐ Not Applicable / Did not read any documents

3. **Eutrophication/Undesirable Algae BUI**
   Choose the statement that best describes your opinion for the status of Eutrophication or Undesirable Algae BUI in the Niagara River (Ontario) AOC.

   - ○ I agree with the recommendation to change the status to 'Not Impaired'
   - ○ I do not agree with the recommendation to change the status to 'Not Impaired'
   - ○ I don't know

4. **Plankton Populations BUI**
   Choose the statement that best describes your opinion for the status of Phytoplankton & Zooplankton Populations BUI in the Niagara River (Ontario) AOC.

   - ○ I agree with the recommendation to change the status to 'Not Impaired'
   - ○ I do not agree with the recommendation to change the status to 'Not Impaired'
   - ○ I don't know

5. **General Comments**
   Please provide any additional comments or concerns related to the recommendation to change the status of the two BUIs.

_____

_____

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APPENDIX 4:
Supporting Communication and Outreach Materials

Summary: *Eutrophication or Undesirable Algae* (BUI #8)

Niagara River (Ontario) Area of Concern

It is recommended that the Niagara River (Ontario) RAP change the status of *Eutrophication or Undesirable Algae* BUI from "Impaired" to "Not Impaired".

BACKGROUND

Algae are tiny plant-like organisms that are an important part of the food web as they are the main source of food for planktivorous fishes and zooplankton. However, when algae are overabundant (often referred to as an algal bloom) they can cause disruptions to the aquatic ecosystem, result in fish kills, pose a risk to human health and/or impair recreational enjoyment of the waterbody (boating, swimming). This is the reason *Eutrophication or Undesirable Algae* is listed as one of the 14 potential beneficial use impairments (BUIs) in the Niagara River Area of Concern (AOC). Pollution from human sources such as municipal and industrial wastewaters, agricultural runoff, fertilizers on lawns and golf courses, and poorly maintained septic systems are sources of nutrients that can contribute to "eutrophication", a term that describes the enrichment of nutrients within a waterbody. Natural sources of nutrients from sediments (due to erosion) can also contribute to eutrophication.

The Niagara River AOC is a 58 km bi-national connecting channel linking Lake Erie to Lake Ontario. The watercourses that flow into the Niagara River (i.e., Welland River and other small creeks) are considered a potential source of pollution to the AOC but are not included in the AOC boundaries. A 1985 assessment of the BUI indicated it was not impaired in the Niagara River; however, a 1993 RAP Report indicated the status was "Impaired" for *Eutrophication* and "Not Impaired" for *Undesirable Algae* due to nutrient-related problems in the tributaries (i.e, Welland River and other creeks), not the Niagara River. Both parts of the BUI were changed to "Impaired" in 2009, however, because of poor water quality and observations of algae in the Welland River. No information was noted for the condition of the Niagara River.

An assessment initiated in 2014 examined all recent data (2003-2013) from multiple sources collected in the Niagara River (and Chippawa Creek/Niagara power canal) from multiple agencies for five key eutrophication metrics: total phosphorus (TP), phosphate/soluble reactive phosphorus (SRP), chlorophyll *a*, dissolved oxygen (DO) and Secchi disc depth. A scientific weight-of-evidence approach (as is used by other AOCs) was used to interpret data and determine the status of the *Eutrophication or Undesirable Algae* BUI. **The results of the assessment indicate that there is no eutrophication or undesirable algae impairment in the Niagara River.**

RESULTS OF BUI ASSESSMENT

Below is a summary of the scientific evidence indicating no eutrophication or undesirable algae impairment in the Niagara River AOC:

- Total phosphorus (TP) concentrations were evaluated against the Provincial Water Quality Objective (PWQO) criterion of 30 ug/L. The review identified that some values exceeded the PWQO likely due to known sources upstream of the Niagara River AOC. **TP concentrations upstream and downstream in the Niagara River showed no significant difference, suggesting minimal sources of TP within the AOC.**

- **Phosphate and chlorophyll *a* concentrations were generally equivalent to or less than those measured in comparable reference areas;**

- **Dissolved oxygen (DO) concentrations were generally above the screening criterion of 6.5 mg/L.** Of the two DO observations below 6.5 mg/L, impact to biota was not expected;

- **Historical Secchi disc depth values in the Niagara River were generally on par with or better than current day values in comparable reference areas;**

- The BUI is listed as "Not Impaired" on the New York side of the Niagara River because of declines in phosphorus and chlorophyll *a* levels in Lake Erie between 1968-1985, high levels of DO, and the absence of nuisance algal blooms.

Scientific evidence shows there are no issues related to excess nutrients or algae in the AOC.

FOR MORE INFORMATION

To obtain more information and to download the technical summary or detailed report, please visit:
www.ourniagarariver.ca

This project was made possible with support from the Government of Canada and the Province of Ontario, in partnership with the Niagara Peninsula Conservation Authority.

Tipping the Scales Toward Delisting

Public Information Open House

Wednesday, November 15th, 2017 / 6:30–8:30 PM

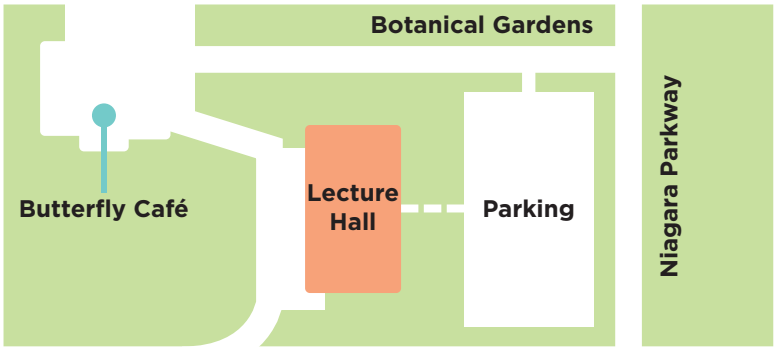
Presentations at 7 PM / Light refreshments provided

Recent scientific research shows that two of the Niagara River's environmental indicators are not impaired. The Niagara River Remedial Action Plan (RAP) Team invites you to learn about these two recent scientific assessments and to have your say about the recommendation to change the status of two ecological indicators related to Eutrophication and Plankton Populations in the Niagara River.

Scientists from the Department of Fisheries and Oceans Canada and the Ontario Ministry of the Environment and Climate Change will provide information on their research and will be available to answer your questions. There will also be an opportunity to learn more about the RAP program and to be a part of this important discussion.

Have Your Say!

Online · Email · In Person



Niagara Parks School of Horticulture Lecture Hall
2405 Niagara Parkway, Niagara Falls, Ontario

For more information:

ourniagarariver.ca/latest-news • info@ourniagarariver.ca • (905) 788-3135 x243

NIAGARA RIVER
Remedial Action Plan
ourniagarariver.ca

Rolling by the River Bus Tour

Wednesday, October 25th, 2017 / 10 AM–3 PM

You're invited to join a special Niagara River Remedial Action Plan (RAP) bus tour to explore and learn about the Niagara River Area of Concern (AOC) and some of the great projects completed or in progress that help us achieve a healthier Niagara River ecosystem

Coffee & Conversation 9:30 am / Bus Boards 10 am / Lunch provided
Meet at NOTL Community Centre (Mori Room) / 14 Anderson Lane / Niagara-on-the-Lake, ON

Highlights

- Review of the RAP Program
- Sediment Remediation
- Habitat Restoration
- Monitoring & Research

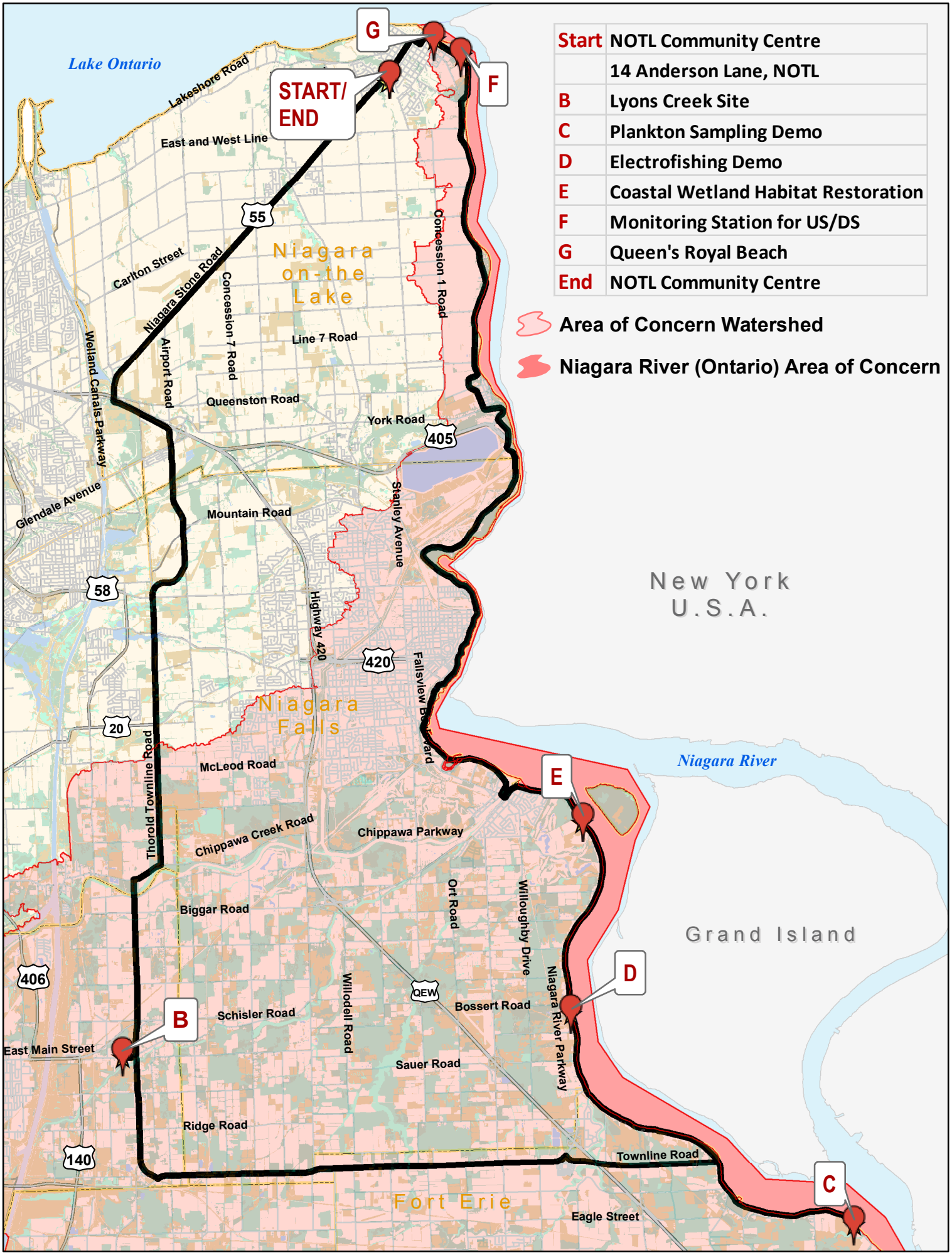
Space is limited! Please RSVP by October 17th, 2017 to confirm your spot
ngreen@npca.ca / (905) 788-3135 x243

Rolling by the River 2017
RAP Highlights Bus Tour Schedule*

9:30 am – 10 am	**Meet at the NOTL Community Centre, 14 Anderson Lane (A)** Sign-in / Meet and Greet in the Mori Room / coffee, tea, cookies provided
10 am	**Board Bus (Depart no later than 10:30 am)**
10:30 am – 11 am	On Route to Lyon's Creek site Topic: Housekeeping / RAP Overview / GLWQA Revisions Speakers: Natalie Green & Mark Chambers (ECCC)
11 am	**Lyon's Creek site (B)** **Topic: Sediment Studies / Benthos** **Speaker: Natalie Green & Cheriene Vieira (MOECC)**
11:10 am	On route to Upper Niagara River site Topic: Watershed Water Quality Monitoring Speaker: Josh Diamond (NPCA)
11:35 am	**DFO Freshwater Ecosystem Research (C)** **Speakers: Heather Niblock and Robert Bonnell**
12:00 pm	Board bus / Lunch on route to next site
12:30 pm	**MNRF Fish Assessment Demo (D)** **Topic: Fish Population Assessments / Electrofishing** **Speaker: Joad Durst (MNRF)**
1:00 pm	On route to stop E (Habitat Restoration) / Free time
1:10 pm	**Arrive at Habitat Restoration Sites (E)** **Topic: Prairie and Coastal Wetland Habitat Restoration** **Speakers: Corey Burant (NPC)**
1:40 pm	On route to stop F Topic: Upstream/Downstream Monitoring & Niagara River Toxics Management Plan Speaker: Cheriene Vieira (MOECC)
2:30 pm	**Arrive at Stop F (pause, do not get out)** **View downstream monitoring station and Lower Niagara River**
2:35 pm	On route to Stop G (Queen's Royal Beach)
2:40 pm	**Arrive at Queen's Royal Beach** **Topic: water quality investigations (*E. coli* related to Beach Closings)** **Speaker: Brett Ruck (Town of NOTL)**
3 pm	**Arrive at NOTL Community Centre; End.**

[Turn over for map]

*Times are estimated and route is subject to change due to adverse weather or other issues.


Start NOTL Community Centre
14 Anderson Lane, NOTL
B Lyons Creek Site
C Plankton Sampling Demo
D Electrofishing Demo
E Coastal Wetland Habitat Restoration
F Monitoring Station for US/DS
G Queen's Royal Beach
End NOTL Community Centre
Area of Concern Watershed
Niagara River (Ontario) Area of Concern
Lake Ontario
START/ END
G
F
E
D
C
B
Lakeshore Road
East and West Line
55
Carlton Street
Niagara Stone Road
Concession 7 Road
Concession 1 Road
Niagara on-the Lake
Line 7 Road
Airport Road
Welland Canals Parkway
Queenston Road
York Road
405
Glendale Avenue
Mountain Road
Stanley Avenue
58
Highway 420
420
Fallsview Boulevard
Niagara Falls
20
Thorold Townline Road
McLeod Road
Niagara River
Chippawa Creek Road
Chippawa Parkway
Ort Road
Willoughby Drive
Biggar Road
Grand Island
406
QEW
Bossert Road
Niagara River Parkway
Schisler Road
Willodell Road
East Main Street
Sauer Road
Ridge Road
140
Townline Road
Fort Erie
Eagle Street
New York
U.S.A.

MEDIA RELEASE

For immediate release

NIAGARA RIVER REMEDIATION TEAM SEEKS PUBLIC INPUT ON STATUS OF TWO ENVIRONMENTAL INDICATORS

Studies show the base of the food web is healthy

WELLAND, Ont. (October 23, 2017) – The Niagara River (Ontario) Remedial Action Plan Team is seeking public input on the recommendation to change the status of two of the Niagara River's environmental indicators. Two separate scientific studies were completed that show that the base of the food web is healthy and there are no issues related to excess algae and plankton populations in the Niagara River.

Plankton such as algae, microbes and water fleas are small organisms that live in the water. "Plankton form the base of the food web in aquatic environments and are an important food source for Niagara River fishes such as Yellow Perch, Emerald Shiner, and Gizzard Shad, which in turn are eaten by larger sport fishes" explains Dr. Warren Currie, research scientist at Fisheries and Oceans Canada. "Too little or too much plankton can be an indicator of ecosystem disruption."

The two separate scientific studies examined water quality parameters, water chemistry and plankton densities to determine if there were problems with excess algae and plankton populations in the Niagara River. Water chemistry in the Niagara River is consistent with water from eastern Lake Erie. Results of the plankton assessment indicate plankton populations are lower than Lake Erie, but consistent with expectations for a high-velocity, low nutrient (oligotrophic) river system. Dominant plankton species found were those that survive in fast-flowing environments. Water quality parameters compiled from various sources showed there are no issues with excessive or undesirable algae in the Niagara River. Although the Wellland River and other tributaries to the Niagara River may have localized impacts related to water quality, overall, they do not appear to directly impact the Niagara River in relation to nutrient levels or algae.

There are many ways for the public to learn about the research and have a say on the recommended status change. The reports are available for review online and comments can be submitted until November 25 by completing a short electronic survey, via email, by mail and in-person at a **Public Information Open House on November 15, 2017 from 6:30 pm to 8:30 pm at the Niagara Parks School of Horticulture Lecture Hall (2405 Niagara Parkway, Niagara Falls, Ontario).** The Open House will provide

the opportunity to hear from the scientists, ask questions, and submit comments in person. Light refreshments will be provided.

The Niagara River is one of 36 remaining degraded locations called an Area of Concern in the Canada-U.S. Great Lakes Water Quality Agreement and the federal-provincial Canada-Ontario Agreement. Historically, each of these areas faced significant water quality problems that caused negative impacts on the way people or wildlife use the water resource. These negative impacts are known as Beneficial Use Impairments. *Eutrophication or Undesirable Algae* and *Degradation of Phytoplankton and Zooplankton Populations* are two of 14 potential indicators that inform us about the health of the Niagara River Area of Concern.

The goal of the Niagara River Remedial Action Plan is to address the environmental issues related to the Beneficial Use Impairments, and ultimately, to restore water quality and ecosystem health in the Niagara River and remove it from the list of Great Lakes Areas of Concern. A separate but complementary plan is in place on the American side of the river.

FOR MORE INFORMATION visit ourniagarariver.ca/latest-news. Follow us on Facebook and Twitter for more updates.

###

The Niagara River Remedial Action Plan is a community-based partnership to restore and protect water quality and ecosystem health in the Niagara River Area of Concern. This initiative is made possible with funding from the Government of Canada and the Province of Ontario, in partnership with the Niagara Peninsula Conservation Authority. To get involved, contact info@ourniagarariver.ca.

Media Contact:

Natalie Green, Niagara River RAP Project Manager
Niagara Peninsula Conservation Authority
ngreen@npca.ca
905-788-3135 x243

MEDIA ADVISORY

Public invited to learn about recent progress on Niagara River ecosystem

WELLAND, Ont. (November 13, 2017)— The Niagara River (Ontario) Remedial Action Plan Team is seeking public input on the recommendation to change the status of two of the Niagara River's environmental indicators.

Two separate scientific studies were completed, which show that the base of the food web is healthy and there are no issues related to excess algae and plankton populations in the Niagara River. The reports are available for review online and comments can be submitted until November 25 by completing a short electronic survey, via email, by mail and in-person at the Public Information Open House. Light refreshments will be served.

WHAT: Niagara River Public Information Open House

WHEN: Wednesday, November 15, 2017
6:30 to 8:30 p.m.

WHERE: Niagara Parks School of Horticulture Lecture Hall
2405 Niagara Parkway
Niagara Falls, ON

OPPORTUNITY:

The public and the media will get an opportunity to learn about the research related to two ecosystem indicators and to have a say on the recommended status change in the Niagara River Area of Concern.

Scientists from Fisheries and Oceans Canada, the Ministry of the Environment and Climate Change and representatives from the Niagara River Remedial Action Plan initiative will be available for interviews and photos.

For more information, please contact Natalie Green at ngreen@npca.ca or 905-788-3135 x243.

FOR MORE INFORMATION visit ourniagarariver.ca/latest-news. Follow us on Facebook and Twitter for more updates.

