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Lake Erie Loadings Estimations in support of the Great Lakes Nutrient Initiative (GLNI)

Environment Canada, Water Quality Monitoring and Surveillance Division

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Sharing Loading Estimation Experiences Workshop
January 20^{th}, 2015
Guelph, Ontario

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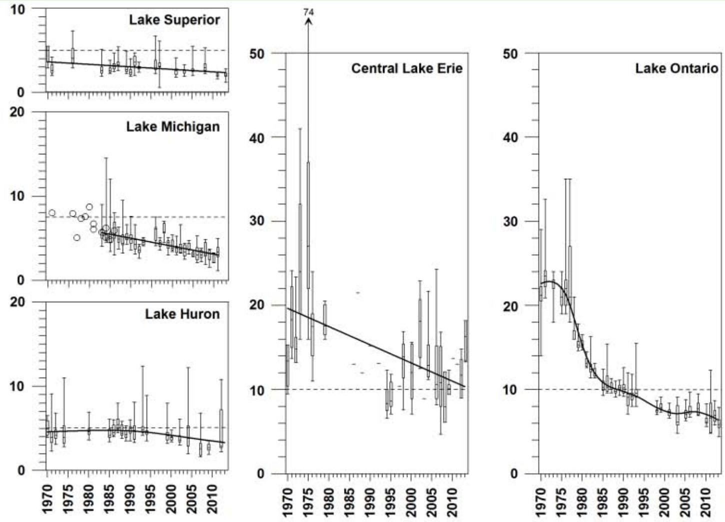
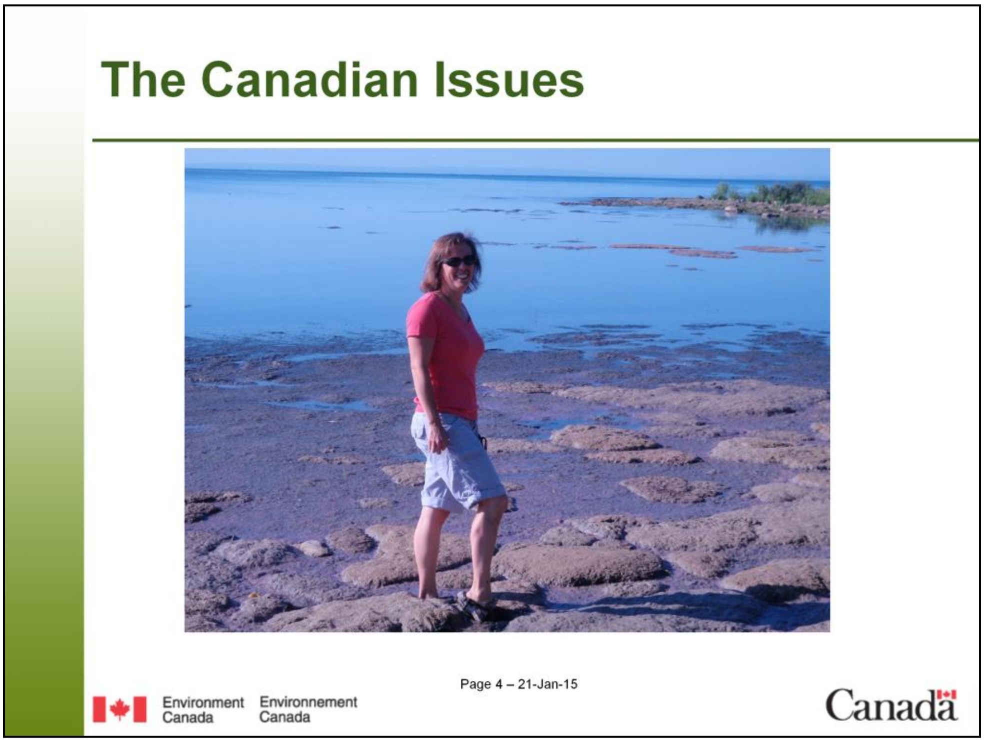
Ausable Bayfield Conservation Authority

Background – Great Lakes TP Trends



Total Phosphorus concentrations have decreased in all the Great Lakes over time, but water quality issues remain; especially in Lake Erie where TP still exceeds guidelines and where nearshore eutrophication has recently worsened, as evidenced by the re-emergence of nuisance algae blooms (chladophora).

