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Nutrient Load Estimation and Reporting

Loading Calculations Technical Symposium

NOAA GLIER, Ann Arbor

Alice Dove and Sean Backus

Water Quality Monitoring & Surveillance

Isaac Wong and Phil Fong

Watershed Hydrology and Ecosystem Research Division

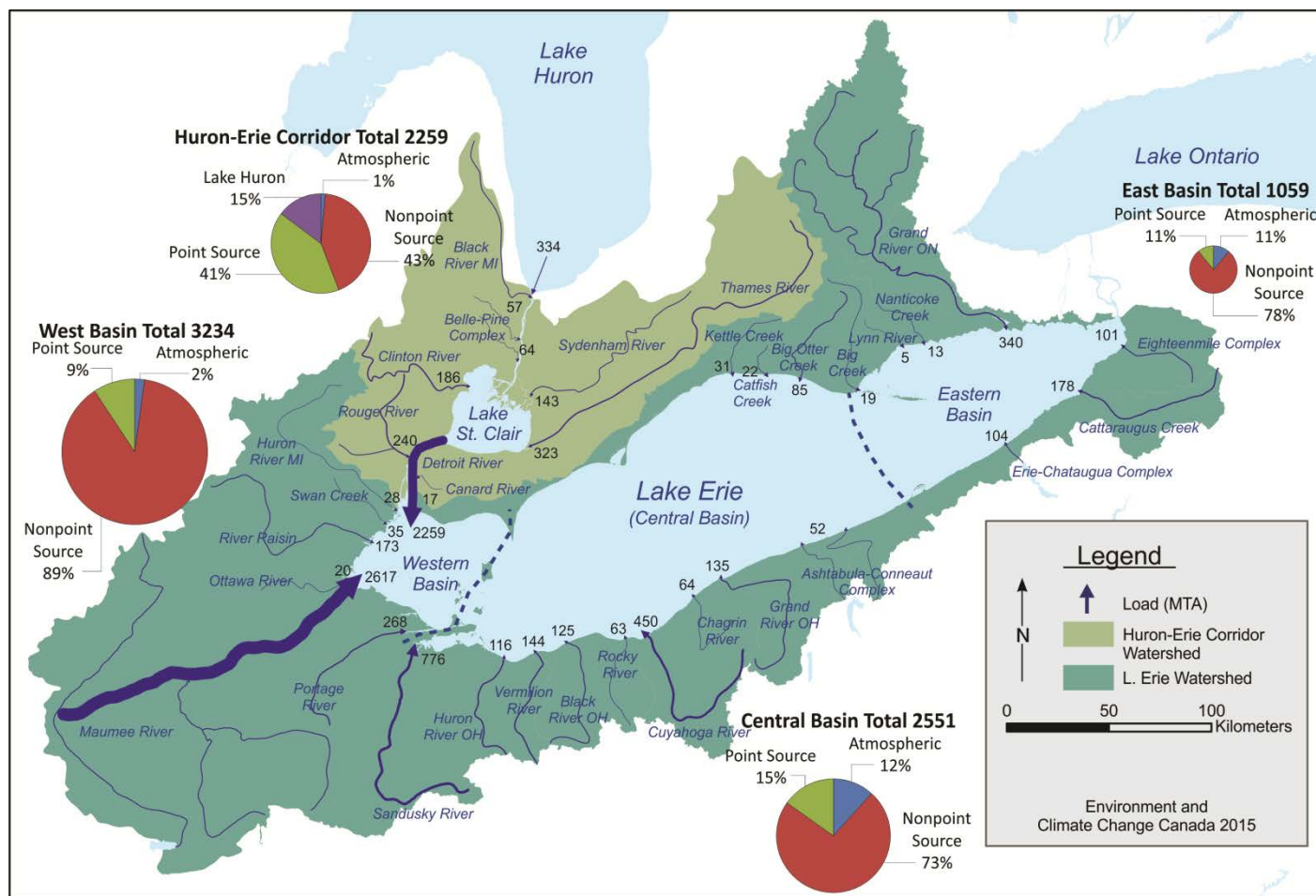
April 6, 2017

Contents

- Whole Lake Loads
- Tributary Monitoring
 - Sampling Methods and Load Estimation Methods
- Connecting Channel Monitoring
 - Unique opportunity to validate corridor estimates
 - Overview of St. Clair, Detroit and Niagara Loads
- Loading Estimate Decision Support System