###

The Niagara River Remedial Action Plan is a community-based partnership to restore and protect water quality and ecosystem health in the Niagara River Area of Concern. This initiative is made possible with funding from the Government of Canada and the Province of Ontario, in partnership with the Niagara Peninsula Conservation Authority. To get involved, contact info@ourniagarariver.ca.

Open house to discuss Niagara River health

Postmedia Staff

The health of the Niagara River's ecosystem seems to be improving, according to new scientific research conducted on the waterway.

As a result of those studies, the Niagara River Remedial Action Plan is inviting the community to an open house to discuss the potential of upgrading the status of the river – one of 36 waterways listed as areas of concern in the Canada-U.S. Great Lakes Water Quality Agreement and the Canada-Ontario Agreement.

In a media release issued Monday, the organization run in partnership with the Niagara Peninsula Conservation Authority, says two separate scientific studies looked into water quality parameters, chemistry and plankton densities and determined that the food web base was healthy, and that there were no issues related to excess algae and plankton populations.

There has been significant water quality problems within the river in past years, negatively impacting people and wildlife.

Reports on the studies are available online at ourniagarariver.ca/latest-news, and comments can be submitted online until Nov. 25, or in person at a public information open house, Nov. 15 from 6:30 to 8:30 p.m. at the Niagara Parks School of Horticulture Lecture Hall, 2405 Niagara Parkway, Niagara Falls, where scientists involved in the studies will be available to discuss their findings and answer questions.

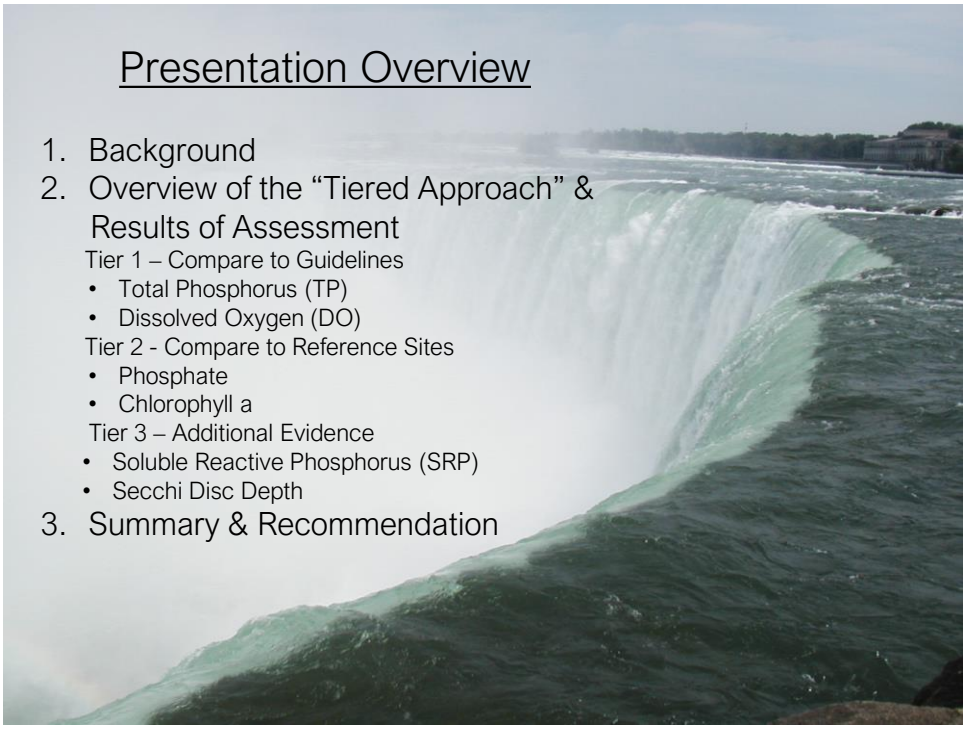
APPENDIX 5:
Presentation slide deck - Assessment of the *Eutrophication or Undesirable Algae* Beneficial Use Impairment in the Niagara River (Ontario) Area of Concern

Assessment of the *Eutrophication or Undesirable Algae* Beneficial Use Impairment in the Niagara River (Ontario) Area of Concern

Tanya Long, Environmental Scientist, Great Lakes
Ontario Ministry of the Environment and Climate Change

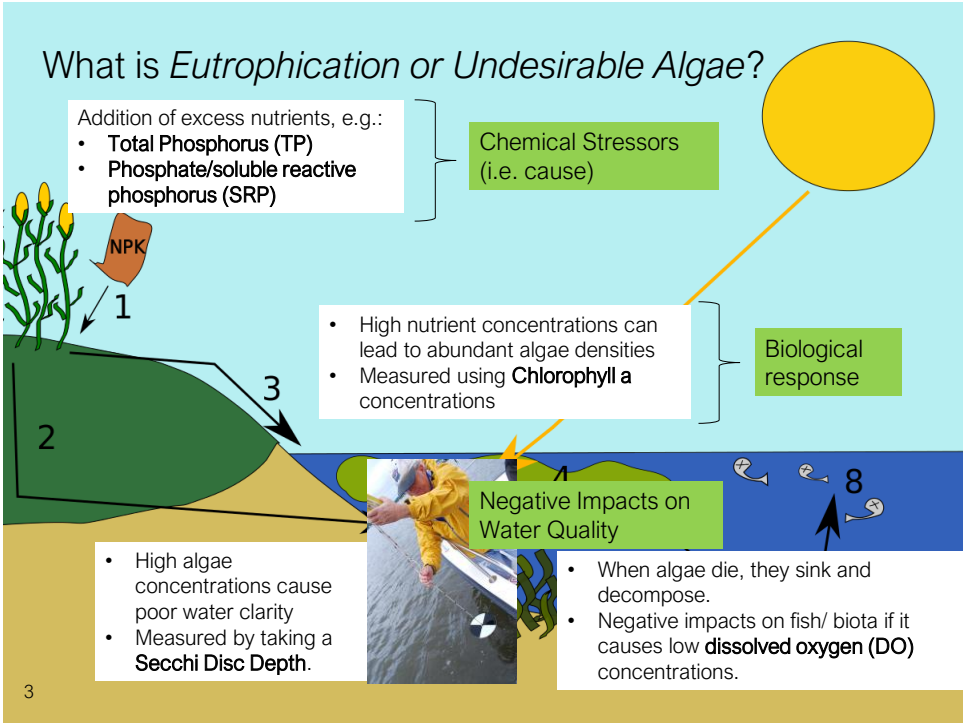
Niagara River RAP Public Information Open House
November 15, 2017

Ontario



Presentation Overview

1. Background
2. Overview of the "Tiered Approach" & Results of Assessment
   - Tier 1 – Compare to Guidelines
     - Total Phosphorus (TP)
     - Dissolved Oxygen (DO)
   - Tier 2 - Compare to Reference Sites
     - Phosphate
     - Chlorophyll a
   - Tier 3 – Additional Evidence
     - Soluble Reactive Phosphorus (SRP)
     - Secchi Disc Depth
3. Summary & Recommendation



History of the Niagara River the Status of *Eutrophication or Undesirable Algae* BUI

1985
- International Joint Commission (IJC) indicated that the Niagara River did not suffer from eutrophication
- Niagara River listed as an Area of Concern (AOC) in 1987 due to "conventional pollution", contaminated sediment, & fish advisories

1993
- Niagara River RAP Stage 1 report lists BUI status as:
  - Eutrophication – Impaired (Welland River only); and
  - Undesirable Algae – Not Impaired

2009
- Niagara River RAP Stage 2 Update changes overall BUI status to "Impaired" based on anecdotal evidence of undesirable algae in Welland River

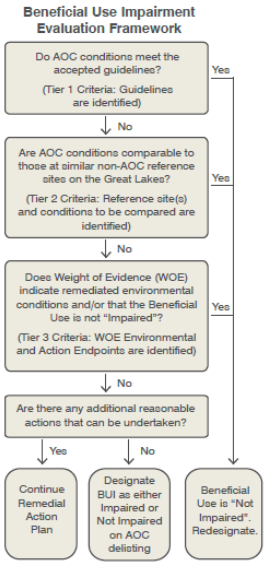
4

Ontario

Data Considered in BUI Assessment

- Most recent decade of data used to characterize current conditions (2003 – 2013)
- Geographical scope:
  - Canadian side of NR between Fort Erie (FE) and Niagara-on-the-Lake (NOTL)
  - Chippawa Creek/Niagara Power Canal
- Data sources:
  - Environment & Climate Change Canada (ECCC)
  - Ontario Ministry of Environment & Climate Change (MOECC)
  - Niagara Peninsula Conservation Authority (NPCA)
  - New York State Department of Environmental Conservation (NYSDEC)
  - State University of New York (SUNY) Brockport

Ontario



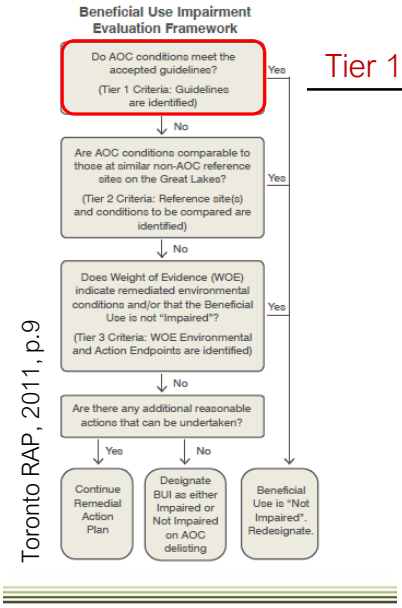
Toronto RAP, 2011, p.9

Overview of the "Tiered Approach"

The "Tiered Approach":

- Is a transparent, science-based framework for assessing beneficial use impairments (BUIs)
- Was developed by the Toronto RAP in 2011
- Is an approach now used by other AOCs and jurisdictions (e.g. Grand River Watershed)

Ontario



Toronto RAP, 2011, p.9

Tier 1 →

TIER 1 = Compare to Guidelines

Total Phosphorus (TP)

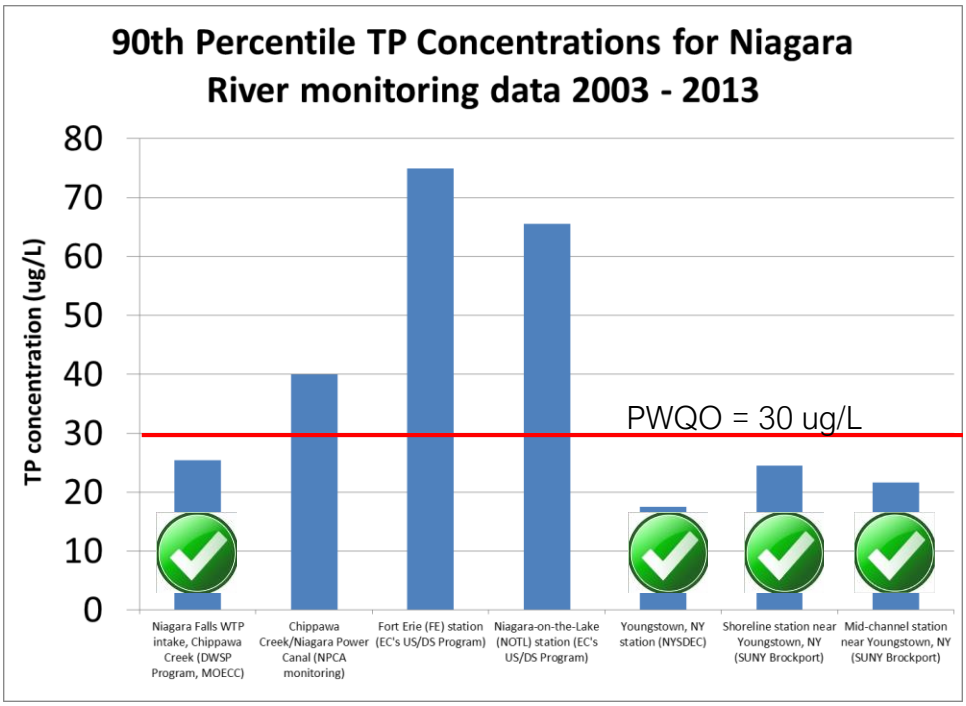
- compared to Interim Provincial Water Quality Objective (PWQO) of 30 ug/L for streams/rivers (MOEE, 1994)

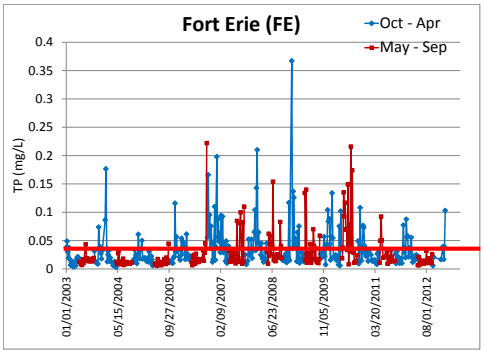
Dissolved Oxygen (DO)

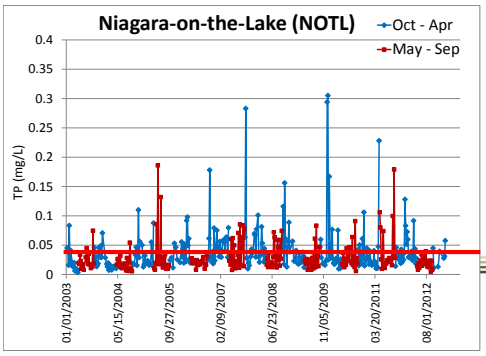
- Data screened against 6.5 mg/L
  - Canadian Water Quality Guideline (CWQG) for coldwater biota, non-early life stages (CCME, 1999);
  - PWQO at 5-10° C (MOEE, 1994).

PWQO[1]: **Dissolved oxygen concentrations should not be less than the values specified below for cold water biota (e.g. salmonid fish communities) and warm water biota (e.g. centrarchid fish communities):**

Dissolved Oxygen Concentration				
Temperature	Cold Water Biota		Warm Water Biota	
°C	% Saturation	mg/L	% Saturation	mg/L
0	54	8	47	7
5	54	7	47	6
10	54	6	47	5
15	54	6	47	5
20	57	5	47	4
25	63	5	48	4





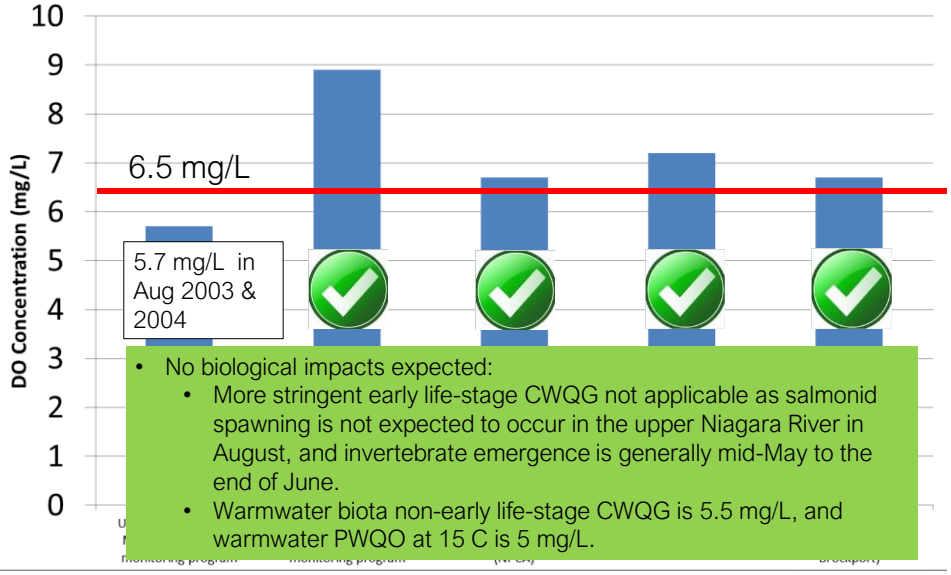


Environment and Climate Change Canada's Upstream/Downstream Data

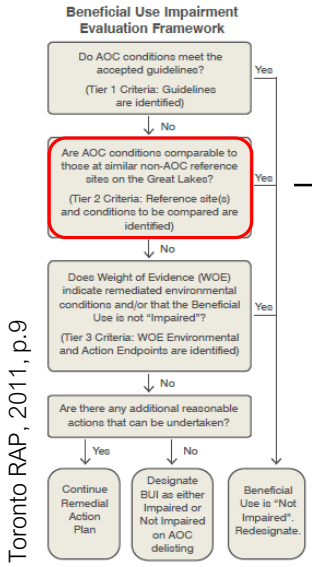
- TP concentrations may be higher relative to other sampling programs due to:
  - higher sampling frequency capturing more peak TP concentrations
  - Year-round sampling
- The 90th percentile TP concentration fails the 30 ug/L criterion at FE
- No statistically significant difference between TP at FE and NOTL; no obvious impact of Welland River on NR

Ontario

Minimum DO Concentrations in the Niagara River 2003 - 2013



- No biological impacts expected:
  - More stringent early life-stage CWQG not applicable as salmonid spawning is not expected to occur in the upper Niagara River in August, and invertebrate emergence is generally mid-May to the end of June.
  - Warmwater biota non-early life-stage CWQG is 5.5 mg/L, and warmwater PWQO at 15 C is 5 mg/L.