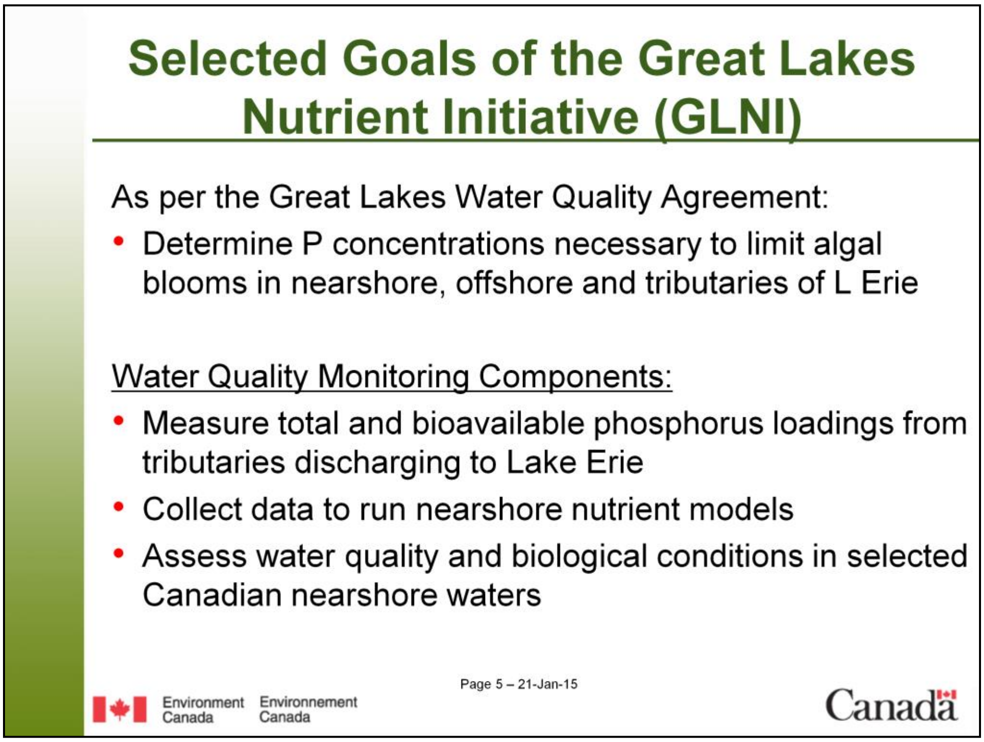
We need to be able to examine and quantify the relationship between nutrient loadings and nearshore water quality, and be able to quantify and track the proportions of total nutrients that are contributed by the bioavailable fractions. Because the nearshore is greatly impacted by invasive mussels, and because they may be redirecting nutrients away from the Great Lakes offshore to the nearshore via the nearshore shunt, there is a need for better understanding about the relationship between nutrient loadings, nearshore water quality and nearshore biological indicators. These are the major goals of GLNI.



For Canada, the major nutrient issues in Lake Erie are related to nuisance algal blooms in the eastern basin, and our possible contribution to the harmful algal blooms in the western basin.

Algae blooms have economic, social and environmental implications. Toxic and nuisance algae blooms can lead to increased water treatment needs, disruptions to utilities by clogged water intakes, and negative effects on recreational activities such as swimming, commercial and recreational fishing, and tourism. Generally, communities along the shores of the Great Lakes experience diminished quality of life and economic prosperity when excessive algae are prevalent.

How can we better manage nutrients leaving the watersheds to reduce lake impacts and improve environmental conditions?



The Great Lakes Nutrient Initiative was announced in 2012 federal budgets. The Great Lakes Nutrient Initiative will provide $16 million in funding to address the complex problems of recurrent toxic and nuisance algae in the Great Lakes

The Initiative will advance the science to understand and address the complex problem of recurrent toxic and nuisance algae in the Great Lakes. The Initiative will focus on Lake Erie, the smallest and shallowest of the Great Lakes and most susceptible to nearshore water quality issues. The science and policy approaches developed through the Initiative will be transferable to the other Great Lakes and bodies of water in Canada.

The Initiative will target five priority areas:

- Establishing current nutrient loadings from selected Canadian tributaries;
- Enhancing knowledge of the factors that impact tributary and nearshore water quality, ecosystem health, and algae growth;
- Establishing binational lake ecosystem objectives, phosphorus objectives, and phosphorous load reduction targets;
- Developing policy options and strategies to meet phosphorous reduction targets;
- Developing a binational nearshore assessment and management framework.

The Initiative will also help Canada to deliver on key commitments under the recently amended Canada – United States Great Lakes Water Quality Agreement.

The primary focus will be to set phosphorus concentration targets in the tributaries, the nearshore receiving waters as well as the open lake waters of the Great Lakes. These targets will allow lake managers to determine the best practice to achieve a healthy nearshore that limits the recurrence of nuisance and toxic algal blooms.

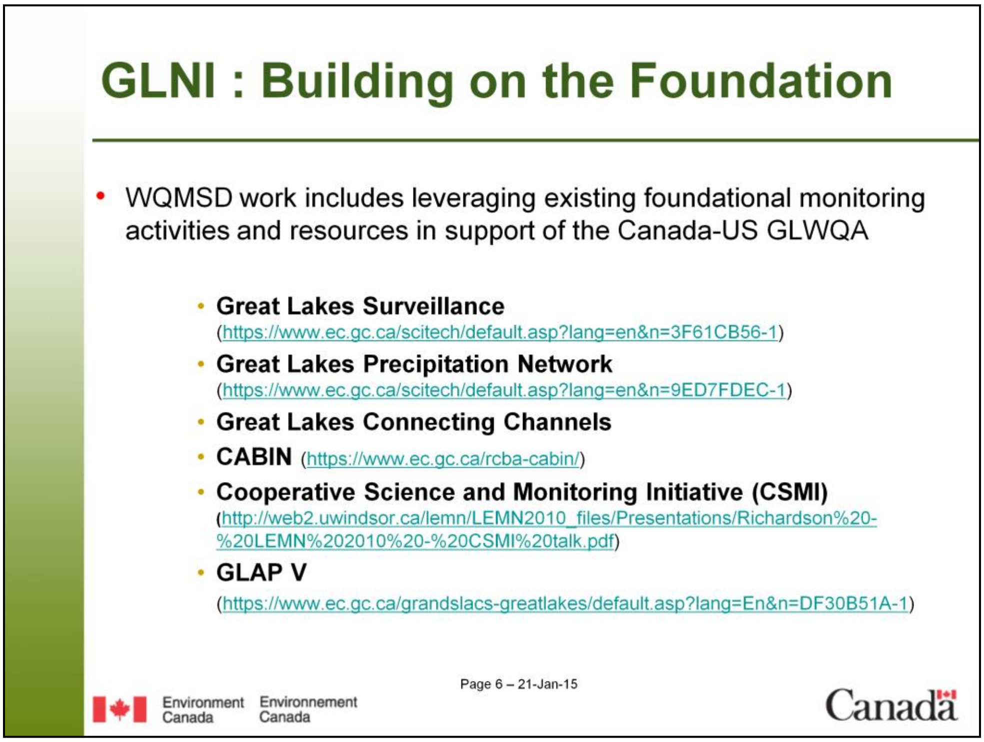
The process or framework that is developed at the end of the 5 years will be transferrable to other large lakes in Canada that are affected by similar issues.