Mean TP Loads to Lake Erie, 2003-2013 (MTA)

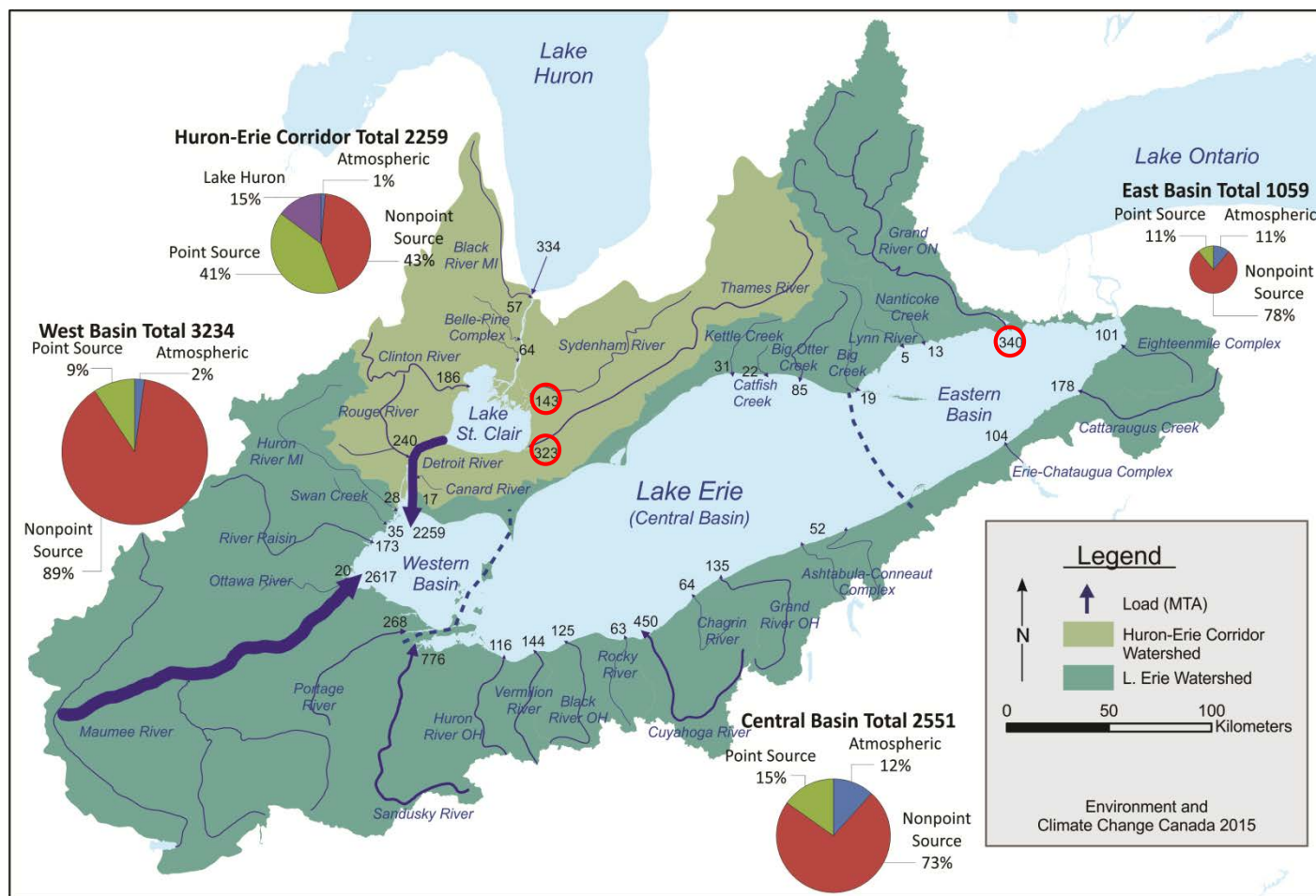


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Mean TP Loads to Lake Erie, 2003-2013 (MTA)



Tributary Sampling Approach



Field Program:

- Year-round, including the critical winter and early spring times
- Emphasis on rain and snow events plus low flow
- At automated sites:
 - Samples taken every 8 hours
 - On-site refrigeration
 - Samples are collected weekly
 - Retrospective analysis of the hydrograph for sample selection to target runoff events