Toronto RAP, 2011, p.9

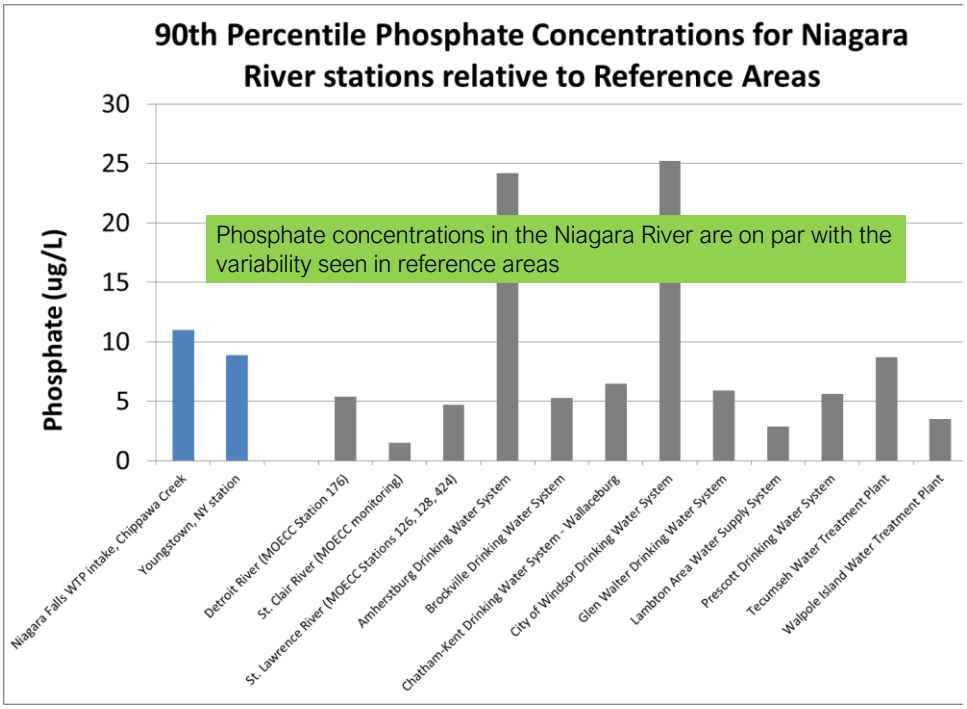
Tier 2 →

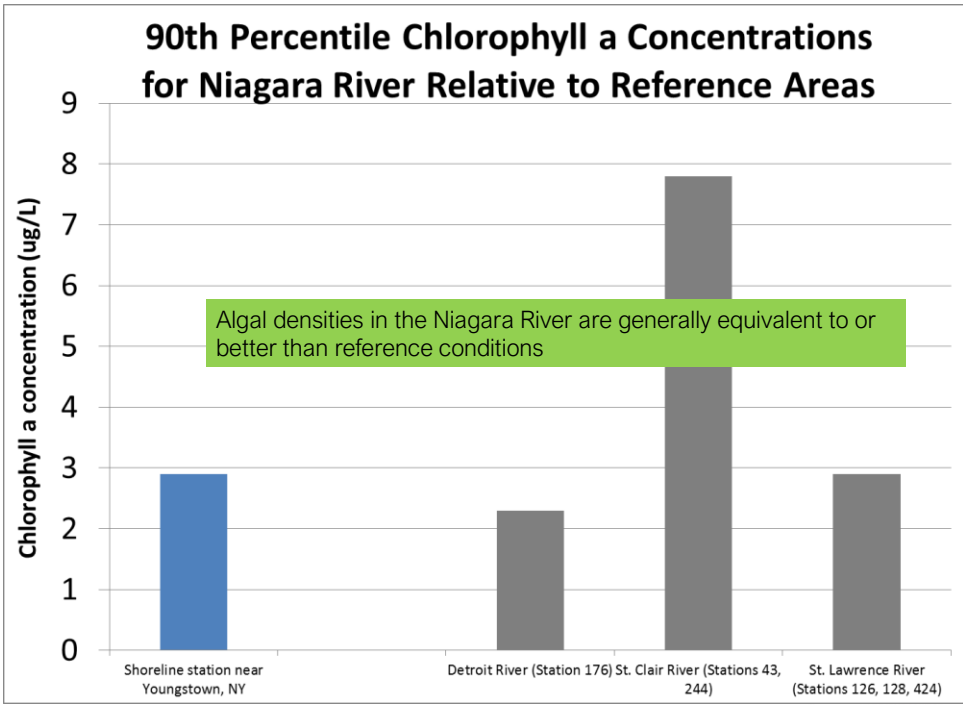
TIER 2 = Compare to Reference Sites

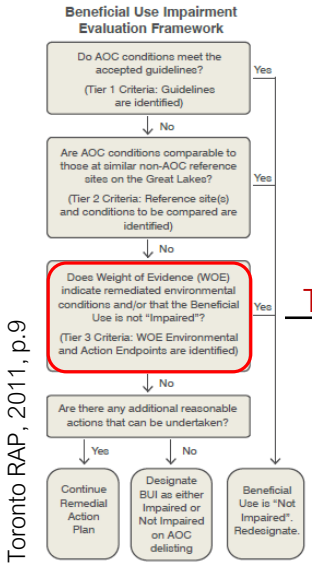
Phosphate and Chlorophyll a

- Other connecting channels in the lower Great Lakes were used as reference sites:
  - Detroit River
  - St. Clair River
  - St. Lawrence River
- Although these 3 areas are also AOCs, *Eutrophication or Undesirable Algae* is not impaired
- Conditions in the Niagara River (NR) were considered unimpaired if recent data were comparable to or better than current day conditions in reference areas

Ontario







Toronto RAP, 2011, p.9

Tier 3 →

TIER 3 = Additional Evidence

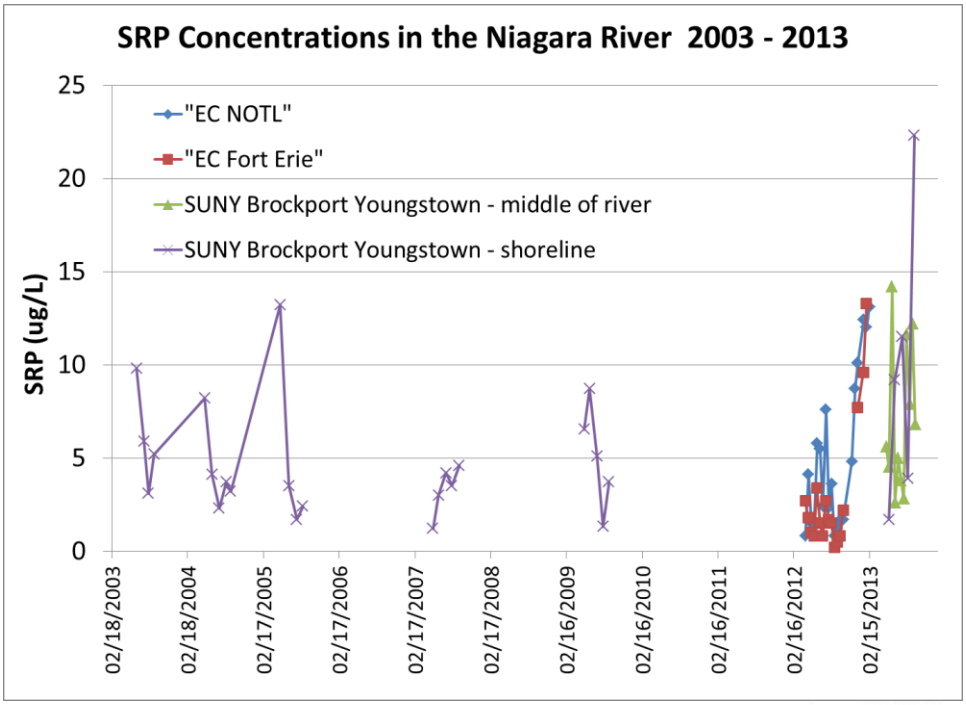
Soluble Reactive Phosphorus (SRP)

- Additional forms of phosphorus examined
- SRP data not available for reference areas
- A spatial and temporal trend analysis was conducted to determine any statistical increases in concentration along the length of the River, and over time

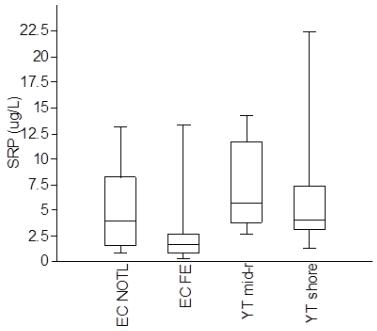
Secchi Disc Depth (SDD) Data

- Recent data not available for NR, so historical NR data examined for:
  - Temporal trends
  - Comparison to recent SDD data in reference areas
- Trends along length of River not conducted due influence of the Falls

Ontario



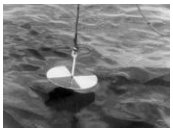
Soluble Reactive Phosphorus (SRP)

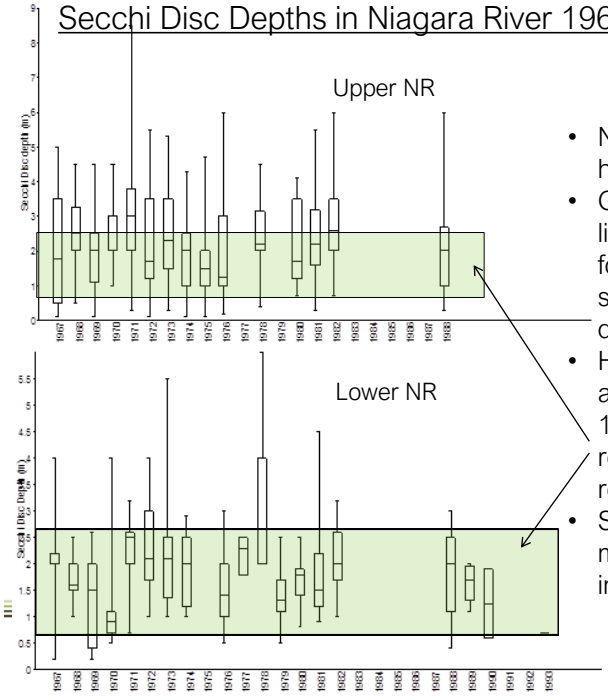


- No statistically significant difference between FE and NOTL SRP concentration data (p = 0.48)
- Lack of a clear Niagara River source of SRP
- More (consistently analyzed) data would be needed to determine with higher certainty if SRP concentrations in the Niagara River are indicative of an eutrophication impairment

Ontario

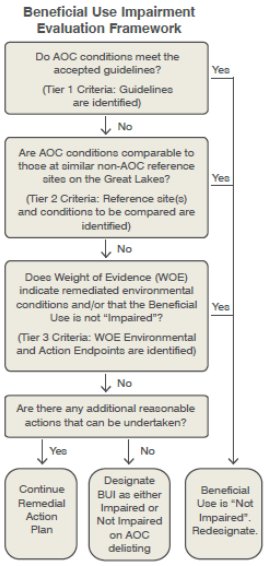
Secchi Disc Depths in Niagara River 1967 - 1993





- No clear time trend, but not historically "impaired"
- Greater variability in lower NR likely due to stronger erosive forces and prominent role of suspended solids in determining water clarity
- Historical SDDs from the NR are on par with or better than 10th percentiles of those recently measured in reference areas (0.7 – 2.6 m)
- Strong currents in NR are a major caveat to use of SDDs in this AOC

Ontario



Toronto RAP, 2011, p.9

Summary

- TP concentrations did not all meet the PWQO; however:
  - The PWQO was exceeded at Fort Erie
  - Upstream and downstream TP concentrations showed no significant difference, suggesting minimal sources of TP within the AOC
- DO concentrations were generally above the screening criterion of 6.5 mg/L. Of the two DO observations below 6.5 mg/L, impact to biota was not expected;
- Phosphate, chlorophyll *a* concentrations and historical Secchi disc depth values were generally equivalent to or better than those measured in comparable reference areas.

Ontario

Other lines-of-evidence include:

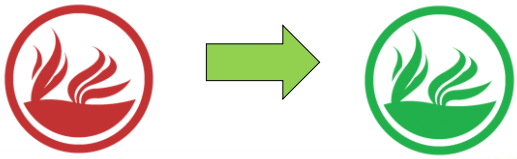
- High flow conditions are not favourable for algal bloom formation (Dodds, 2006; Maier et al., 2001).
- The historical "Not Impaired" status of this beneficial use, and little evidence that eutrophication indicators have since changed;
- The lack of historical linkage of an "Impaired" status to the NR; status changes pertained to issues in the Welland River (out of scope)
- Consistent with "Not Impaired" status for *Eutrophication or Undesirable Algae* in the Niagara River (New York) AOC:

> *Declines in phosphorus and chlorophyll a levels in Lake Erie between 1968 and 1985 along with high dissolved oxygen levels measured in the Niagara River and the absence of nuisance algal blooms or accumulation are evidence that eutrophication is not a serious problem in the River.* (NYSDEC, 2008)

Ontario

Recommendation

Based on the weight-of-evidence,
it is recommended that the status of the
Eutrophication or Undesirable Algae BUI
be changed to "**Not Impaired**" in the
Niagara River (Ontario) AOC.



Ontario

Acknowledgements

Many thanks to those who supplied data:

- MOECC: Paul Pu (Great Lakes Unit data); Patrick McInnis, Nazma Khan & Carline Rocks (DWSP data)
- NPCA: Joshua Diamond
- ECCC: Brad Hill
- NYSDEC: Margaret Novak and Jason Fagel
- SUNY at Brockport: Joseph Mackarewicz

Thanks are also extended to those who reviewed the assessment and/or provided other guidance or assistance:

- Natalie Green (Project Manager, Niagara River RAP)
- Sarah Day, Lisa Richman, Cheriene Vieira (MOECC)
- Veronique Hiriart-Baer, Martha Guy (ECCC)
- Fred Luckey, Paula Zevin (US EPA)
- Mark Filipski, Don Zelazny (NYSDEC)
- Mary Ellen Scanlon (formerly MOECC), Don Williams (formerly EC), Valerie Cromie (former Niagara River RAP Coordinator), Rimi Kalinauskas (formerly ECCC)

Ontario

APPENDIX 6:
Technical Report - Assessment of the *Eutrophication or Undesirable Algae* Beneficial Use Impairment in the Niagara River (Ontario) Area of Concern

Assessment

of

Eutrophication or Undesirable Algae

Beneficial Use Impairment

in the Niagara River (Ontario) Area of Concern

October 2017

NIAGARA RIVER
Remedial Action Plan

Executive Summary

Algae are tiny plant-like organisms that are an important part of the food web as they are the main source of food for planktivorous fishes and zooplankton. However, when algae are overabundant (often referred to as an algal bloom) they can cause disruptions to the aquatic ecosystem, result in fish kills, pose a risk to human health and/or impair recreational enjoyment of the waterbody (boating, swimming). This is the reason *Eutrophication or Undesirable Algae* is listed as one of the 14 potential beneficial use impairments (BUIs) in the Niagara River Area of Concern (AOC). Pollution from human sources such as municipal and industrial wastewaters, agricultural runoff, fertilizers on lawns and golf courses, and poorly maintained septic systems are sources of nutrients that can contribute to "eutrophication", a term that describes the enrichment of nutrients within a waterbody. Natural sources of nutrients from sediments (due to erosion) can also contribute to eutrophication.

The Niagara River is one of 36 remaining AOCs in the Great Lakes due to historical water quality pollution from human sources. The Remedial Action Plan (RAP) process guides restoration efforts with the ultimate goal of improved environmental conditions and subsequent removal of the river from the list of Great Lakes AOCs. Historically, the boundaries of the AOC included the Niagara River and its entire watershed. In 2012, the Great Lakes Water Quality Agreement was revised indicating that the focus of AOCs is to include the "Waters of the Great Lakes and the connecting river systems of St. Mary's, St. Clair, Lake St. Clair, Detroit, Niagara, and St. Lawrence at the international boundary or upstream from the point at which the river becomes the international boundary between Canada and the United States, including all open and nearshore waters." The boundary for the Niagara River AOC is now defined as the connecting channel itself flowing from the mouth of Lake Erie to Lake Ontario. Its tributaries are considered as a potential source of impairment instead of part of the AOC itself.

The *Eutrophication or Undesirable Algae* BUI was first listed as impaired in the 1993 Stage 1 RAP Report; however, it was considered in two parts. The *Eutrophication* component of the BUI was listed as "Impaired" due to issues in the Welland River; for *Undesirable Algae*, the Niagara River AOC and its largest tributary was designated as "Not Impaired" because there was no evidence of persistent algae. The status of the entire BUI was changed to "Impaired" during the RAP Stage 2 Update (2009) for the Niagara River and its largest tributary based on anecdotal evidence of poor water quality and observations of algae in the Welland River. Based on the refinement of the AOC boundaries and in the absence of a data review for the Niagara River, the RAP Team agreed to pursue an assessment of all relevant data to determine the status of the *Eutrophication or Undesirable Algae* BUI for the Ontario portion of the Niagara River.

The assessment initiated in 2014 examined all recent data (2003-2013) from multiple sources collected in the Niagara River (and Chippawa Creek/Niagara power canal) from multiple agencies for five key eutrophication metrics: total phosphorus (TP), phosphate/soluble reactive phosphorus (SRP), chlorophyll *a*, dissolved oxygen (DO) and Secchi disc depth. A scientific weight-of-evidence approach (as is used by other AOCs) was used to interpret data and determine the status of the *Eutrophication or Undesirable Algae* BUI. The results of the

assessment indicate that there is no eutrophication or undesirable algae impairment in the Niagara River.

Below is a summary of the scientific evidence indicating no eutrophication or undesirable algae impairment in the Niagara River AOC.

- The 90th percentiles of TP concentrations did not unequivocally meet the criterion of 30 ug/L; however, this was attributed to TP sources upstream from the Niagara River and out of scope of the RAP;
- Phosphate and chlorophyll *a* concentrations were generally equivalent to or less than those measured in unimpaired reference areas (SRP data were inconclusive);
- Dissolved oxygen (DO) concentrations were generally above the screening criterion of 6.5 mg/L. Of the two DO observations below 6.5 mg/L, impact to biota was not expected;
- Historical Secchi disc depth values in the Niagara River were generally on par with or better than current day values in unimpaired reference areas;
- The BUI is listed as Not Impaired on the New York side of the Niagara River (Niagara River New York RAP, 2012).

Therefore, it is recommended that the status of *Eutrophication or Undesirable Algae* for the Niagara River (Ontario) AOC be changed to "Not Impaired".

Acknowledgements

Thanks are given to the following individuals who were instrumental in the compilation of data that were used to complete the Technical Assessment of Eutrophication or Undesirable Algae BUI for the Niagara River (Ontario) AOC:

- Paul Pu (Ontario Ministry of the Environment and Climate Change (MOECC)) – MOECC's Great Lakes Unit data
- Patrick McInnis, Nazma Khan & Carline Rocks (MOECC) – MOECC's Drinking Water Surveillance Program (DWSP) data
- Joshua Diamond (Niagara Peninsula Conservation Authority (NPCA)) - NPCA data
- Brad Hill (Environment Canada (EC)) - EC's Upstream/Downstream (US/DS) data
- Margaret Novak and Jason Fagel (New York State Department of Environmental Conservation (NYSDEC)) - NYSDEC data
- Joseph Mackarewicz (State University of New York (SUNY) at Brockport) – SUNY Brockport data

Assistance in various forms is also much appreciated from the following individuals: Sarah Day (MOECC), Fred Luckey (United States Environmental Protection Agency (US EPA)), Lisa Richman (MOECC), Mary Ellen Scanlon (formerly MOECC), Don Williams (formerly EC), Paula Zevin (US EPA).

Reviewers: Mark Filipski (NYSDEC), Martha Guy (EC), Veronique Hiriart-Baer (EC), Rimi Kalinauskas (formerly EC), Don Zelazny (NYSDEC) and Cheriene Vieira (MOECC).

Background written by Valerie Cromie and updated by Natalie Green (Niagara River RAP Coordinators), Niagara Peninsula Conservation Authority (NPCA)

BUI Assessment and Evaluation written by: Tanya Long, Environmental Scientist, Great Lakes, Ontario Ministry of the Environment and Climate Change

Suggested citation: Long T, Green N, Vieira C, and V Cromie. 2017. Assessment of Eutrophication and Undesirable Algae Beneficial Use Impairment in the Niagara River (Ontario) Area of Concern. Niagara River (Ontario) Remedial Action Plan. Welland, ON. 53 pages.

Table of Contents

1.0 Introduction

Algae, tiny plant-like organisms that are an important part of the food web, are the main source of food for planktivorous fishes and zooplankton. However, when algae are overabundant (often referred to as an algal bloom) they can cause disruptions to the aquatic ecosystem, result in fish kills, pose a risk to human health and/or impair recreational enjoyment of the waterbody (boating, swimming). Furthermore, cyanobacteria, also known as blue-green algae, can release a toxic chemical that may pose a risk to human health. This is the reason *Eutrophication or Undesirable Algae* is listed as one of the 14 potential beneficial use impairments (BUIs) in the Niagara River Area of Concern (AOC).