Modeling will be used to understand what factors are creating an environment that is conducive to nuisance and toxic algal outbreaks in the lake and tributary.

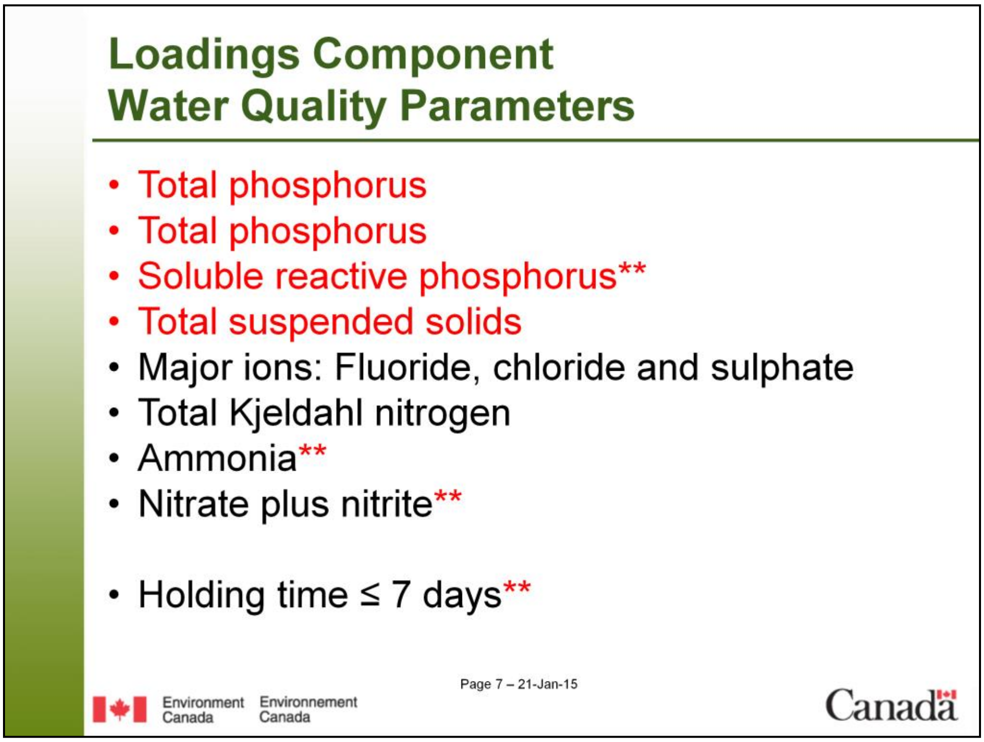
GLMRS area of responsibility is:

- Establishing binationally agreed upon, ecosystem based, phosphorus concentration objectives for the open waters and nearshore zones of Lake Erie, and the phosphorus load reduction targets
- Assessing and developing policy options and strategies for reducing phosphorus loadings from urban and agricultural point and non-point sources to Lake Erie

WQMS is working on three components (nearshore WQ, nearshore biology and tributary loadings). Today, I will be discussing the tributary loadings component.

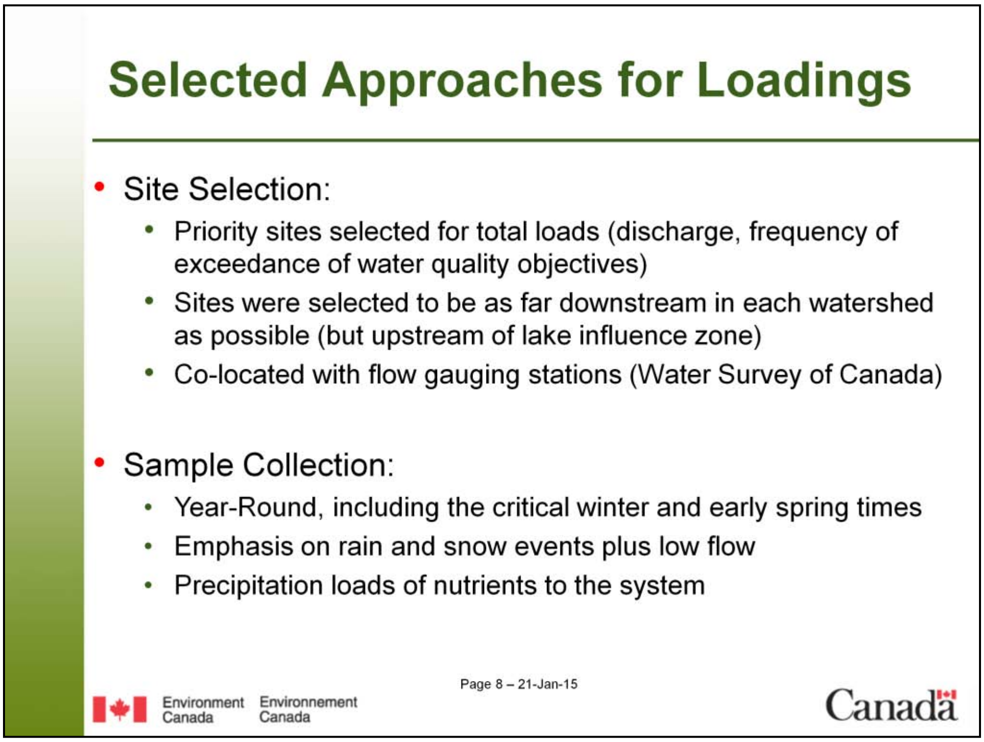


I would like to take the opportunity to mention that the GLNI program builds upon Environment Canada's foundational monitoring of environmental quality and ecosystem health in the Great Lakes. These include projects to assess offshore water quality, nutrient loads from precipitation, water quality in the Great Lakes connecting channels, benthic health, and monitoring in support of beneficial use impairments (BUIs) in Areas of Concern.



This is the list of compounds we are analyzing and for which we are calculating total loadings.

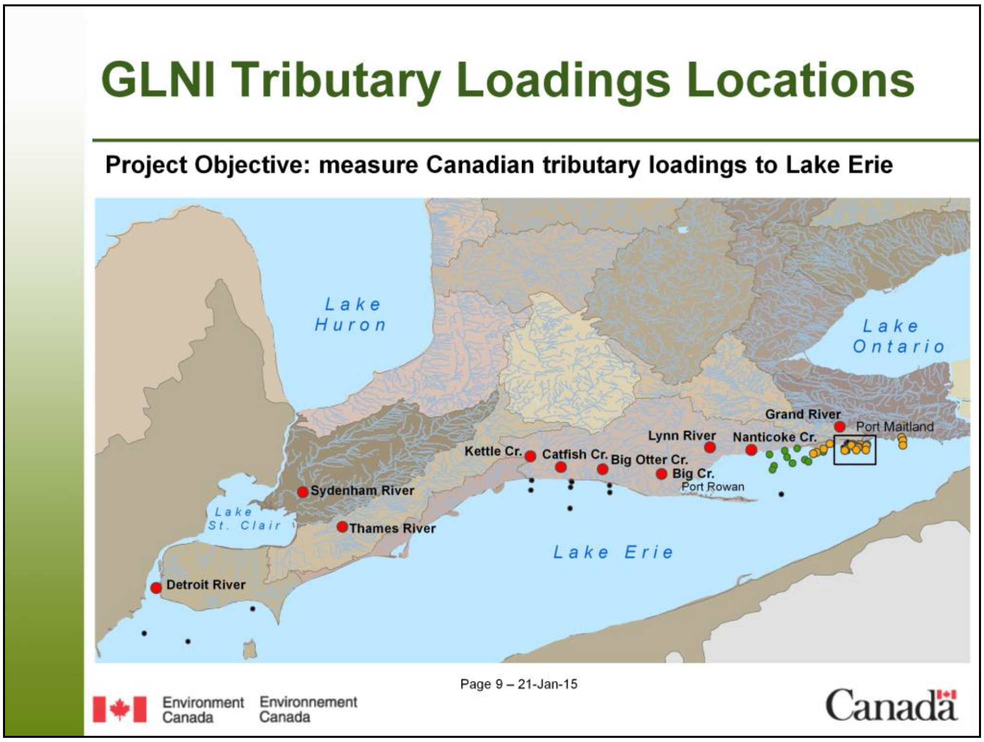
Loads have been computed for water year 2012 and 2013 for the items in red, and loadings for all parameters are currently being computed up to and including the 2014 water year.



The sampling sites in the tributaries are co-located at a Water Survey of Canada gauging station. These stations provide flow information which is a required component in determining loadings.

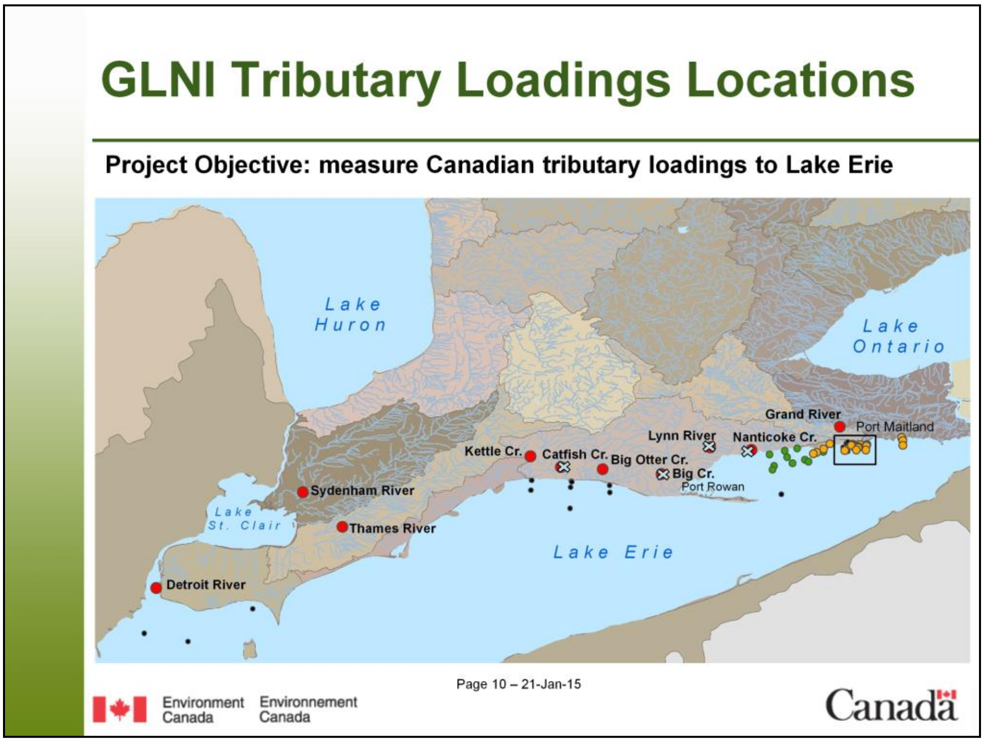
We sample year-round, which means capturing winter and spring conditions; a missing component to most sampling programs. According to the USGS, the biggest input of nutrients to the lake occurs during the winter and spring months when strong storm events and spring runoff bring in big pulses to the lake.