Eutrophication is the process by which a waterbody becomes overly enriched with nutrients. Pollution from human sources such as municipal and industrial wastewaters, agricultural runoff, fertilizers used on lawns and golf courses, and poorly maintained septic systems are sources of nutrients that can contribute to eutrophication of a waterbody. Natural sources of nutrients from sediments (due to erosion) can also contribute to eutrophication

The Niagara River is a 58 km binational connecting channel linking Lake Erie to Lake Ontario. Waters from Lake Erie, the most productive of the Great Lakes, flow rapidly into the Niagara River at a rate of 0.6 to 0.9 m/s and eventually discharge into Lake Ontario. Due to historical water quality pollution from human sources the Niagara River is one of 36 remaining Great Lakes Areas of Concern (AOCs) identified through the Canada-U.S. Great Lakes Water Quality Agreement (GLWQA) (refer to Appendix 1). As part of the requirement of the GLWQA, a Remedial Action Plan (RAP) was developed in collaboration with local residents, community groups, First Nations and Métis, government, scientists and industry to identify, guide and complete restoration efforts with the ultimate goal of improved environmental conditions and subsequent removal of the river from the list of Great Lakes AOCs, referred to as “delisting”. Delisting occurs when all locally-defined actions are completed and scientific evidence shows that beneficial water uses (be it ecological, recreational and economic) are restored. When something interferes with the functioning or enjoyment of a water use, it is called a beneficial use impairment (BUI). There are 14 potential BUIs (see list below) identified in the GLWQA (common to all AOCs) that the RAP uses to focus restoration needs, track progress and report on success. To find out more about the current status of all of the Niagara River’s BUIs and to track progress, visit our website: ourniagarariver.ca.

According to the Great Lakes Water Quality (2012), a BUI is **a reduction in the chemical, physical or biological integrity of the Waters of the Great Lakes to cause any of the following**:

1) restrictions on fish and wildlife consumption
2) tainting of fish and wildlife flavour
3) degradation of fish and wildlife populations
4) fish tumors or other deformities
5) bird or animal deformities or reproduction problems
6) degradation of benthos
7) restrictions on dredging activities
8) eutrophication or undesirable algae
9) restrictions on drinking water consumption, or taste and odor problems

10) beach closings
11) degradation of aesthetics
12) added costs to agriculture or industry
13) degradation of phytoplankton and zooplankton populations
14) loss of fish and wildlife habitat

Historically, the RAP defined the AOC as the Ontario side of the Niagara River including its watersheds extending to the headwaters of the Welland River (NRRAP, 1993). However, the boundaries of the Niagara River AOC were re-defined due to recent guidance from the GLWQA (2012) indicating the focus of AOCs is to include the "Waters of the Great Lakes and the connecting river systems of St. Mary's, St. Clair, Lake St. Clair, Detroit, Niagara, and St. Lawrence at the international boundary or upstream from the point at which the river becomes the international boundary between Canada and the United States, including all open and nearshore waters." The **Niagara River AOC is now defined as the connecting channel itself flowing from the mouth of Lake Erie to Lake Ontario** (Figure 1). The land area that drains into the river is referred to as the AOC watershed. Restoration efforts and the criteria for delisting the AOC are focused on the river itself but some projects are implemented in the AOC watershed, when deemed necessary, because of their potential impact to the River.

Although the Niagara River is identified as a bi-national AOC, there are separate but complementary RAP processes on both sides of the border. **This assessment is for the Ontario side of the Niagara River AOC only.**

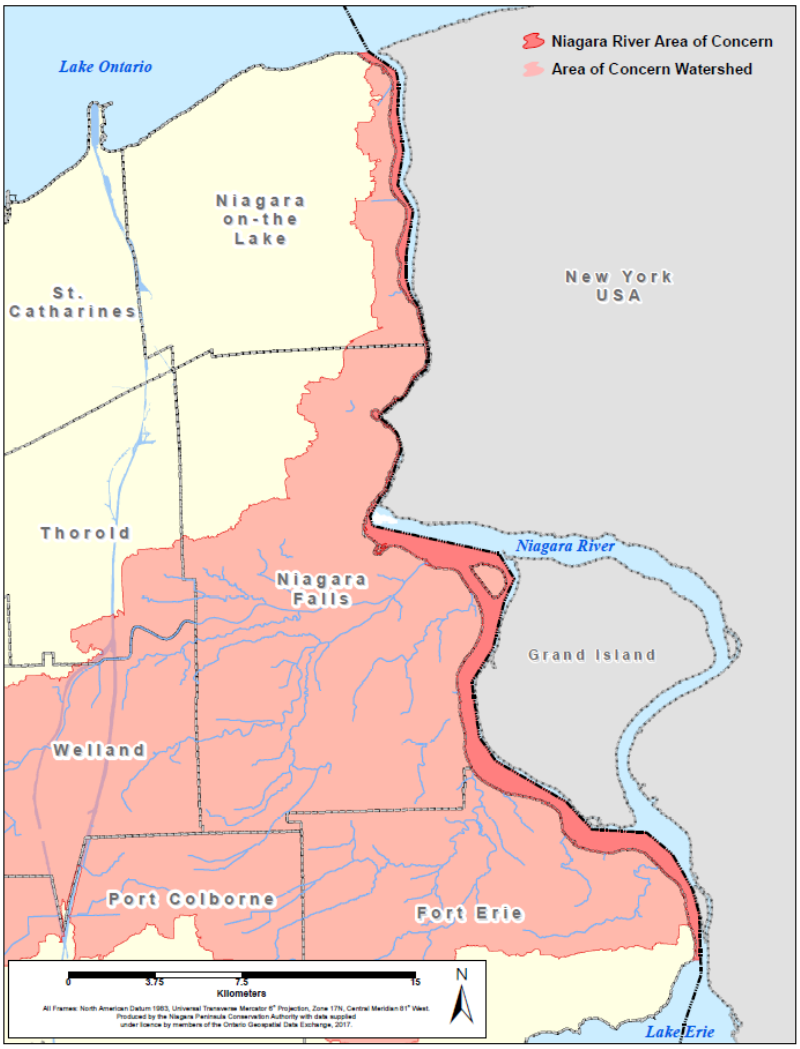


Figure 1 *(right)***:** Map showing the current extent of the Niagara River Area of Concern (Ontario side only) and a portion of its watersheds**.**

1.1 Historical review of the *Eutrophication or Undesirable Algae* BUI

According to the International Joint Commission (IJC), the Eutrophication and Undesirable Algae BUI applies "[w]*hen there are persistent water quality problems attributed to excessive nutrient discharges from point (end-of-pipe) or nonpoint (diffuse land uses) sources. Typically, the impairment manifests itself as nuisance or harmful algal blooms, dissolved oxygen depletion in bottom waters, and decreased water clarity"* (IJC, 2017). Locally-developed delisting criteria for this BUI were never historically developed. Instead, the RAP team recently used a scientific weight-of-evidence approach (as is used in other AOCs) to determine the status of *Eutrophication or Undesirable Algae* in the Niagara River (Ontario) AOC.

The Niagara River (Ontario) RAP process was initiated in 1989. Although a 1985 International Joint Commission (IJC) assessment indicated that the Niagara River did not suffer from eutrophication (NRRAP, 2013b), the status of the *Eutrophication or Undesirable Algae* BUI has undergone several status changes since the inception of the RAP (Table 1).

Table 1. A summary of the status of the *Eutrophication or Undesirable Algae* BUI in various RAP reports and the reason for the status.

Supporting Document	Status	Reason
1993 RAP Stage 1 Report	Eutrophication: Impaired	Accelerated eutrophication in the Welland River and tributaries of the Niagara River.
	Undesirable Algae: Not Impaired	Some algal species found but not at nuisance levels. Less desirable algae can be carried from Lake Erie but only occasionally.
1995 RAP Stage 2 Report	Eutrophication: Impaired	No change in status.
	Undesirable Algae: Not Impaired	
2009 RAP Stage 2 Update	Impaired	The Undesirable Algae portion was changed to Impaired (from "Not Impaired") because of observations of algae in the Welland River. No conclusion was given on the Niagara River. From this point on, the BUI was no longer considered in two parts.

The 1993 Stage 1 Report was the first major document to examine and identify environmental problems in the Niagara River AOC. The main concerns leading to the Niagara River being listed as an AOC were contamination in water, sediments and/or biota due to organic and/or inorganic substances, excluding phosphorus (NRRAP, 1993). Overall trends in the concentration of phosphorus in the Niagara River were examined between 1967 to 1981 which revealed a significant decrease of approximately 1 ug/L per year (NRRAP, 1993). However, the report indicated an exceedance of [Great Lakes] nutrient objectives for the Niagara River's

tributaries, particularly for the Welland River due to low flow conditions and elevated nutrient levels in the summer months. The “Impaired” status of the *Eutrophication* component is linked to “accelerated eutrophication in the Welland River and parts of the Niagara River’s tributaries”, not the Niagara River itself. The report indicated very limited observations of algal growth and that no formal studies had been conducted to assess algal populations in the Niagara River. Filamentous algae were noted in an isolated area in the Welland River directly downstream of the Cyanamid plant but not at nuisance levels; therefore, the *Undesirable Algae* portion of the BUI was considered “Not Impaired” (NRRAP, 1993).

Immediately following the completion of the 1993 Stage 1 Report, the RAP Team began working on the Stage 2 Report to address the environmental concerns described in Stage 1. A concise set of 16 goals was outlined in the Stage 2 Report (Niagara River RAP, 1995). The status of the *Eutrophication or Undesirable Algae* remained unchanged from the 1993 Report but three of the goals included were related to the eutrophication impairment in the Welland River:

> *“Continually improve the quality of treated discharges of municipal and industrial sewage effluent with no spills or discharges causing fish kills or other undesirable impacts.*
>
> *Reduction and virtual elimination of Combined Sewer Overflows.*
>
> *Control nutrient loading levels to a point that excessive weed and algal growth do not occur.”*

The goals in the 1995 Stage 2 Report were not finalized into an implementation plan until 2000 when the Niagara Peninsula Conservation Authority, Ontario Ministry of the Environment and Environment Canada entered into an agreement to coordinate the activities for the Niagara River RAP. A full review and update of the RAP Stage 2, including a technical review of the BUIs and their delisting criteria, began in 2004 with assistance from various local groups, industries, all levels of government and the general public. As a result of the review, the Stage 2 Update Report was completed in 2009 and provided science-based recommendations for changes to impairment status, delisting criteria (for BUIs other than *Eutrophication or Undesirable Algae*), and monitoring and assessment activities. Through the 2009 Stage 2 Update, the “Impaired” designation for the *Eutrophication* part of the BUI remained unchanged but the *Undesirable Algae* portion was changed to “Impaired” (from “Not Impaired”) based on observations of algae in the Welland River (NRRAP, 2009). Furthermore, because there was an absence of key evidence of how the Welland River system was responding biologically to excess phosphorus, delisting criteria could not be recommended. Conditions in the Niagara River itself were not specifically discussed, and no evidence was presented which might suggest a new issue in the Niagara River proper (Niagara River RAP, 2013b).

Based on a recommendation in the Stage 2 Update, the Welland River Eutrophication Study Technical Working Group (TWG) was formed in 2008 to design and implement a project to collect further data towards the development of delisting criteria for the Welland River watershed Results from the 3-year study are summarized in the March 2011 final report (Diamond, 2011) and major findings were:

- The Welland River is a eutrophic watershed characterized by very high phosphorus concentrations. Mean total phosphorus (TP) concentrations ranged from 200% to 1500% greater than the Provincial Water Quality Objective depending on the subwatershed.
- Subwatersheds with especially high TP concentrations (mean > 0.4 mg/L) are Beaver Creek, Big Forks Creek and Oswego Creek.

- Biologically-available phosphorus concentrations generally increased as water moved downstream through the Welland River watershed but a decrease was noted in the lower reaches where mixing occurs with water from the Niagara River.

It is now recognized that the *Eutrophication and Undesirable Algae* issues of the Welland River (and largest tributary to the Niagara River) are not specific to the AOC and generally reflect conditions in Ontario with similar land use patterns (MOE, 2012). Also, the impact of the flow reversal near the mouth of the Welland River for hydroelectric power generation at the Sir Adam Beck Hydroelectric Generating Station contributes to the less than desirable water quality in the Welland River. However, the RAP Team recognizes that tributaries such as the Welland River can potentially contribute to adverse issues in the nearshore waters of the Great Lakes. As such, if a tributary is shown to be adversly affecting the Niagara River AOC, it will be investigated appropriately.

1.2 The U.S. Connection: Niagara River (New York) BUI status

The *Eutrophication or Undesirable Algae* BUI is “Not Impaired” for the U.S. side of the Niagara River AOC (Niagara River (NY) RAP, 2012). In summary, the 1994 Niagara River (New York) RAP report states that declines in phosphorus and chlorophyll *a* levels in Lake Erie between 1968 and 1985, along with high dissolved oxygen levels measured in the Niagara River and the absence of nuisance algal blooms or accumulation, are evidence that eutrophication is not a serious problem in the Niagara River (NYSDEC, 1994).

1.3 Purpose of Assessment

In keeping with the intent of the focus of GLWQA (2012) and due to absence of key evidence to confirm the status of the BUI in the Niagara River itself, the RAP Team agreed, in 2014, to pursue a science-based assessment. This study was commissioned to review all relevant data to determine the status of the *Eutrophication or Undesirable Algae* BUI for the Ontario portion of the Niagara River. If an impairment to this beneficial use was found, the assessment would also ascertain what impact, if any, does the Niagara River watershed (i.e., Welland River and other creeks that drain to the AOC) have on the Niagara River’s water quality.

2.0 BUI Assessment and Evaluation - Methodology

Evaluation of the status of a beneficial use in an Area of Concern (AOC) is typically conducted by comparing ambient monitoring data against specific delisting criteria. These criteria are developed by the Remedial Action Plan (RAP) for the AOC to reflect conditions deemed representative of a restored beneficial use. As outlined in Section 1.0 of this report however, the Niagara River RAP currently does not have delisting criteria for the Beneficial Use Impairment (BUI) *Eutrophication or Undesirable Algae.* Nonetheless, an evaluation of the BUI is still required to determine status because if impaired, it ultimately needs to be determined what remaining actions are still required to restore the beneficial use. As a first step in conducting an assessment of the *Eutrophication or Undesirable Algae* BUI in the Niagara River AOC, indicators that have been used in the evaluation of this impairment at other connecting channel AOCs were reviewed (Appendix III).

Based on their applicability and prevalence of use at other connecting channel AOCs, total phosphorus (TP), chlorophyll *a*, dissolved oxygen (DO) and Secchi disc depth were parameters selected for inclusion in the BUI evaluation for the Niagara River. In addition, any available ortho-phosphate (phosphate) and soluble reactive phosphorus (SRP) data were also included in this assessment, parameters which are measures of a more bioavailable form of phosphorus relative to TP. Although phosphate and SRP are not included in delisting criteria at other AOCs, the exclusion of these topical parameters at other AOCs is likely due to a lack of data or difficulty in their monitoring (Wetzel, 2001 in CCME, 2004) rather than the applicability or relevance of such indicators.

The parameters included in this assessment are comprehensive in nature as they measure various aspects of eutrophication including both chemical stressors and the response of the biological community. TP and phosphate and/or SRP are chemical stressors included as indicators and are measures of phosphorus, the nutrient which typically drives eutrophication (Schindler, 1977). As for measures of the biological response to eutrophication, chlorophyll *a* was included as it is a proxy for measuring algal density in water. Although not an ideal indicator for assessing primary productivity in a fast-flowing river, chlorophyll *a* is a standard metric among sampling programs and assessments of AOCs, and data on a potentially more meaningful biological metric for a river, such as periphyton density, are sparse or non-existent. Some of the potential negative impacts of eutrophication on water quality such as reduced water clarity (as measured by Secchi Disc depth) and low DO due to respiration from an overabundance of algae or the decomposition of such algae, were also included in the assessment.

Following the selection of indicators to be used in the assessment, the method for evaluating the data for these indicators was examined. Direct application of delisting criteria from other AOCs to the Niagara River AOC was not considered appropriate. For example, other AOCs likely have differences in underlying geology and biological response relative to the Niagara River. In addition, many delisting criteria for other AOCs describe conditions in both the adjacent watersheds and the connecting channel (e.g. St. Lawrence River (Cornwall) RAP), rather than just the connecting channel or “waters of the Great Lakes” in accordance with the

2012 Protocol (Appendix I). The spatial scope of this assessment is the Canadian side of the Niagara River proper from Fort Erie (FE) to Niagara-on-the-Lake (NOTL), as well Chippawa Creek and the Adam Beck power canal (Figure 2). Chippawa Creek and the Adam Beck power canal are included in this assessment because water in these areas is Niagara River water. At Chippawa, a flow reversal was historically engineered to divert water from the Niagara River to Chippawa Creek (lower Welland River) and subsequently the power canal, to meet the needs of the Adam Beck power plant. Other tributaries which outlet to the Niagara River were not considered in this evaluation unless it was demonstrated in the assessment the beneficial use is impaired in the Niagara River, and the tributaries could be directly linked to the impairment. As such, if conditions in the Niagara River are not considered degraded, the Niagara River watersheds were considered out of scope of this assessment.

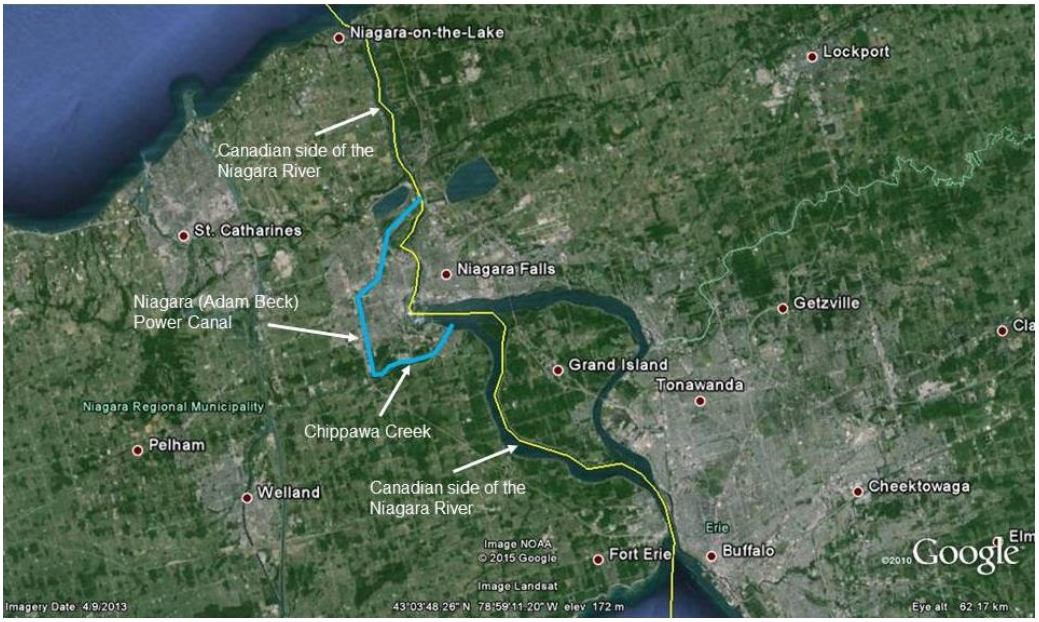


Figure 2: Map of the geographical scope of the *Eutrophication or Undesirable Algae* assessment for the Niagara River (Ontario) AOC, including the Canadian side of the Niagara River, the Niagara (Adam Beck) Power Canal and Chippawa Creek. Canada-United States international border is shown by a yellow line bisecting the Niagara River.