Also, while our sampling is focused on events we also collect grab samples during low flow conditions.

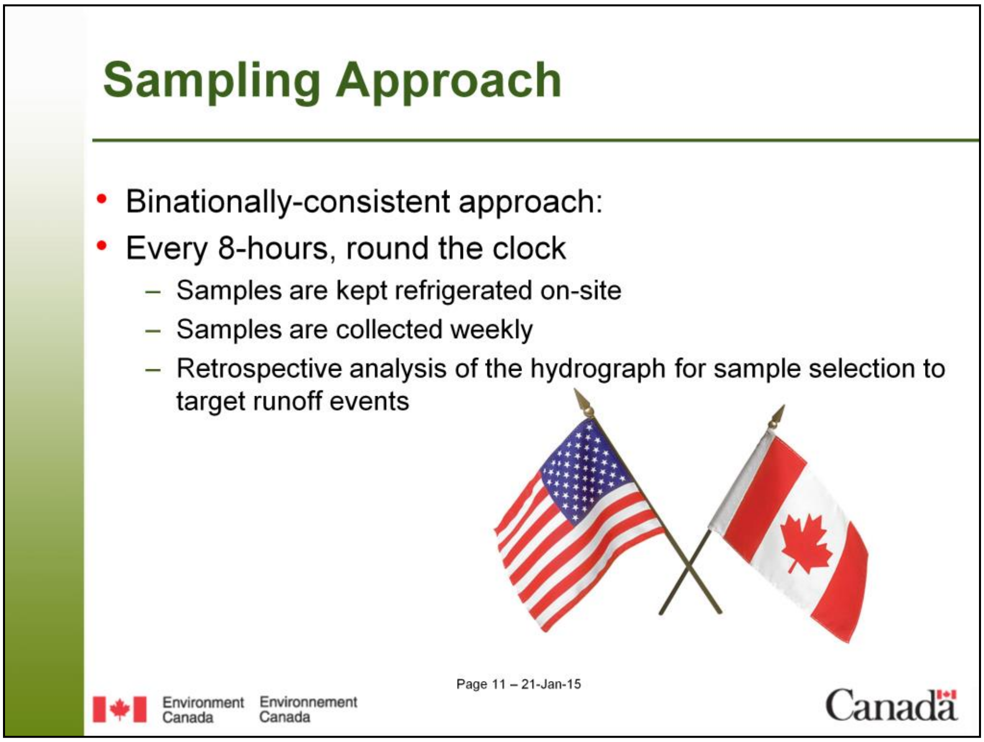


The overall objective of the GLNI loadings component is to measure Canadian tributary loadings to Lake Erie. The highest priority tributaries were selected, based on the watershed size and their in-stream nutrient concentrations. Based on these criteria, some of the highest priority Canadian tributaries do not discharge directly to Lake Erie but discharge upstream. In addition, Detroit River is the conduit for upstream and direct loads to the western basin of Lake Erie.

- Priority tributaries to Lake Erie north shore
- Priority tributaries to Lake St. Clair
- Detroit River is the conduit for upstream and direct loadings to the western basin



Several smaller tributaries were discontinued after one or two years of data collection in order to focus efforts on the larger, higher priority tributaries and the Detroit River.