Although most indicators in this assessment were selected based on their use at other AOCs, the evaluation methods for the data were not based on what has been conducted at the other connecting channel AOCs (Appendix III). A method for evaluating the data for the five selected *Eutrophication or Undesirable Algae* indicators was required for the Niagara River AOC. A BUI evaluation method recently developed by the Toronto RAP, termed the “Tiered” approach, was considered highly applicable and pragmatic for use in the Niagara River. The “Tiered” approach was developed to assess beneficial uses in the absence of clear delisting criteria, and can be used for any indicator.

2.1 Application of "Tiered" Approach to BUI Assessment

The Toronto RAP's "Tiered" approach is a transparent, science-based framework for assessing the impairment status of beneficial uses, and is especially relevant in the absence of clear delisting criteria (Toronto RAP, 2011). In addition to use by AOCs, this framework has also been used to develop watershed-specific targets in the Grand River watershed (Grand River Water Management Plan, 2013). This framework sets out the order in which three potential data evaluation methods, or "tiers", are to be applied, and then based on the outcomes of these evaluations, makes a recommendation to the status of impairment and potential re-designation of the beneficial use (Figure 3). The tiers in order of their application in this framework are:

- Tier 1 – Acceptable guidelines or standards against which AOC conditions can be compared
- Tier 2 – Identification of appropriate reference sites against which AOC conditions can be compared
- Tier 3 – Weight-of-evidence - An unstructured approach to evaluating AOC conditions which makes use of available data to form lines-of-evidence towards an overall assessment of the potential for impairment. Lines-of-evidence may include identification of anomalies, temporal trends, spatial trends, etc.

This framework was used to evaluate the data selected for inclusion in the Niagara River *Eutrophication or Undesirable Algae* assessment, namely the TP, phosphate/SRP, chlorophyll *a*, DO and Secchi disc depth data. As the nature of each of these indicators or metrics differ in the availability of applicable guidelines or standards, or availability of similar data collected at an appropriate reference site, the tier against which each of these indicators will be evaluated is described in turn below.

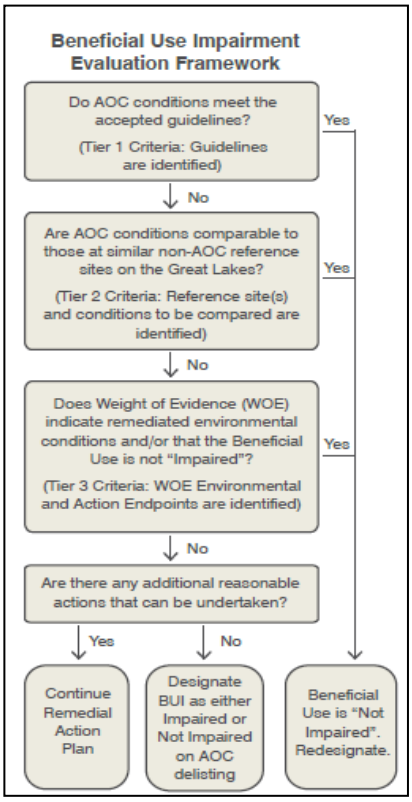


Figure 3 (*right*): Toronto RAP's "Tiered" Beneficial Use Impairment Evaluation Framework
Source: Toronto RAP, 2011, p.9.

2.1.1 Tier 1 Assessment of Total Phosphorus (TP) and Dissolved Oxygen (DO)

A Tier 1 assessment of TP and DO concentrations in the Niagara River was conducted as there are relevant guidelines against which TP and DO concentrations can be evaluated. The TP concentrations were compared to the interim Provincial Water Quality Objective (PWQO) of 30 ug/L for TP in rivers which was set to prevent excessive plant growth (MOEE, 1994a). TP concentrations in the Niagara River were considered to meet the guideline if the majority (i.e. 90th percentile) of recent data were below this benchmark. The choice of using the 90th percentile over a mean or median value is a more conservative approach as it does not allow extreme values to occur as frequently. Relative to "average" conditions, extreme TP concentrations are more of a concern for eutrophication as they are believed to be a major driver behind the formation and/or promotion of algal blooms. Water quality guidelines and standards are designed such that each individual measurement can be evaluated for context against the benchmark, however, not all observed TP concentrations are required to be below the 30 ug/L target. It is recognized that some degree of environmental variability occurs naturally, and further, not all TP concentration peaks have a direct biological consequence. That is, elevated TP concentrations do not always result in an accumulation of undesirable algae as algal growth is determined by a number of different factors, not TP concentrations alone. Use of the 90th percentile in an overall assessment is consistent with the allowable exceedance frequency endorsed by the US EPA (i.e. 10% allowable exceedance; US EPA, 1997). It is also consistent with recent changes and updates by the Hamilton Harbour Remedial Action Plan (HH RAP) to their TP concentration goal. Following a recent review, the HH RAP now allows a 10% exceedance frequency during each year's monitoring season to the TP goal of a maximum of 20 ug/L (HH RAP, 2012). It is important to note that use of the 90th percentile is more conservative (protective) than the Ontario Ministry of the Environment's "Green Book" default of using a 75th percentile standard to determine acceptable background water quality in evaluations of surface water bodies in Ontario (MOEE, 1994b).

Other relevant phosphorus benchmarks were also examined, but were not considered appropriate for the context of the Niagara River Eutrophication Assessment. While there is a Great Lakes Water Quality Agreement (GLWQA) TP target of 10 ug/L, this target is for the open waters of the lower Great Lakes and use of it in a connecting channel such as the Niagara River is not an appropriate application of the target. TP processes differ between lakes and rivers, as reflected by the higher PWQO for TP in rivers and streams of 30 ug/L relative to the PWQO for TP in lakes of 10-20 ug/L. There is no GLWQA target for connecting channels, which themselves are unique surface water bodies due to the vast volume of water moving quickly between the lakes.

Additionally, there is no federal Canadian Water Quality Guideline (CWQG) for phosphorus, although the Canadian Council of Ministers of the Environment (CCME) do have a guidance framework which accommodates the non-toxic endpoint associated with phosphorus loading and permits site-specific management of phosphorus based on desired trophic status and pre-defined "trigger ranges" (CCME, 2004). Because use of the CCME approach requires that reference conditions are established to determine which "trigger range" will be used for

comparison to the site of interest, this approach is more consistent with a “Tier 2” rather than “Tier 1” assessment. Nonetheless, the PWQO of 30 ug/L is in the CWQG “meso-eutrophic” trigger-range of 20 – 35 ug/L for lakes and rivers, thus use of the PWQO is consistent with the CWQG approach whereby TP concentrations below 30 ug/L should prevent eutrophication. Alternative TP targets have recently been developed through other processes and resulted in the Ontario Ecoregion Phosphorus Guidelines (Gartner Lee Limited, 2006) and the National Agri-Environmental Standards Initiative (NAESI) (Chambers et al., 2008). Application of these guidelines are also not applicable, however, as the frame of reference for these approaches is undisturbed conditions (Grand River Water Management Plan, 2013) which is inconsistent with the goals of a RAP which are intended to restore beneficial uses, not restore water quality to pristine or pre-colonial conditions.

The DO concentrations in the Niagara River were also compared to relevant guidelines, specifically the PWQOs, as well as the federal CWQGs. DO guidelines are designed to be protective of fish, and are based on the different habitat needs of warmwater and coldwater fish communities. As the Niagara River supports a diversity of fish communities including coldwater species such salmon and trout which have more stringent DO requirements, selection of coldwater DO guidelines is the more conservative approach. The coldwater species PWQO is a range in DO concentrations spanning different ambient temperatures; at the upper end of the temperature range, DO concentrations should be a minimum of 5 mg/L at 25°C, and at the lower end of the range, DO should have a minimum concentration of 8 mg/L at 0°C (MOEE, 1994a). Similarly, the coldwater CWQG for DO has more than one guideline, but is based on life stage, with a minimum DO concentration of 9.5 mg/L for early life stages, and 6.5 mg/L for all other life stages (CCME, 1999). Due to the differences in recommended DO concentrations by the available guidelines and the variable nature of DO needs pending ambient temperatures and/or biotic life stage, DO concentrations in the Niagara River were initially screened against the CWQG of 6.5 mg/L for non-early life stages, which corresponds to the PWQO for coldwater biota down to a temperature of 5 – 10°C. The more conservative CWQG of 9.5 mg/L and PWQO of 8 mg/L at 0°C, both for coldwater species, were not used in the initial screening as these DO guidelines were considered overly conservative given the context of the assessment. RAPs are intended to mitigate BUIs, rather than restore water quality to pristine conditions. For any measured DO concentrations below 6.5 mg/L, further analysis was then conducted to assess whether a less stringent DO guideline might be appropriate due to the ambient temperatures at the time of the measurement, or if data in fact suggested potential stress on aquatic biota.

During this assessment, the context of DO as a secondary indicator of eutrophication was considered. The PWQO and CWQG for DO reflect the direct habitat needs of fish and are not designed to be indicative of an oxygen deficit due directly to eutrophication processes. The DO guidelines are nonetheless still relevant for indicating if DO concentrations in the Niagara River are less than optimal, and thus, impaired. If DO concentrations were to be considered impaired, other lines-of-evidence would be needed to determine whether nutrient-driven processes were the cause of low DO, or if other factors outside the scope of this assessment (e.g. high loadings of substances with high biological oxygen demand (BOD), nitrogeneous

oxygen demand (NOD) or chemical oxygen demand (COD)) were likely the primary cause of hypoxia or anoxia.

2.1.2 Tier 2 Assessments of Phosphate and Chlorophyll *a*

There are no relevant guidelines against which phosphate and chlorophyll *a* concentrations in a river or connecting channel can be evaluated. As a result, a Tier 2 assessment of phosphate and chlorophyll *a* concentrations in the Niagara River was conducted using data collected in reference areas. Other AOCs are generally not recommended for use as reference sites as specified in the "Tiered" approach (Figure 2), however, all connecting channels on the Great Lakes have AOCs which suggests that a Tier 2 approach cannot be used for connecting channels on the Great Lakes. In this assessment focused on one BUI however, other connecting channels will be used as reference sites because *Eutrophication or Undesirable Algae* is not impaired in the Detroit River and St. Clair River AOCs, and in the main channel of the St. Lawrence River (Cornwall) AOC (only watersheds are impaired); the rationale for the unimpaired status of this BUI at these three AOCs are outlined in Appendix III. As such, available phosphate and chlorophyll *a* data from the Detroit River, St. Clair River and St. Lawrence River were considered reference site conditions for the Niagara River in the strict context of evaluating the beneficial use *Eutrophication or Undesirable Algae*. Important to note in this report, the St. Lawrence River as a reference area only refers to the Ontario portion of the river, that is, from Wolfe Island to Cornwall. Conditions in the Niagara River were considered unimpaired with regard to *Eutrophication or Undesirable Algae* if recent data were comparable to or better than current day conditions in the connecting channel reference areas.

2.1.3 Tier 3 Assessment of Soluble Reactive Phosphorus (SRP) and Secchi Disc Depth

Reference area data for soluble reactive phosphorus (SRP) concentrations were not available so a Tier 3 assessment on the Niagara River data was conducted. A spatial comparison was conducted to determine any increases in SRP concentration along the length of the river which might suggest a Niagara River source. SRP data were evaluated by comparing all available data for each location and monitoring program against one another. Statistically significant differences among locations were determined by the Kruskal-Wallis statistical test and subsequent Mann-Whitney pairwise comparisons. Statistics were run in the PAST software package (Hammer, 2009) and results were considered statistically significant for p-values less than 0.05. Time trends in SRP concentrations were also examined as increasing concentrations over time may be indicative of a problematic SRP source.

A Tier 3 or weight-of-evidence approach was also used to evaluate Secchi disc depth as recent (collected within the past decade) Secchi disc depth data were not available for the Niagara River. Historical data are however available, and these data were examined for long-term temporal trends as a line-of-evidence on the impairment status of this indicator. In addition, the magnitude of historical Secchi disc depths were compared to those recently measured in reference areas as another line-of-evidence. Instead of using the 90th percentile to

evaluate whether the majority of the data reflected desirable water clarity, the 10th percentile was used as greater Secchi disc depths (greater water clarity) are more desirable than smaller depths (reduced water clarity), the converse of the situation when examining chemical parameters such as TP concentrations. A spatial trend along the length of the river (i.e. a comparison between upstream and downstream concentrations) was not conducted because it was hypothesized that the falls and turbulence of the lower Niagara River increase suspended sediment concentrations which in turn influences Secchi disc depth. As such, it is suspected that a comparison of water clarity between the upper and lower Niagara River would not reveal meaningful data on any difference in algal density between these two stretches of the Niagara River as water clarity data may be overwhelmed by inorganic particulate which is a result of the hydrology of the River.

Further to this caveat about use of Secchi disc depth as a non-ideal proxy for algal density in an environment such as the Niagara River, this assessment further acknowledges that use of this metric is not ideal simply due to the high velocity of the Niagara River. In many cases, only rough estimates of Secchi disc depth could be made by survey crew, especially in the Upper Niagara River. The deployed Secchi disc extended out behind the survey vessel at some distance due to the strong currents, and due to the extreme angle of the line, the gauged depths were not accurate (C. DeBarros, 2013, pers. comm.). The extensive nature of caveats for use of Secchi disc depth suggest that little would be lost from eliminating this metric from the suite of indicators used in this assessment, however, Secchi disc depth data that are available are presented to be consistent with use of this indicator at other AOCs and to ensure due diligence was conducted in this assessment. Care was taken to not over-interpret the available Secchi disc depth data, and caution was employed to ensure that any conclusions based on this metric followed common sense given trends observed for other metrics and parameters.

2.1.4 Evaluation of all Indicators to Form Overall Impairment Status

Following the independent assessments of TP, phosphate/SRP, chlorophyll *a*, DO and Secchi disc depth data, findings from each of these five assessments were used together to form an holistic evaluation of the *Eutrophication or Undesirable Algae* beneficial use. Nutrient concentrations were interpreted with caution because as mentioned previously, elevated nutrient concentrations do not always result in an accumulation of undesirable algae. This is especially relevant for rivers where scouring due to high flow or flow through may prevent formation of local algal blooms. It is the biological response which is the utmost concern, as controlling levels of the chemical stressors such as TP and phosphate/SRP are only a means to an end, as understood through the context of the PWQO for TP which was set for the protection against “excessive plant growth” (MOEE, 1994a).

In addition, it is reasonable to assume that one or more metrics may be more greatly influenced by factors other than eutrophication, and may be reflecting issues out of scope of this assessment. For example, low DO concentrations can result from the presence of oxygen-demanding chemicals in the water, rather than the decomposition of algae near the sediment bed. Similarly, low Secchi disc depths or water clarity can result from high concentrations of seston (suspended solids), rather than high algal densities. Further, the geographical scope of

this assessment was another caveat in the interpretation of data. Designation of a BUI is contingent on the source of the issue being within the boundary of the AOC. As illustrated in Figure 3, the final question in the "Tiered" approach is "Are there any additional reasonable actions that can be undertaken?" If a source is shown to originate upstream from the AOC boundary, it is also out of scope as the source cannot be addressed by management actions of the Niagara River RAP. Thus, it is the impairment status suggested by the majority of the indicator assessments and emphasis on the biological-response metrics and geographical scope that was used to determine the overall status of *Eutrophication or Undesirable Algae* for the Niagara River AOC.

2.2 Data Sources

Existing data collected by Environment Canada (EC), the Ontario Ministry of the Environment and Climate Change (MOECC), the Niagara Peninsula Conservation Authority (NPCA), New York State Department of Environmental Conservation (NYSDEC) and State University of New York (SUNY) at Brockport were used to assess the eutrophication status of the Niagara River. Data collected over the past 10 years (2003 to 2013) were used to characterize current conditions, and any historical data (collected up to and including 2002) were only used in in the assessment if there was a gap in the dataset for the past decade. Although not within the Niagara River (Ontario) AOC boundary, data collected from the American side of the lower Niagara River were also considered in this assessment to increase sample size and to be as comprehensive as possible given scarcity of data for some parameters. Although the data collected by NYSDEC and SUNY at Brockport were a vital part of this assessment due to data gaps in the Canadian monitoring programs, there is a caveat to the inclusion of data collected from the American side of the Niagara River. "While there have not been any definitive source inputs identified along the lower reach of the river, any contaminant inputs downstream of the rapids would not be well mixed and would tend to flow along the shoreline from which they were released" (Hill and Klawunn, 2011).

Programs and data sources that were used in the *Eutrophication or Undesirable Algae* assessment for the Niagara River include:

- EC's Upstream/Downstream (US/DS) monitoring program;
- MOECC's Great Lakes Unit monitoring data;
- MOECC's Drinking Water Surveillance Program (DWSP);
- NPCA's monitoring data for Chippawa Creek/Niagara power canal;
- NYSDEC data;
- SUNY Brockport data.

Additional data sources that were considered for this study include MOECC's West Central Region Technical Support Section's monitoring data, and the MOECC's Great Lakes Intake Program data; however, no data within scope were available from these monitoring programs. The Niagara Falls drinking water plant is not included in the Great Lakes Intake Program which focuses on long-term trends of nutrient status and phytoplankton in the Great

Lakes. Fort Erie's Rosehill water treatment plant is included in the Great Lakes Intake Program, however, data from this plant was determined to be outside of the geographical scope of this eutrophication assessment as water is drawn from Lake Erie, not the Niagara River. All the data sources used in this eutrophication assessment are described in turn below.

2.2.1 Environment Canada's Upstream/Downstream (US/DS) Program

For the past few decades, Environment Canada has collected water quality data at monitoring stations at Fort Erie (FE; upstream location) and Niagara-on-the-Lake (NOTL; downstream location) with the primary goal of quantifying Niagara River sources of contaminants. Details of the upstream/downstream (US/DS) program including frequency of sampling, sampling protocols and analytical methods are described elsewhere (Hill and Klawunn, 2011). TP and SRP data collected since 1975 were compiled for this evaluation; EC has no data for chlorophyll *a*, DO or Secchi disc depth.

2.2.2 Ontario Ministry of the Environment and Climate Change's Great Lakes monitoring data

The MOECC's Great Lakes monitoring staff have been collecting water quality data in the Niagara River for the past few decades for a variety of projects and surveys. These data were initially collected by the Ontario Water Resources Branch, but are now collected by the Great Lakes Monitoring Unit at the MOECC's Environmental Monitoring and Reporting Branch. Data collected since 1967 were available for the Niagara River eutrophication assessment and included data on TP, phosphate, chlorophyll *a*, DO and Secchi disc depth.

Phosphate, chlorophyll *a* and Secchi disc depth data from the Detroit River, St. Clair River and St. Lawrence River, also collected through MOECC Great Lakes monitoring programs, were used in the Niagara River eutrophication assessment to establish reference area conditions where appropriate. Important to note is that DO data collected by the MOECC are spot measurements and not from deployment of continuous data loggers.