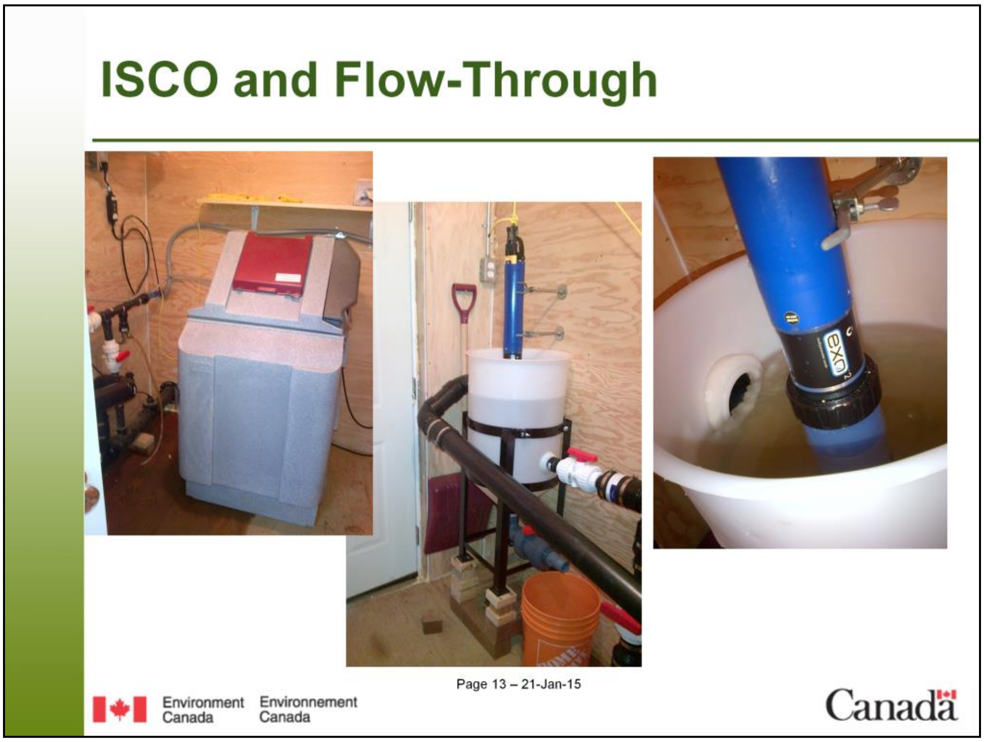


We initially attempted to implement a flow-weighted event mean concentration approach in order to optimize the laboratory analysis. By combining aliquots of samples collected during a hydrographic response in a flow-proportional manner, we could submit fewer samples for analysis. We found the approach was not feasible for these very large rivers. The time for the rivers to respond could be many days, and could span over the date of sample collection. This was also variable across the rivers being sampled.

Automated sampling using an alternative approach of routine sampling and retrospective sample selection according to hydrographic response was implemented at selected sites (Grand River, Thames River, Sydenham River) with grab sampling at the remaining sites. We sample every 8 hours and samples are collected weekly from each site. The hydrograph is consulted and we have developed an SOP for selecting samples for analysis. Runoff events are targeted; we have been able to successfully capture most if not all runoff events using this method.

After much investigation, we determined to use in-river pumps to deliver a continuous flow to huts that are installed adjacent to the rivers, from which we collect samples for water quality. These pumps need to be strong enough to deliver water into the hut, need to not become plugged by debris, and need to withstand very high flows (up to 800 m3/s!) that can scour the river beds. We need to be able to flush the pumps also in order to prevent blockages.

We use a groundwater pump that is housed in a protective casing and anchored using a sewer grate. The equipment was installed by divers using winches to lower the pumps into the river.



In the hut, we use a flow-through system. River water is continuously pumped up to the hut via a line wrapped with heat trace wiring to prevent freezing. The ISCO automated water quality sampler samples from the line as per its program. The water flows through an in-line reservoir, into which a YSI sonde collects real-time measurements of conductivity and other parameters.

The YSI data collection follows the National Standard for quality assurance, including QA and calibration.

Huts

As mentioned, huts have been installed adjacent to WSC huts at the river sites. Here, Thames River hut and Florence River hut are shown left and right, respectively.

In the Detroit River, a different level of effort is required in order to capture the cross-sectional variability in water quality. Here, the water quality is very different depending on where you sample in the river. Poorer water quality plumes tend to hug the shore; it is here that the signature from the Sydenham and the Thames may enter Lake Erie. Building upon work we started in about 2004, we have implemented transects that are sampled by boat and we have also have installed three automated samplers.

Here, the methods to calculate loadings are very different and beyond the scope of what can be covered today; briefly, we are analysing relationships between water quality at the fixed ISCO locations with water quality in the transects so that we can determine total loads based on the ISCOs only. The automated samplers collect water hourly and these are integrated into daily samples. Selected samples are analyzed at the laboratory.

Loadings Calculations

Stratified Beale ratio estimator chosen

- Binationally consistent'
- Appropriate for large rivers
- EC Decision Support Tool developed and implemented

Assumptions used:

- Discharge threshold at 80% of recent three-year time period chosen to stratify baseflow and runoff
- Loadings calculated on water year basis
- Daily time-step

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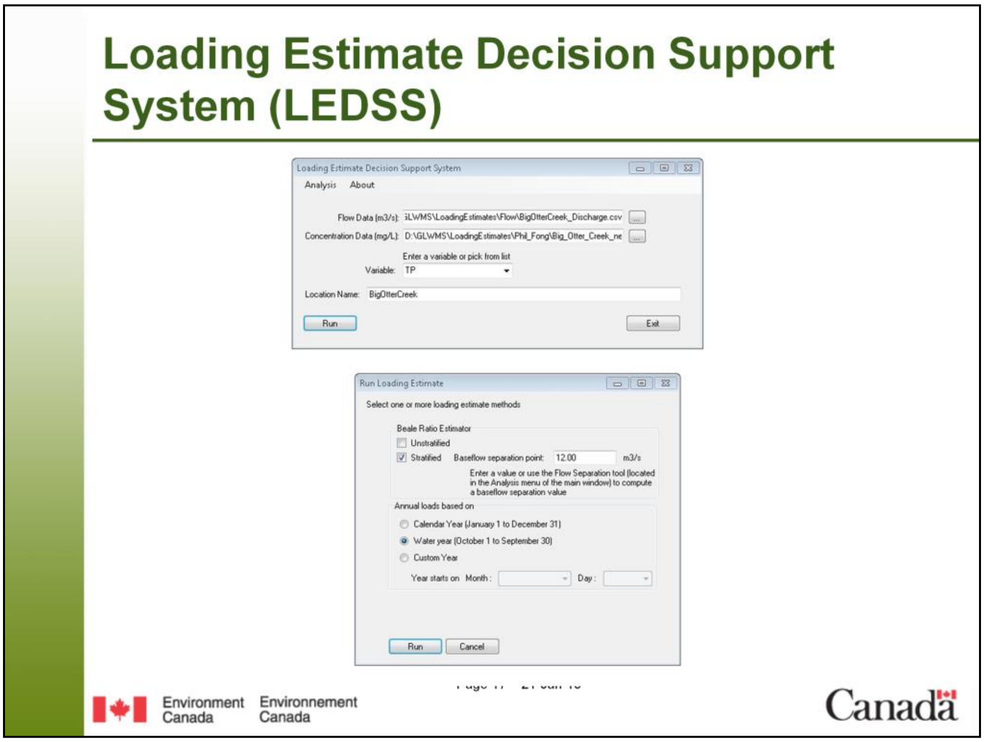
For several reasons (appropriate for large rivers, used by USGS and Heidelberg College therefore binationally consistent, availability of tool developed by EC to calculate loads), we chose the stratified Beale method to calculate flow. Some of the assumptions we used include using the 80% threshold to stratify baseflow from runoff, using recent discharge data rather than long-term (to better represent current scenarios), and calculations are based on a daily time-step.