2.2.3 Ontario Ministry of the Environment and Climate Change's Drinking Water Surveillance Program

The MOECC's Drinking Water Surveillance Program (DWSP) was initiated in 1986 and collects raw water samples from intakes at select water treatment plants (WTPs) in Ontario for research purposes. The WTP for the City of Niagara Falls, Ontario, is included in the DWSP program, and is described as follows:

The Niagara Falls Water Treatment Plant (WTP) draws its water from the Chippawa Creek, which is the portion of Welland River just upstream of the point of confluence with the Niagara River. At this point, the normal flows of the Welland River have been artificially reversed by an Ontario Power Generation hydroelectric plant diversion. The plant's raw water is therefore taken from the Niagara River (P. McInnis, 2013, pers. comm).

Chlorine is occasionally added to the raw water to address zebra mussel fouling of the water intake pipes at the WTP, and as such, many of the raw water samples are chlorinated. As chlorine is a strong oxidant and can impact the nature of the ambient water quality, samples in the database were flagged as to whether each raw water sample had been chlorinated for zebra mussel control. The detection of any one of the following chemicals indicates chlorination:

- *Total trihalomethanes (THMs)*
- *Chloroform*
- *Bromodichloromethane*
- *Dibromochloromethane*
- *Bromoform*
- *Dichloroacetonitrile*
- *Field free chlorine residual*
- *Field combined chlorine residual*
- *Field total chlorine residual* (P. McInnis, 2013, pers. comm.)

Samples which showed evidence of chlorination were flagged, but were still included in the assessment of eutrophication of the Niagara River. TP and phosphate data collected under the DWSP program did not demonstrate any clear bias according to whether the sample had been chlorinated (Figure 4).

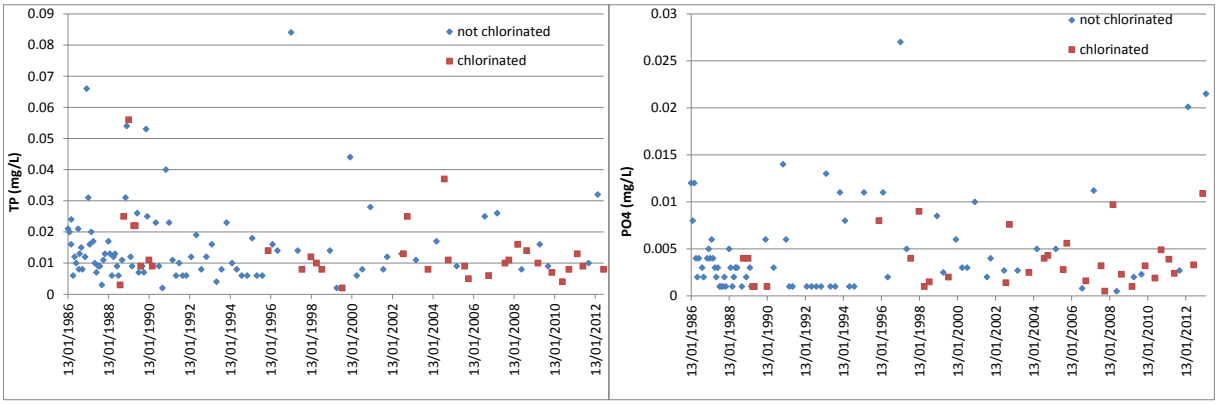


Figure 4: Time series of TP (left) and phosphate (right) concentrations in raw intake water at the Niagara Falls WTP, as presented by samples that were and were not chlorinated for zebra mussel control.

In addition to the WTP for the City of Niagara Falls, additional WTPs that participate in the DWSP program were also included in the eutrophication assessment as reference areas for phosphate concentrations. These reference WTPs have source water from the St. Clair, Detroit and St. Lawrence Rivers as outlined in Table 2.

Table 2: Water Treatment Plants included in the DWSP program that have source water from the St. Clair, Detroit or St. Lawrence Rivers and were sampled in 2003 - 2013

Water Treatment Plant Name	Source Water
Amherstburg Drinking Water System	Detroit River
Brockville Drinking Water System	St. Lawrence River
Chatham-Kent Drinking Water System - Wallaceburg	St. Clair River via Chenal Ecarte
City of Windsor Drinking Water System	Detroit River
Glen Walter Drinking Water System	St. Lawrence River
Lambton Area Water Supply System	St. Clair River
Prescott Drinking Water System	St. Lawrence River
Tecumseh Water Treatment Plant	Detroit River
Walpole Island Water Treatment Plant	St. Clair River via Chenal Ecarte

2.2.4 Niagara Peninsula Conservation Authority's monitoring data for Chippawa Creek/Niagara power canal

In 2012 and 2013, the NPCA in collaboration with the Region of Niagara conducted water quality monitoring at a number of stations in the Niagara Region. Station PR001 (43.125°N, 79.081°W) is located within the geographical scope of this assessment as it is in the Chippawa Creek/Niagara power canal at Whirlpool Road, Niagara Falls. Water quality samples collected from this station were submitted for analysis for a broad suite of parameters, including TP and phosphate. In-situ water quality measurements were also collected using a YSI probe, and the DO data collected in this monitoring was also included in the Niagara River eutrophication assessment. Important to note is that these DO data are spot measurements and not from deployment of continuous data loggers.

2.2.5 New York State Department of Environmental Conservation (NYSDEC) monitoring data for the Niagara River

NYSDEC has a sampling station in the Niagara River near Youngstown, New York (Station ID: 21NYDECA), which has water column samples collected 6 times each year in the time period from April to October (M. Novak, 2013, pers. comm.). Samples have been collected at the site for approximately 25 years. The data are maintained on the United States

Environmental Protection Agency (US EPA) STORET national data warehouse, which can be accessed from the EPA website or through the national water quality portal at http://www.waterqualitydata.us/.

2.2.6 State University of New York (SUNY) at Brockport monitoring data for the Niagara River

Water quality data were collected 4 to 16 times per year from two locations in the Niagara River by SUNY at Brockport for 2003-2005, 2007, 2009 and 2013. Both stations are located near Youngstown, New York, although one station is located near the shoreline (43.2597° N, 79.0580° W) and one is located mid-channel (43.2576° N, 79.0602° W), close to the Canada-United States international border. The 2013 mid-channel data were collected by the United States Fish and Wildlife Service. All the water quality analyses were done in the SUNY Brockport ELAP certified lab (J. Makarewicz, 2013, pers. comm.).

3.0 BUI Assessment and Evaluation – Results and Discussion

3.1 Total Phosphorus

Total phosphorus (TP) concentrations underwent a Tier 1 assessment and samples collected from the Niagara River over the past decade were compared to the PWQO of 30 ug/L. TP concentrations demonstrated high variability among datasets, and variability was high even within a single sampling station and dataset. As such, there was inconsistency in results among the datasets as the 90th percentile of TP concentrations collected through MOECC's DWSP monitoring, NYSDEC's monitoring, and SUNY's Brockport monitoring (both shoreline and mid-channel) met the PWQO of 30 ug/L, while the 90th percentile of TP concentrations collected through NPCA's Chippawa Creek/Niagara Power Canal monitoring and EC's US/DS monitoring program (FE and NOTL) did not meet the PWQO of 30 ug/L (Table 3).

Initially in this eutrophication assessment, TP data collected through EC's US/DS program were flagged as potentially anomalous as these TP concentrations were substantially higher relative to results collected through other agency monitoring programs. In particular, the comparison between TP concentrations measured at EC's NOTL station with NYSDEC and SUNY Brockport samples was notable given two-fold higher TP concentrations at NOTL despite the close proximity with the monitoring stations on the US side of the Niagara River.

In part due to the large difference in TP concentrations obtained through the US/DS program relative to other Niagara River data, EC initiated a Quality Assurance/Quality Control (QA/QC) investigation into their dataset. Initial findings have suggested that TP concentrations collected under the auspices of EC's US/DS monitoring program are valid (B. Hill, 2015, pers. comm.). Although a final report on EC's QA/QC investigations is pending, the preliminary assessment of the US/DS dataset has suggested that TP concentrations may be higher relative to other sampling programs because the higher sampling frequency of the US/DS program is

capturing more of the peak or extreme TP concentrations occurring in the Niagara River (B. Hill, 2015, pers. comm.). Peak concentrations may be driven by storm events or other infrequent incursions not readily captured through *ad hoc* or infrequent monitoring programs.

Table 3: Summary table of recent TP concentrations (ug/L) in the Niagara River according to data source and/or dataset.

Data source/Program (Agency)	Spatial extent	Years included	Number of data points (n)	90th Percentile	Mean (standard deviation)	Min	Max
DWSP (MOECC)	Niagara Falls WTP intake, Chippawa Creek	2003 - 2013	27	25.4	12.9 (8.1)	4	37
Chippawa Creek/Niagara Power Canal monitoring (NPCA)	Chippawa Creek/Niagara Power Canal	2012 - 2013	10	40	19.0 (12.0)	<10 (less than detection limit)	40
US/DS program (EC)	Fort Erie (FE) station	2003 - 2013	474	75	33.1 (37)	2.8	367
US/DS program (EC)	Niagara-on-the-Lake (NOTL) station	2003 - 2013	465	65.5	35.1 (34.7)	3.5	305
NYSDEC	Youngstown, NY station	2003-2007; 2009-2010; 2012	48	17.5	11.6 (5.3)	4.8	30.9
SUNY Brockport	Shoreline station near Youngstown, NY	2003-2005, 2007, 2009, 2013	29	24.5	17.4 (13.4)	6.5	60.8
SUNY Brockport	Mid-channel station near Youngstown, NY	2013	11	21.7	15.2 (5.9)	7.1	27.6

Notes:
No recent TP data for MOECC's Great Lakes Monitoring Program in the Niagara River. NPCA dataset had one of 10 datapoints less than detection limit (<10 ug/L); this value was assumed to be at the detection limit of 10 ug/L to calculate the 90th percentile, mean and standard deviation of the dataset, so summary stats represent an upper limit.

Additionally, the US/DS monitoring program collects samples year-round, while many other monitoring programs are focused only on the summer ice-free season, typically from May to September. Empirical evidence that many of the TP concentration spikes occurred during the October to April period was observed in the US/DS dataset (Figure 5), further lending support to seasonal variability as an explanatory factor for differences in results among sampling programs. Watershed sources of TP can be as high in winter as other seasons (Long et al., 2014) or even higher than other seasons (MOE, 2012), meaning year-round sampling programs such as the US/DS program are needed to capture the full range of TP concentrations present in the Niagara River. The nature of the differences among sampling programs may also explain why recent TP concentrations collected under the US/DS program also appear higher than the historical (1969 – 1983) TP range of 13 ug/L to 40 ug/L along the length of the Niagara River (Chan and Clignett, 1978; Kuntz, 1988; Post et al., 1987; Kauss, 1983; OWRC, 1970). As TP concentrations are highly variable, sampling conditions should be similar between any two datasets for a comparison to have meaningful results.

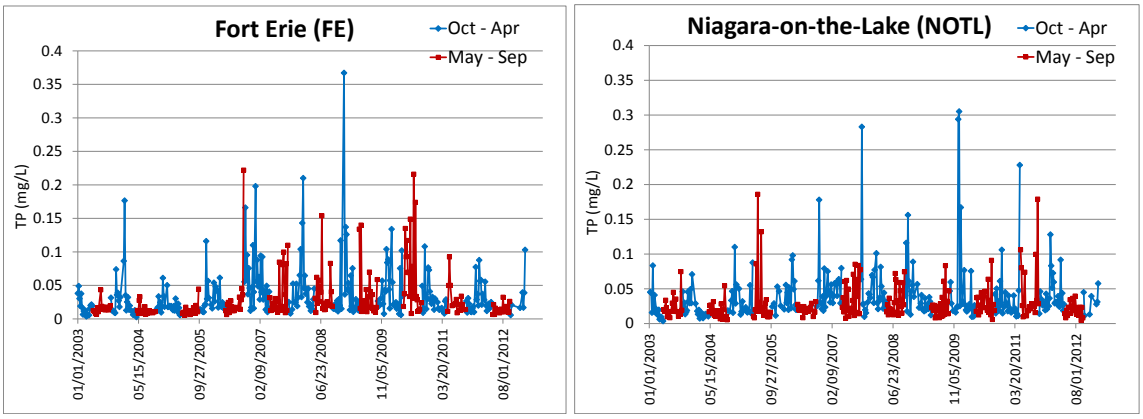


Figure 5: Recent (2003 – 2013) TP concentrations measured through Environment Canada's Upstream/Downstream (US/DS) monitoring program at Fort Erie (FE) and Niagara-on-the-Lake (NOTL).

As the US/DS monitoring program dataset is the largest and most comprehensive dataset included in this assessment, further analysis was conducted to obtain greater context on the data and its meaning to the assessment of the BUI. A full spatial analysis of the data collected within the AOC is beyond the scope of this assessment, however; the upstream and downstream locations of the FE and NOTL monitoring stations on the Niagara River provide greater context to the data especially with regard to scoping local AOC versus upstream or regional TP sources. The 90th percentile of TP concentrations collected under the US/DS program fail the criterion of 30 ug/L at Fort Erie, the location where water first enters the Niagara River AOC. These findings suggest that upstream sources are contributing high levels of TP to the Niagara River AOC; potential sources include the Buffalo waste water treatment plant (WWTP) / Buffalo River (OWRC, 1970; Kauss, 1983; Plumb and Sweeney, 1980) and the nearshore of eastern basin of Lake Erie where Cladophora are problematic (Lake Erie LaMP, 2009).

Additionally, there was no significant difference between 2003-2013 TP concentrations at the FE and NOTL stations ($t = 0.85$, $p_{(two\text{-}tailed)} = 0.39$) suggesting minimal TP sources being contributed from within the AOC boundary relative to upstream sources. This finding is consistent with historical investigations on the Niagara River which demonstrated an absence of major phosphorus sources in the Chippawa Channel of the Niagara River (the Canadian side of Grand Island in the upper Niagara River) and the lower Niagara River (Kauss, 1983). That is, although the Welland River and other tributaries to the Niagara River may have local impacts, they do not appear to be overall directly impacting TP concentrations in the Niagara River; TP concentrations at the Niagara River inflow is equivalent to that at the outlet. Should a desire exist to reduce TP concentrations in the Niagara River, management actions will need to target upstream sources which are outside the scope of the Niagara River (Ontario) RAP.

Another important consideration in placing the TP concentrations into context is that during the time period when the AOC was being declared and the establishment of the Niagara River RAP Stage 1 Report, *Eutrophication or Undesirable Algae* was considered unimpaired for the Niagara River proper (see Section 1.1.3). The little change in TP concentrations between historical conditions considered as "unimpaired" relative to recent conditions at both FE and NOTL (Figure 6) are another line-of-evidence that TP concentrations should remain considered as "unimpaired".

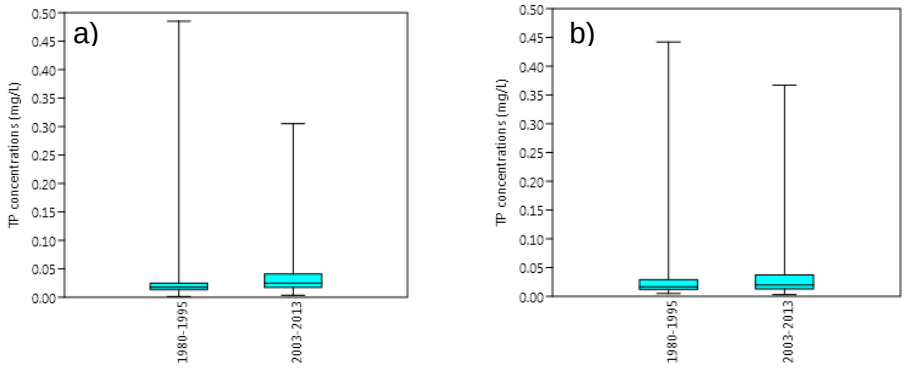


Figure 6: Boxplot comparison of historical (1980-1995) versus recent (2003-2013) TP concentrations collected under EC's US/DS program for: a) Niagara-on-the-Lake (NOTL) station; and b) Fort Erie (FE) station.

3.2 Phosphate and Soluble Reactive Phosphorus (SRP)

As mentioned in Section 2 of this report, one reason phosphate and soluble reactive phosphorus (SRP) have not been incorporated into the suite of delisting parameters at other AOCs is the challenge associated with the monitoring and analysis of these forms of phosphorus. Variability in sampling and analysis protocols among the different agencies and labs which have collected samples and reported phosphate and SRP data was an issue that was encountered in this assessment as well. It was found that the differences in reporting among laboratories were not always clear and further, it is questioned if results were different among labs and studies because there was a real difference in phosphate or SRP concentrations, or if results were simply not directly comparable between labs. For example, some labs reported "phosphate as P" and others "phosphate as PO_4", and if it was known which of these two analysis methods was used, a conversion factor was used to standardize the reported results to "phosphate as P". Such was the case for the NPCA phosphate data, and "phosphate as PO_4" as reported by the lab was converted to "phosphate as P" for use in this report by multiplying by 0.326 (J. Diamond, 2013, pers. comm.). This increased the comparability of the NPCA data; however, often labs do not specify the reporting metric making such anomalies in other datasets unknown.

Other reasons why data may not be directly comparable include the resolution of the reporting increments, and differences in detection limits. While such issues are always present when comparing data among different labs and agencies, it is especially pronounced for phosphate. For example, the NPCA dataset has phosphate reported in increments of 10 ug/L and has a detection limit of 30 ug/L; because the resolution in the reporting increments is large relative to the actual magnitude of ambient phosphate concentrations in the Niagara River, and the detection limit is the same as the PWQO for total phosphorus (of which a portion is composed of phosphate), little can be gained from data at this resolution except for using the results to screen for anomalously high phosphate concentrations indicative of a clear problem. This reporting framework introduces a high degree of imprecision into the reported data. Despite all these noted data quality concerns, the available phosphate and SRP data are reported with caveats in this report, and because of the overall uncertainty in the results, a greater difference between Niagara River data and reference area data would be required to declare an impairment, relative to other parameters where uncertainty in the reported results is not as great.

Recent phosphate concentrations were available for Chippawa Creek as well as the main channel of the Niagara River (Table 4). The 90th percentile phosphate concentration was 11.0 ug/L for the Niagara Falls WTP intake and 8.9 ug/L for the NYSDEC data collected at Youngstown, NY; a 90th percentile was not calculated for the NPCA Chippawa Creek/Niagara Power Canal dataset as 6 of the 9 datapoints were less than the detection limit, and results would not be meaningful. As there is no water quality guideline for phosphate, a Tier 2 assessment was undertaken in that Niagara River phosphate concentrations were compared to those in the Detroit River, St. Clair River and St. Lawrence River references areas (Table 5).

Table 4: Summary table of recent phosphate concentrations (ug/L) in the Niagara River.

Data Source/Program	Spatial extent	Years included	Number of data points (n)	90th Percentile	Mean (standard deviation)	Min	Max
DWSP (MOECC)	Niagara Falls WTP intake, Chippawa Creek	2003 - 2013	29	11.0*	4.9 (5.2)*	<0.5 (less than detection limit)	21.5
Chippawa Creek/Niagara Power Canal monitoring (NPCA)	Chippawa Creek/Niagara Power Canal	2012 - 2013	9	n/a (6 of 9 datapoints below detection limit)	n/a (6 of 9 datapoints below detection limit)	<10 (less than detection limit)	10
NYSDEC	Youngstown, NY station	2006-2009; 2011-2012	36	8.9*	5.5 (4.6)*	<2 (less than detection limit)	25.1

Notes: No recent phosphate data for EC's US/DS program or MOECC's Great Lakes Monitoring Program in the Niagara River. NPCA phosphate data was reported as "phosphate as PO4"; these values were converted to "phosphate as P" for reporting in this table by multiplying "phosphate as PO4" results by 0.326. NYSDEC phosphate data was a mix of numerous reporting metrics (phosphate as P, phosphate as PO4, total, dissolved, etc.); as such, those metrics that were not believed to be comparable to the rest of the dataset were removed from the above summary.

*DWSP (MOECC) dataset had 2 of 29 datapoints less than detection limit (<0.5 ug/L) and the NYSDEC dataset had 6 of 36 datapoints less than detection limit (<2 ug/L). The <DL values were assumed to be at the detection limit to calculate the 90th percentile, mean and standard deviation of each dataset, so summary stats represent an upper limit.

Table 5: Summary table of recent phosphate concentrations (ug/L) in reference areas (St. Clair, Detroit and St. Lawrence Rivers).

Data Source/Program (Agency)	Spatial extent	Years included	Number of data points (n)	90th Percentile	Mean (standard deviation)	Min	Max
Great Lakes Monitoring Program (MOECC)	Detroit River (Station 176)	2004, 2007, 2010	16	5.4	2.5 (1.2)	DL (0.5)	6.3
Great Lakes Monitoring Program (MOECC)	St. Clair River	2004, 2007	7	1.5	0.84 (0.83)	DL (0.5)	2.7
Great Lakes Monitoring Program (MOECC)	St. Lawrence River (Stations 126, 128, 424)	2006, 2009, 2012	29	4.7	2.1 (1.6)	DL (0.5)	5.4
DWSP (MOECC)	Amherstburg Drinking Water System	2003 - 2013	29	24.2	11.5 (11.1)	1.8	46.6
DWSP (MOECC)	Brockville Drinking Water System	2003 - 2013	30	5.3	3.2 (1.8)	DL (0.5)	7.5
DWSP (MOECC)	Chatham-Kent Drinking Water System - Wallaceburg	2003 - 2013	36	6.5	2.7 (2.3)	DL (0.5)	8.2
DWSP (MOECC)	City of Windsor Drinking Water System	2003 - 2013	57	25.2	11.4 (12.5)	DL (0.5)	67.5
DWSP (MOECC)	Glen Walter Drinking Water System	2003 - 2013	29	5.9	3.5 (1.9)	DL (0.5)	6.9
DWSP (MOECC)	Lambton Area Water Supply System	2003 - 2013	30	2.9	2.0 (2.3)	DL (0.5)	10.1
DWSP (MOECC)	Prescott Drinking Water System	2003 - 2013	30	5.6	3.3 (1.9)	DL (0.5)	7.9
DWSP (MOECC)	Tecumseh Water Treatment Plant	2003 - 2005	10	8.7	4.0 (3.7)	DL (0.5)	10.6
DWSP (MOECC)	Walpole Island Water Treatment Plant	2003 - 2013	39	3.5	1.9 (1.6)	DL (0.5)	7.0

Notes: Values less than the detection limit were assumed to be at the detection limit to calculate the 90th percentile, mean and standard deviation of each dataset, so summary stats represent an upper limit. Duplicates were averaged prior to calculating summary statistics.

The 90th percentile phosphate concentrations for the Amherstburg WTP (24.2 ug/L) and the City of Windsor WTP (25.2 ug/L), both sourced from the Detroit River, were over twice that observed in the Niagara River datasets (11.0 ug/L, 8.9 ug/L). Additionally, MOECC's DWSP Chatham-Kent Drinking Water System – Wallaceburg on the St. Clair River via Chenal Ecarte (6.5 ug/L), and MOE's DWSP Tecumseh Water Treatment Plant on the Detroit River (8.7 ug/L) had 90th percentile phosphate concentrations close to those measured in the Niagara River. Given that two datasets from the Detroit River reference area had phosphate concentrations clearly above those in the Niagara River, and two datasets from two of the three reference areas had phosphate concentrations on par with those in the Niagara River, this comparison suggests that phosphate concentrations in the Niagara River are on par with the variability seen in reference areas.

To further assist in interpretation of the overall status of forms of phosphorus in the Niagara River, SRP data collected under EC's US/DS program and by SUNY Brockport were also examined. The 90th percentile of SRP concentrations was 8.5 ug/L at FE, 12.0 ug/L at NOTL, 10.3 ug/L at Youngstown (shoreline) and 12.2 ug/L at Youngstown (mid-channel) (Table 6). Interesting to note is that EC's US/DS SRP data are not any higher than the SUNY Brockport data despite two-fold differences in TP concentrations between these two datasets (see Section 3.1). As SRP data were not available for reference locations, a Tier 3 assessment was conducted by examining both spatial and temporal trends in the available data to form lines-of-evidence on whether SRP concentrations are suggestive of an eutrophication impairment.

Table 6: Summary table of recent soluble reactive phosphorus (SRP) concentrations (ug/L) in the Niagara River according to data source.

Data source/ Program (Agency)	Spatial extent	Years included	Number of data points (n)	90th Percentile	Mean (standard deviation)	Min	Max
US/DS program (EC)	FE station	2012 - 2013	17	8.5	3.1 (3.6)	0.2	13.3
US/DS program (EC)	NOTL station	2012 - 2013	20	12.0	5.1 (4.2)	0.8	13.1
SUNY Brockport	Shoreline station near Youngstown, NY	2003-2005, 2007, 2009, 2013	28	10.3	5.6 (4.5)	1.2	22.3
SUNY Brockport	Mid-channel station near Youngstown, NY	2013	11	12.2	7.0 (4.0)	2.6	14.2

SRP concentrations observed at upstream (FE) and downstream (NOTL and Youngstown) locations were compared to assess if there is a clear Niagara River source of SRP. Although the 90th percentiles of NOTL and Youngstown SRP concentrations were greater than that observed upstream at Fort Erie, statistically significant differences ($p<0.05$) were only observed between EC's FE and SUNY Brockport's stations (Kruskal-Wallis Test; Mann-Whitney pairwise comparisons). As the EC and SUNY Brockport data were collected and analyzed under different methods, and do not represent the same time period, the meaning of these differences in SRP concentration is not clear. It is more important to note that there was no statistically significant difference between EC's paired FE and NOTL SRP concentration data ($p = 0.48$), which suggest the lack of a clear Niagara River source of SRP. Also important to note is that the datasets are not representative of long-term trends as three of the four datasets examined represent less than a year's worth of monitoring, and the data that were collected demonstrated high variability.

When examining the time series of SRP concentrations at the upstream and downstream locations measured under EC's US/DS program, paired concentrations were higher at NOTL relative to FE at the beginning of the dataset (April – October 2012), but SRP concentrations at FE were on par with or greater than those at NOTL towards the end of the dataset (December 2012 – January 2013) (Figure 7); reasons for this are not known. Overall temporal trends in SRP concentrations were considered for another line-of-evidence in the Tier 3 assessment, however, no clear time trends were observed. In summary, the lack of clear trends and high uncertainty in the SRP dataset do not unequivocally demonstrate a conclusion either way; more data would be needed to determine with higher certainty if SRP concentrations in the Niagara River are indicative of an eutrophication impairment.

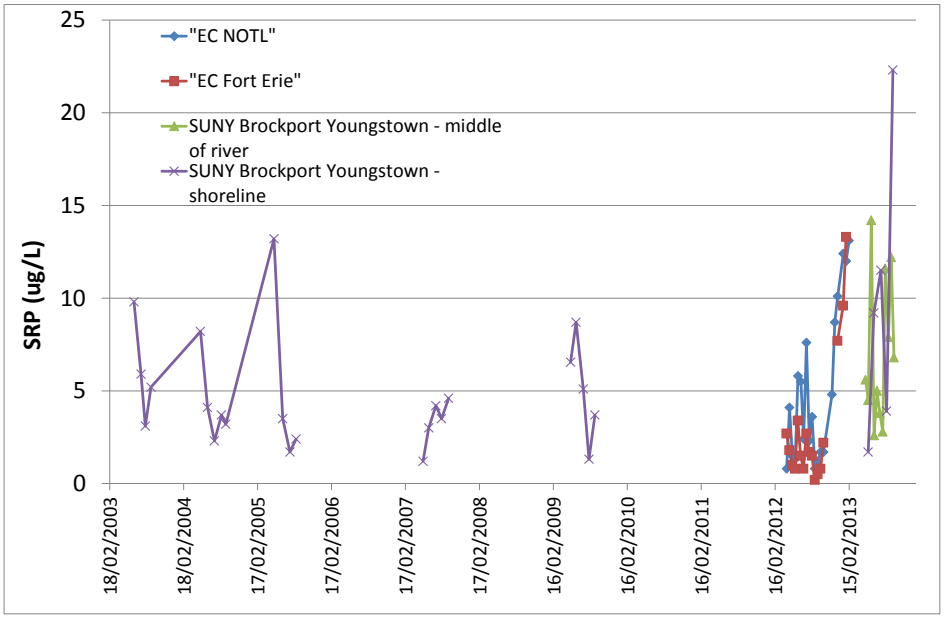


Figure 7: Recent SRP concentrations in water from EC's Fort Erie (FE) and Niagara-on-the-Lake (NOTL) stations, and SUNY Brockport's Youngstown stations.

3.3 Chlorophyll *a*

There are no recent chlorophyll *a* data collected under EC's US/DS program, MOECC's Great Lakes Monitoring Program, MOECC's DWSP program, NPCA's Chippawa Creek/Niagara Power Canal monitoring or NYSDEC monitoring; however, recent chlorophyll *a* data are available through the SUNY at Brockport monitoring program (Table 7). Chlorophyll *a* concentrations measured in the Niagara River were compared to concentrations measured in the Detroit River, St. Clair River and St. Lawrence River reference areas as part of a "Tier 2" assessment.

Table 7: Summary table of recent chlorophyll *a* concentrations (ug/L) in the Niagara River according to data source

Data source/ Program (Agency)	Spatial extent	Years included	Number of data points (n)	90th Percentile	Mean (standard deviation)	Min	Max
SUNY Brockport	Shoreline station near Youngstown, NY	2003-2005; 2007, 2009; 2013	28	2.9	1.6 (0.9)	0.1	4.1

Notes: chlorophyll *a* concentrations were not noted to be corrected or total values, so concentrations assumed to be total chlorophyll *a*.

The chlorophyll *a* 90th percentile concentration for the Niagara River was 2.9 ug/L, which is less than the 90th percentile for the St. Clair River (7.8 ug/L), equivalent to the 90th percentile for the St. Lawrence River (2.9 ug/L), and greater than the 90th percentile for the Detroit River (2.3 ug/L) (Table 8). Further, the mean chlorophyll *a* concentration of 1.6 ug/L in the Niagara River is less than the mean concentration in all three reference locations. These data are a line-of-evidence that (planktonic) algal densities in the Niagara River are generally equivalent to or better than reference conditions, suggesting a lack of impairment.

Table 8: Summary table of recent chlorophyll *a* concentrations (ug/L) in the St. Clair, Detroit and St. Lawrence Rivers according to data source.

Data source/Program (Agency)	Spatial extent	Years included	Number of data points (n)	90th Percentile	Mean (standard deviation)	Min	Max
Great Lakes Monitoring Program (MOECC)	Detroit River (Station 176)	2004, 2007, 2010	16	2.3	1.8 (0.5)	1	2.4
Great Lakes Monitoring Program (MOECC)	St. Clair River (Stations 43, 244)	2004, 2007	7	7.8	3.2 (5.5)	0.5	15.5
Great Lakes Monitoring Program (MOECC)	St. Lawrence River (Stations 126, 128, 424)	2006, 2009, 2012	30	2.9	1.7 (0.7)	0.7	3.0

Notes: Duplicates were averaged prior to calculating summary statistics. Chlorophyll *a* (total) concentrations are shown; chlorophyll *a* (corrected) concentrations were not included in the above summary.

The chlorophyll *a* data which do not suggest an algal issue in the Niagara River are consistent with the expectation based on the literature which suggests high velocity rivers like the Niagara tend not to have eutrophication problems. For example, thermal stratification was a determinant in cyanobacteria bloom formation in a major river in Australia (Maier et al., 2001) and in Anabaena bloom formation in the St. Lawrence River (A. Bramburger, 2013, pers. comm). The development of thermal stratification in a riverine system is controlled by a number of factors (e.g. prolonged low mean wind speed, low flow velocity, etc.; Maier et al., 2001), and because thermal stratification isn't expected to occur in the Niagara River due to persistent high flow velocities and the falls, the naturally existing conditions in the Niagara River are not favourable for bloom formation.

3.4 Dissolved Oxygen

Dissolved oxygen (DO) concentrations in the Niagara River underwent a Tier 1 assessment as all measured DO concentrations were compared to the screening target of 6.5 mg/L. Datapoints that did not meet this target underwent a more detailed analysis for potential biological impacts. Although DO concentrations demonstrated variability at most locations sampled, the minimum DO concentration measured in all datasets except one was above the screening target 6.5 mg/L (Table 9). For the MOECC Upper Niagara River dataset which had a minimum DO concentration of 5.7 mg/L and did not meet the screening target of 6.5 mg/L, this

dataset was more thoroughly assessed to determine if the DO concentrations measured below the screening criterion of 6.5 mg/L may have had biological effects.

Table 9: Summary table of recent DO concentrations (mg/L) in the Niagara River according to data source.

Data source/ Program	Spatial extent	Years included	Number of data points (n)	10th Percentile	Mean (standard deviation)	Min	Max	% of observations < 6.5 mg/L
Great Lakes monitoring program (MOECC)	Upper Niagara River	2003-2004	32	7.5	8.6 (1.0)	5.7	10	6.3
Great Lakes monitoring program (MOECC)	Lower Niagara River	2003-2004	8	8.9	9.9 (0.8)	8.9	10.8	0
Chippawa Creek/ Niagara Power Canal monitoring (NPCA)	Chippawa Creek/ Niagara Power Canal	2012 - 2013	11	9.8	11.5 (2.2)	6.7	15.0	0
NYSDEC	Youngstown, NY station	2003-2012	58	8.7	10.8 (2.1)	7.2	16.2	0
SUNY Brockport	Shoreline station near Youngstown, NY	2003-2005; 2007; 2009; 2013	25	7.5	9.0 (1.6)	6.7	13.6	0

Notes: No recent DO data for EC's US/DS program & MOECC's DWSP program. The 10th percentile is used in the summary statistics instead of the 90th percentile as higher DO concentrations are more desirable than lower DO concentrations.

The DO concentrations that did not meet the screening target of 6.5 mg/L were collected in the Upper Niagara River on August 14, 2003 (5.7 mg/L) and August 14, 2004 (5.7 mg/L). Accompanying measured water temperature data were not available for these two datapoints, so water temperature was assumed to be at least 15°C based on observed water temperature of 19.1°C measured in the Upper Niagara River in August 1980 (Plumb and Sweeny, 1980). The more conservative PWQO for coldwater biota at 15°C is 6 mg/L and for warmwater biota is 5 mg/L (MOEE, 1994a) and the more conservative CWQG for coldwater biota (non-early life stages) is 6.5 mg/L and for warmwater biota (non-early life stages) is 5.5 mg/L. The early life stage CWQGs were not used in this assessment because "the early life stage guideline should be

applied at those times and places where salmonid spawning and invertebrate emergence are known, or are likely, to occur" (CCME, 1999). Salmonid spawning is not expected to occur in the upper Niagara River in August, and invertebrate emergence is generally mid-May to the end of June (CCME, 1999).

The measured DO concentration of 5.7 mg/L in August 2003 and August 2004 may have placed some stress on coldwater species if such concentrations persisted over a prolonged period of time, but are not expected to have impacted warmwater biota. It is not clear however if the area of the upper Niagara River where these data were collected is coldwater fish habitat, and further, the other data collected do not suggest that DO concentrations remain below 6 mg/L for a prolonged period of time. It is important to note that the PWQO and CCME CWQG are not acute limits, that is, mortality is not expected to occur for DO concentrations measured below these thresholds. Thus, the recent DO monitoring data suggest that DO concentrations in the Niagara River during the past decade have not been impaired. This conclusion and assessment is consistent with historical findings by Plumb and Sweeney (1980) who also found lower DO concentrations in the Niagara River in August, which were attributed to seasonal warming of the River; however, the authors also stated that there was no indication of an acute problem as dissolved oxygen concentrations were generally acceptable. Also important to note is that DO is a secondary indicator of eutrophication, as any less than ideal DO concentrations could be due to oxygen demanding substances in the water column (e.g. chemical oxygen demand, nitrogenous oxygen demand, etc.) rather than the decay of algae at the sediment water interface.

3.5 Secchi Disc Depth

There are no recent Secchi disc depth data collected under EC's US/DS program, MOECC's Great Lakes Monitoring Program, MOECC's DWSP program, NPCA's Chippawa Creek/Niagara Power Canal monitoring, NYSDEC monitoring or SUNY at Brockport monitoring. Secchi disc depth data were however collected historically under MOECC's Great Lakes Monitoring Program (Table 10). As such, Secchi disc depths from 1967 to 1993 were examined for long-term temporal trends and for the magnitude of values relative to those recently measured in reference areas, both as lines-of-evidence for a "Tier 3" assessment on whether data suggest an impairment for this parameter.

Table 10: Summary table of historical (1967 - 1993) Secchi disc depth (m) in the Niagara River according to data source

Data source/ Program (Agency)	Spatial extent	Years included	Number of data points (n)	10th Percentile	Mean (standard deviation)	Min	Max
Great Lakes monitoring program (MOECC)	Upper Niagara River	1967-1976; 1978; 1980 – 1982; 1988	1066	1.0	2.3 (1.2)	0.1	8.5
Great Lakes monitoring program (MOECC)	Lower Niagara River	1967-1974; 1976-1982; 1988-1991; 1993	574	0.9	1.8 (0.8)	0.2	6.0

Notes: Duplicates were averaged prior to calculating summary statistics. The 10th percentile is used in the summary statistics instead of the 90th percentile as higher Secchi disc depths (higher water clarity) are more desirable than lower Secchi disc depths (lower water clarity)

The long-term temporal trends for Secchi disc depths in the upper and lower Niagara River were examined and there was no discernable trend (Figure 8). While a trend of improving water clarity over time may be desired, it needs to be reiterated that the eutrophication status in the Niagara River was purportedly never impaired (see Section 1), so historical baseline data could itself be representative of “unimpaired” conditions. Time trends for Secchi disc depths appeared more variable for the lower Niagara River relative to the upper Niagara River; reasons for this are not known at this time, and could be due to any number of factors. In particular, water clarity and hence Secchi disc depth in the lower Niagara River may be more greatly influenced by seston (particulate) due to the erosive forces of the falls and rapids, a factor outside the scope of this eutrophication assessment focused on potential reduction in water clarity due to algal density.