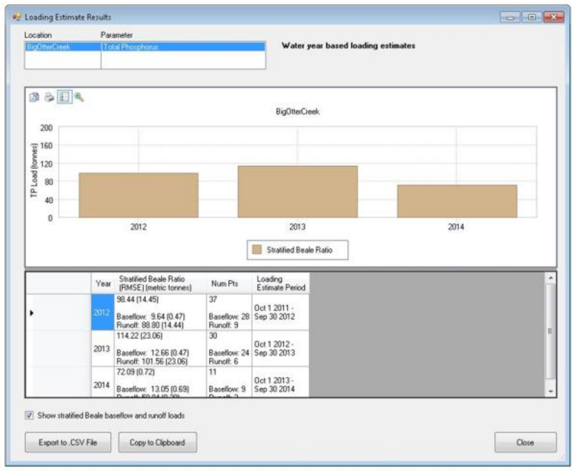


Here's a screen capture showing the input screen for the tool for loadings calculations.

Csv files for water quality data and discharge data are selected.

Method for computation is selected.

LEDSS Output



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Example of output from LEDSS.

Very nice tool – for more information contact Isaac Wong at EC.

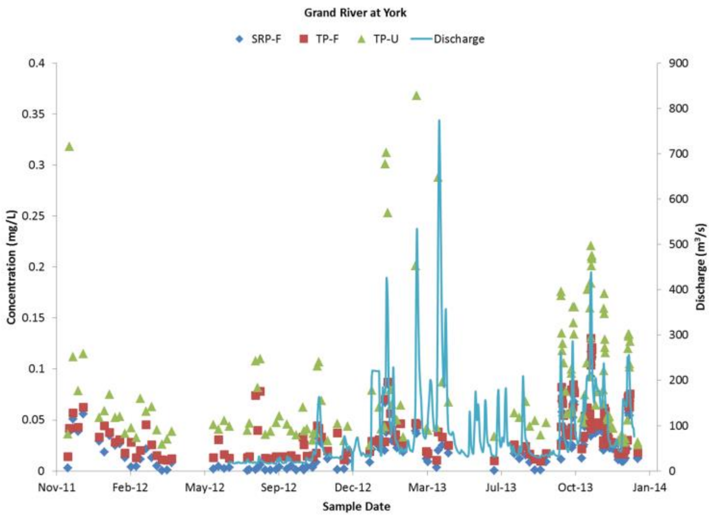
Project Outcomes

- (Draft) Total Phosphorus Loads (metric tonnes)

	2012 Water Year					2013 Water Year				
	Baseflow	Runoff	Total	RMSE	# of pts	Baseflow	Runoff	Total	RMSE	# of pts
Grand River at York	57.14	156.35	213.49	30.52	42	66.99	314.67	381.66	18.88	52
Kettle Creek at St. Thomas	2.27	46.3	48.57	8.51	31	4.5	61.1	65.6	16.31	29
Catfish Creek at Jaffa	2.48	54	56.47	8.67	31	4.09	66.02	70.11	9.02	19
Big Otter Creek near Calton	9.96	89.85	99.82	15.42	37	12.93	102.24	115.17	21.09	30
Big Creek near Walsingham	5.27	6.71	11.98	0.51	36	5.34	16.3	21.63	1.84	20
Lynn River at Simcoe	2.55	1.74	4.29	0.37	37	2.27	2.58	4.85	0.2	20
Nanticoke Creek at Nanticoke	0.28	0	0.28	0.01	11	1.37	8.75	10.12	0.82	12
Thames River at Thamesville	52.9	93.65	146.55	2.18	26	70.7	254.72	325.42	1.3	17
Sydenham River at Florence	8.96	50.05	59.02	4.98	31	9.58	80.87	90.45	0.37	18

Total loads have been calculated for key parameters for 2012 and 2013 water years. 2014 water year loadings currently being calculated.

Additional Project Outcomes



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In addition to total loadings, we are providing full scientific interpretation of the results as necessary to be able to fulfill our obligations.

We have and will be looking at relationships between WQ parameters and discharge.

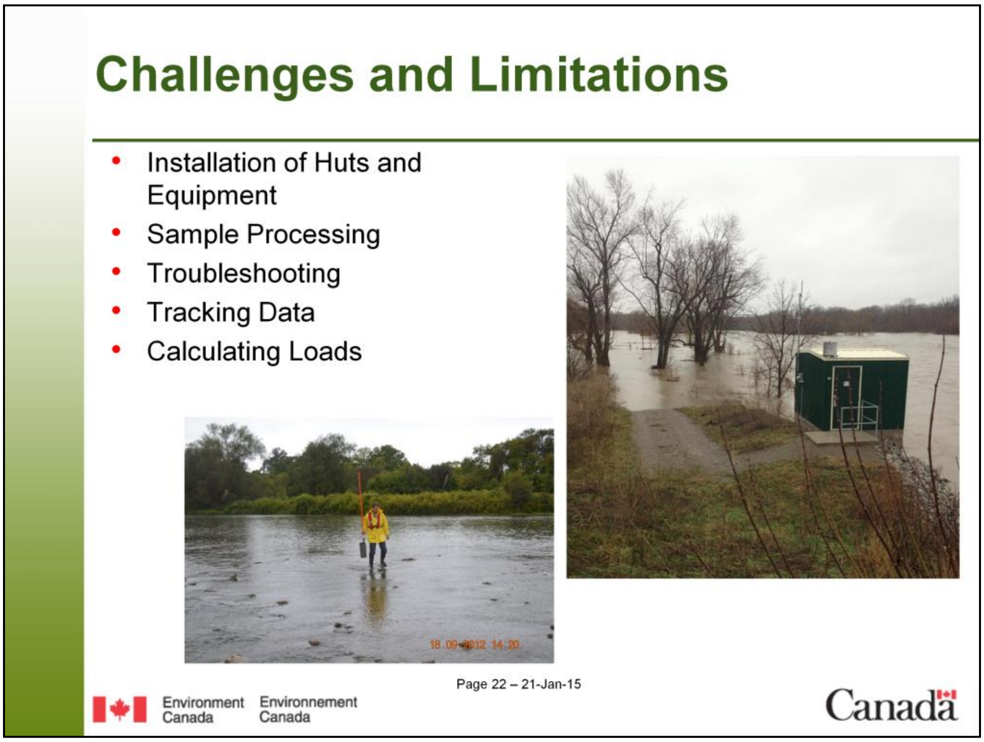
Additional Project Outcomes

	TFP:TP	SRP:TP	SRP:TFP
Site	**mean**	**mean**	**mean**
Big Creek Near Walsingham	0.31	0.21	0.69
Big Otter Creek At Calton	0.34	0.27	0.79
Catfish Creek at Jaffa	0.47	0.37	0.78
Grand River At York	0.49	0.31	0.61
Kettle Creek At St. Thomas	0.37	0.30	0.80
Lynn Creek At Simcoe	0.50	0.44	0.86
Nanticoke Creek At Nanticoke	0.37	0.28	0.75
Sydenham River At Wallaceburg	0.40	0.35	0.84
Sydenham River At Florence	0.41	0.32	0.74
Thames River At Chatham	0.38	0.32	0.80
Thames River At Thamesville	0.40	0.30	0.68

We can also assess differences between sites and years.

And assess nutrient ratios (especially the proportion of SRP:TP).

For example, SRP generally comprised between 20 and 40% of the TP concentration – we can further analyze this to look at seasonality and differences between high and low flows. This will be useful should the new P targets be based on SRP concentrations or loadings.



Where to begin…..This was a HUGE endeavour, made somewhat more difficult by practical limitations such as shortage of human resources. Nonetheless, our team has delivered!

Some of the significant challenges included:

- Hut Installation – formulating a plan, obtaining permissions, permits, hydro
- Sampling Equipment – choosing the right equipment to withstand high flows (ended up with in-stream (all stainless steel groundwater) pumps, a flow-through system to the huts with return flow). Divers and winches were required to install the equipment and are required for periodic maintenace and trouble-shooting
- Sample processing (filtering) – the laboratory was supposed to provide this but we have had to conduct all the sample processing and it is a significant task, requiring one to two staff approximately one to two days per week.
- Troubleshooting! When the ISCOs don't sample; lines freeze, pumps clog, power failures, etc.
- Tracking data – made much easier with EC's databases, but we had a database transformation concurrent with our data collection efforts which complicated things. Tracking when samples were collected is one thing; for multiple samplers this is more complicated (tracking when the samplers are reset, for example, to know which bottle # relates to which date and time).
- Calculating loads – on what basis, also water year versus calendar year

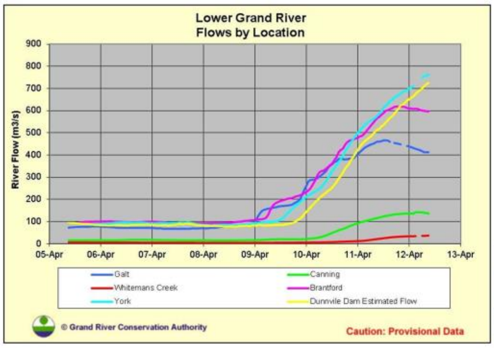
We are very fortunate in that this program is well resourced; we have access also to divers for installation and maintenance which has been key.

Future directions

- GLNI funding through March 2016
- Conduct monitoring and update loadings through water year 2015 at all monitored sites
- Calculate loadings for Detroit River
- Calculate precipitation loadings
- Update Lake Erie loadings estimates through 2013 on a binational basis
- Calculate Canadian loadings contributions
- Data will be published and/or made publicly available through the Canadian data online initiative

Further questions contact AliceDove@ec.gc.ca

Grand River at York, April 2013



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(If needed – this is why flow-proportional sampling is not appropriate for large rivers – could not integrate over time for very large events as the duration of the runoff response lasted over many days and samples were collected during the event.)