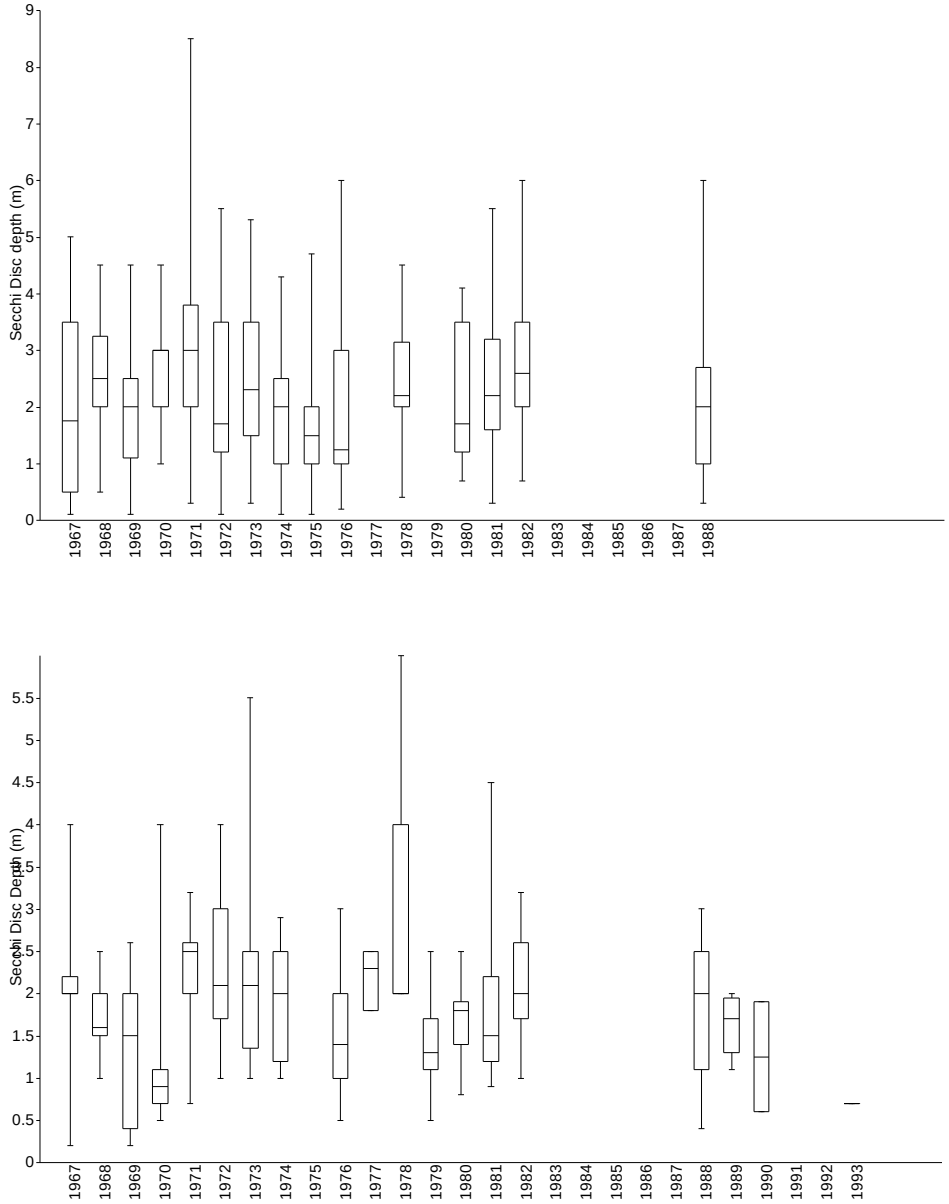


Figure 8: Time series of annual Secchi disc depths from the Upper Niagara River (upper) and Lower Niagara River (lower)

Notes: The boxes show the 25th and 75th quartiles, the median is shown with a horizontal line inside the box and the whiskers denote the minimum and maximum values for each year.

The historical Secchi disc depths in the Niagara River (Table 10) were compared to current day values in three reference areas - the St. Clair River, Detroit River and St. Lawrence River (Table 11). The 10th percentile and mean values in the upper and lower Niagara River were better than values in the Detroit River, better than or on par with values in the St. Clair River, and worse than values in the St. Lawrence River. As historical Secchi disc depths from the Niagara River are on par with or better than those recently measured in two of the three reference areas, this indicator does not suggest a water clarity impairment in the Niagara River, even if water clarity hasn't improved since the late 1980s/early 1990s (Figure 8).

Table 11: Summary table of recent Secchi Disc Depths (m) in the St. Clair, Detroit and St. Lawrence Rivers according to data source.

Data source/ Program (Agency)	Spatial extent	Years included	Number of data points (n)	10th Percentile	Mean (standard deviation)	Min	Max
Great Lakes Monitoring Program (MOECC)	Detroit River (Station 176)	2004, 2007, 2010	8	0.7	1.1 (0.3)	0.6	1.7
Great Lakes Monitoring Program (MOECC)	St. Clair River (Stations 43, 244)	2004, 2007	5	1.0	1.9 (1.1)	0.6	3.5
Great Lakes Monitoring Program (MOECC)	St. Lawrence River (Stations 126, 513)	2004, 2006, 2012	7	2.6	4.9 (2.1)	1.0	7.4

Notes: Duplicates were averaged prior to calculating summary statistics

4.0 Conclusion

Water quality data collected from the Niagara River over the past decade were examined to determine the overall impairment status of the beneficial use *Eutrophication or Undesirable Algae* in the Niagara River (Ontario) AOC. The five metrics used in the assessment were TP, phosphate/SRP, chlorophyll *a*, DO and Secchi disc depth and were assessed using the "Tiered" approach. Based on the weight-of-evidence, **this assessment concludes that *Eutrophication or Undesirable Algae* is Not Impaired in the Niagara River (Ontario) AOC**. The lines-of-evidence investigated in this assessment which support this conclusion include:

- The 90th percentiles of TP concentrations did not unequivocally meet the criterion of 30 ug/L; however, this was attributed to sources upstream from the Niagara AOC and out of scope of the Niagara River RAP;
- Phosphate and chlorophyll *a* concentrations in the Niagara River are generally equivalent to or less than those measured in unimpaired reference areas (SRP data were inconclusive);
- DO concentrations in the Niagara River are generally above the screening criterion of 6.5 mg/L, and for the two observations below 6.5 mg/L, impact to biota was not expected;
- Historical Secchi disc depth values in the Niagara River are generally on par with or better than current day values in unimpaired reference areas.

The conclusion of this assessment is consistent with other lines-of-evidence which have also suggested the lack of impairment for *Eutrophication or Undesirable Algae* in the Niagara River (Ontario) AOC. These include:

- the literature which has suggested that high flows such as those in the Niagara River are unlikely to support undesirable algal growth (Dodds, 2006; Maier et al., 2001);
- the lack of pervasive public opinion that algae is a problem in the NR;
- The historical "Not Impaired" status of this beneficial use in the Niagara River (Ontario) AOC (Niagara River RAP, 1993), and little evidence that eutrophication indicators have since changed (Figure 6); and
- The "Not Impaired" status for *Eutrophication or Undesirable Algae* in the Niagara River (New York) AOC. The Niagara River (New York) RAP has stated that the American side of the Niagara River is not impaired according to the following rationale:

  Declines in phosphorus and chlorophyll a levels in Lake Erie between 1968 and 1985 along with high dissolved oxygen levels measured in the Niagara River and the absence of nuisance algal blooms or accumulation are evidence that eutrophication is not a serious problem in the River. (NYSDEC, 2008)

Thus, the finding of an unimpaired status in this assessment should not be considered a novel description of the trophic status of the Niagara River AOC.

In conclusion, it is recommended that the Niagara River (Ontario) RAP change the status of *Eutrophication or Undesirable Algae* to "Not Impaired".

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Appendix I: The 2012 Protocol of the Great Lakes Water Quality Agreement.

Under the 2012 Protocol, the commitment to ensure that RAPs are developed, periodically updated, and implemented for each AOC is laid out in Annex 1. Each RAP will:

- Identify beneficial use impairments (BUIs - see section 1.1.1) and causes
- Include criteria for restoring beneficial uses to be established in consultation with the local community. "Delisting criteria" are measurable environmental conditions or performance measures that must be achieved for each BUI in order to conclude that the BUI has been completely addressed. The delisting criteria assist the RAP stakeholders to determine when the work of the RAP has been completed and accomplished its objectives;
- Identify remedial measures to be taken and entities responsible for implementing these measures. These actions are undertaken by public, private and community organizations. The scale of these projects can range from outreach and education programs to complex environmental remediation or public infrastructure projects. Funding comes from both public and private sector sources.
- Summarize how remedial measures have been implemented and provide updates on the status of the beneficial uses; and
- Describe surveillance and monitoring processes to track effectiveness and confirm restoration of beneficial uses (Government of the United States of America and the Government of Canada, 2012; Annex 1).

The Protocol also changed the previous reporting requirements for Remedial Action Plans. Up to this point the Niagara RAP met the previous requirements. A Stage 1 report defined the environmental problems of the AOC and the ways in which use and enjoyment of the Great Lakes has been affected by degraded water quality. The Stage 2 and Stage 2 Update reports provided recommendations for actions to restore the beneficial uses that were impaired and defined in the Stage 1 report. In the 2012 GLWQA Protocol, the emphasis is to report on incremental progress and to provide evidence the BUIs are being restored in a timely fashion. Progress is to be reported to the IJC every three years through the Progress Report of the Parties. Further information on the Great Lakes Water Quality Protocol of 2012 is found in http://www.ec.gc.ca/grandslacs-greatlakes/default.asp?lang=En&n=45B79BF9-1

An AOC is delisted when the beneficial use impairments have been addressed. At this point all remedial actions have been completed and monitoring has confirmed that water quality and ecosystem health (i.e., the beneficial uses) have been restored. Or, the status of the AOC could be changed to Area in Recovery if all actions had been implemented and time was needed for the ecosystem to recover. It should be noted that when an AOC is delisted, it means that the water quality issues that caused the AOC to be originally designated at Stage 1 have been addressed. Therefore, conditions in the AOC are comparable to surrounding watersheds. It does not mean that the area has been restored to pristine or pre-settlement conditions. After delisting, it is anticipated that local stakeholders, including government agencies, will continue to maintain and enhance the environmental gains made under the RAP.

The decision to delist a Canadian AOC is made by the Government of Canada in consultation with the Province of Ontario, local RAP partners and the public and, for Niagara, with the U.S. RAP state and federal officials. It is possible for one side of the River to delist before the other.

Delisting an AOC is also undertaken with input from the International Joint Commission.

Figure A1: Map showing the location of Areas of Concern around the Great Lakes Basin.

Appendix II: Summary of activities that address Stage 2 Goals to reduce nutrient inputs to the Niagara River AOC.

- 1988. The Region of Niagara voluntarily implemented a Sewer Use Program under the Municipal Act through the enactment of a Sewer Use Bylaw.
- 1990. The NPCA implemented the Ministry of Environment and Energy's "Clean Up Rural Beaches" program (CURB). The program existed until 2001 and its purpose was to prevent pollution from rural sources to reduce the frequency of rural beach postings in Ontario. Under CURB, the ministry made funds available for nutrient related projects such as improving manure storage, milkhouse washwater disposal systems, fencing and crossings to restrict livestock access, and private sewage systems.
- The Friends of Fort Erie's Creeks conducted the Frenchman's Creek Stream Rehabilitation project, 1995-2000. The group also implemented a natural channel design project and riparian restoration of Black Creek in the 1990s.
- 1991. The NPCA's GIS restoration database was initiated and it contains data on # restoration project types (Non-Point Source) and locations within the AOC.
- 1993. The Environmental Farm Plan (EFP) program was introduced by the Ontario Farm Environmental Coalition with the goal to have in place an Action Plan for every farm in Ontario by 2000. Farmers in the AOC have participated in the program.
- 1994. Environment Canada, through the Great Lakes Cleanup Fund, provided funding to the NPCA to support the development of a rural non-point source monitoring and remediation program for the Niagara River (Ontario) AOC – the "Rural Clean Water Program".
- 1994 -1996. The NPCA conducted water quality monitoring through the Niagara River AOC Tributary Monitoring Program to collect long-term surface water quality data for AOC tributaries.
- 1998. The NPCA, together with watershed partners, initiated the Welland River Watershed Strategy with a 10-year Watershed Action Plan "To restore the ecological health of the Welland River and its watershed" (NPCA, 1999).
- 2001 - 2005. The NPCA sampled and reported on water quality data for AOC tributaries through the Niagara River AOC Tributary Monitoring Program.
- 2003. Phosphorous loading from urban stormwater, agricultural land, and other lands, was determined by mass balance modeling by Niagara Region and MOE's MISA Effluent Monitoring Results and Load Calculations.
- 2006. Niagara Region conducted an audit and evaluation of CSOs under the Niagara Water Strategy. The CSO Management Action Plan was approved by Regional Council in 2007.
- In response to Ontario Procedure F-5-5 for management of wet weather flows, AOC municipalities (i.e. Niagara Falls, Welland, Niagara-on-the-Lake and Fort Erie) have completed Pollution Control Plan studies & implemented facility upgrades, improved operations and used innovative technologies. For example, in 2007, the Niagara Region and the City of Niagara Falls completed construction of a new joint Central Pump Station – High Rate Treatment (HRT) facility, eliminating the Muddy Run CSO discharge to the Niagara River and significantly reducing the number of discharges of untreated waste water

to the environment. The municipalities are obliged to report to MOE under Procedure F5-5 on progress on their CSO improvements.

- In 2007, the NPCA entered into an agreement with OPG to implement “soft engineering” restoration strategies along the Welland River to mitigate the impact of flow reversal and improve habitat, etc. An example of the NPCA’s work in restoring and rehabilitating wetlands to protect water quality is provided by the E.C. Brown Wetland.
- Various restoration activities by partners on Upper Niagara River tributaries have made improvements to Frenchman’s Creek, Black Creek, Ussher’s Creek and Beaver Creek.

Appendix III: Status and Delisting Objectives for the BUI *Eutrophication or Undesirable Algae* in Binational, American and Canadian Connecting Channel and River* Areas of Concern (AOCs)

Area of Concern	Status and Delisting Objectives for "Eutrophication or Undesirable Algae"
St. Mary's River AOC, Binational AOC	Status: Impaired • All embayment waters have persistent total phosphorus concentrations of <20 ug/L, a secchi disc transparency of >1.2 m, dissolved oxygen at saturation, chlorophyll concentration of<10 ug/L, and unionized ammonia <0.02 ug/L. • Phosphorus load from East End Water Pollution Control Plant <I mg/L with a consideration of seasonal variability in receiving water sensitivity. All plants to consistently meet Certificate of Approval limits or MI permit system limits. • Any failure to meet these targets must not be attributable to cultural eutrophication (ie., nutrient inputs from human sources such as sewage). • Conditions above to be maintained for at least five years prior to delisting. • Mean monthly values for delisting targets should be met throughout the river, with sampling points representative of different river reaches and in proximity to known significant sources. (Source: North-South Environmental Inc., 2003)
St. Clair River AOC, Binational AOC	Status: Not impaired 1991 Stage 1 RAP: Little work has been done on smaller phytoplankton; larger species are typical of oligotrophic waters 1995 Stage 2 – Recommended Plan: The waters of the St. Clair river are mesotrophic and algae do not occur at nuisance levels. (Source: Mayne, 2003)

Area of Concern	Status and Delisting Objectives for "Eutrophication or Undesirable Algae"
Clinton River AOC, American AOC	Status: Impaired (localized) Restoration Criteria An AOC water body will be considered restored for the eutrophication impairment if monitoring nutrients, chlorophyll, dissolved oxygen, and secchi depth using the protocols of Michigan's Cooperative Lakes Monitoring Program in any 2 of 3 years indicates that: • There are no growths of undesirable algae in quantities which interfere with a water body's designated uses as defined in Rule 323.1100 of the Michigan Water Quality Standards (e.g., inhibits swimming due to the physical presence of algal mats and/or associated odor; inhibits the growth and production of warm water fisheries and/or indigenous aquatic life and wildlife). Undesirable algae species which may indicate impairment include toxic-producing cyanobacteria (e.g., Microcystis), noxious bloom-forming phytoplankton (e.g., Aphanizomenon), or benthic algae (e.g. *Cladophora*); and • The water body meets the minimum D.O. standards listed in Rule 323.1064 in the Michigan WQS; and • Any deviation from Rule 323.1064 is a direct result of vegetation; and • The waterbody is no longer listed as impaired due to nutrients on the Clean Water Act Section 303(d) list for the state. MDEQ is currently in the process of developing nutrient criteria for the surface waters of the state which will be adopted into the Michigan WQS. BUI restoration will be expanded to include adherence to this nutrient criteria when it is officially adopted (Source: Environmental Consulting & Technology Inc., 2005)

Area of Concern	Status and Delisting Objectives for "Eutrophication or Undesirable Algae"
Detroit River AOC, Binational AOC	Status: Not impaired Delisting Criterion When the nutrient status of the waters of the Detroit River will support the establishment of mesotrophic conditions in the Western Basin of Lake Erie, and the shoreline of the river will support minimal grown of attached algae (e.g., Cladophora). Design and Rationale This BUI has been designated not impaired since the 1991 RAP Report, and as a result, delisting criteria are not required. However, they are provided as rationale for maintaining the not impaired status and to help guide monitoring efforts. The focus of future monitoring for this beneficial use (no undesirable algae) will be on the potential for impacts to Lake Erie. This BUI is closely linked to Degradation of Phytoplankton and Zooplankton Populations in that over 98% of the water flowing through the Detroit River comes from the oligo-mesotrophic Lake Huron and moves through the Huron-Erie corridor very quickly. Furthermore, the target load of 11 tonnes of phosphorus per year (IJC 1987) has been met through industrial/municipal controls. (Source: Green et al., 2010)
Rouge River AOC, American AOC	Status: Middle Branch Impoundments Impaired, in summer 1. Algae species in Middle Branch impoundments characteristic of mesotrophic conditions, for 3 consecutive summers 2. No interference with recreational activities from algae blooms (Source: Rouge River Remedial Action Plan, 2004)

Area of Concern	Status and Delisting Objectives for "Eutrophication or Undesirable Algae"
St. Lawrence River (Cornwall) AOC, Canadian AOC	Status: Environmental conditions improved; partially restored 1. Provincial Water Quality Monitoring Network (PWQMN) Reduction: Demonstrate a reduction in phosphorus concentrations at St. Lawrence River tributaries as measured at PWQMN sites. [Criteria #1 has been met] 2. Lake St Francis: The mean annual TP concentration in Lake St Francis should not exceed 20 ug/L in waters between the two-metre nearshore contour and the open channel. [Criteria #2 has been met] 3. Algal Blooms: No evidence of sustained and widespread undesirable algae blooms in the St. Lawrence River, source-specific to the AOC, whether free-floating or attached to surfaces. Site specific occurrences at tributary mouths and in developed areas should be monitored and nutrient control programs put in place. [Criteria #3 has been met] 4. Tributaries: The long term goal is to prevent further degradation of the water quality in the tributaries and ensure that all practical measures are taken through implementation of source control programs and best management practices to achieve site-specific annual mean TP concentrations as listed in Table 7 of the AECOM report Evaluation of Remedial Action Plan Tributary Nutrient Delisting Criteria for the St. Lawrence River, Cornwall Area of Concern (April 2009). See Appendix 7.2. [Criteria #4 has not been met for AOC Tributaries. On-going restoration and monitoring is required.] (Source: SLRRC, 2012)

Notes: Not all AOCs on rivers are included in the above table; connecting channels in the Great Lakes and tributaries to those connecting channels are included above.