- Total phosphorus
- Total dissolved phosphorus
- Soluble reactive phosphorus**
- Total suspended solids

- Major ions: Cl, F, SO₄
- Total Kjeldahl nitrogen
- Ammonia**
- Nitrate plus nitrite**



All Season Stations



Grand River

Thames River



In-River Pumps



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Flow-Through for ISCO and Sonde



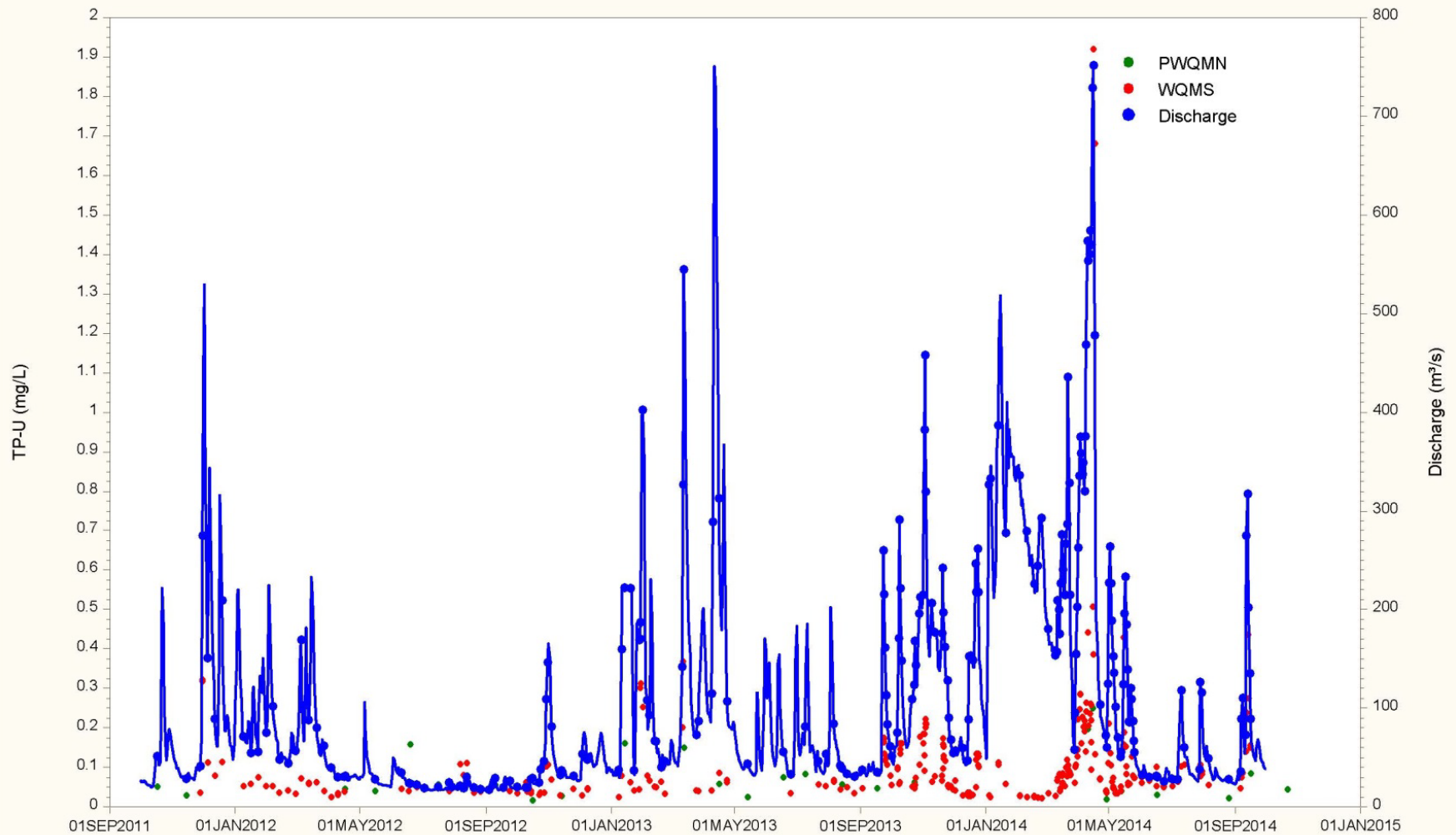
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Samples Achieved

Grand River At York - Phosphorus Total Unfiltered



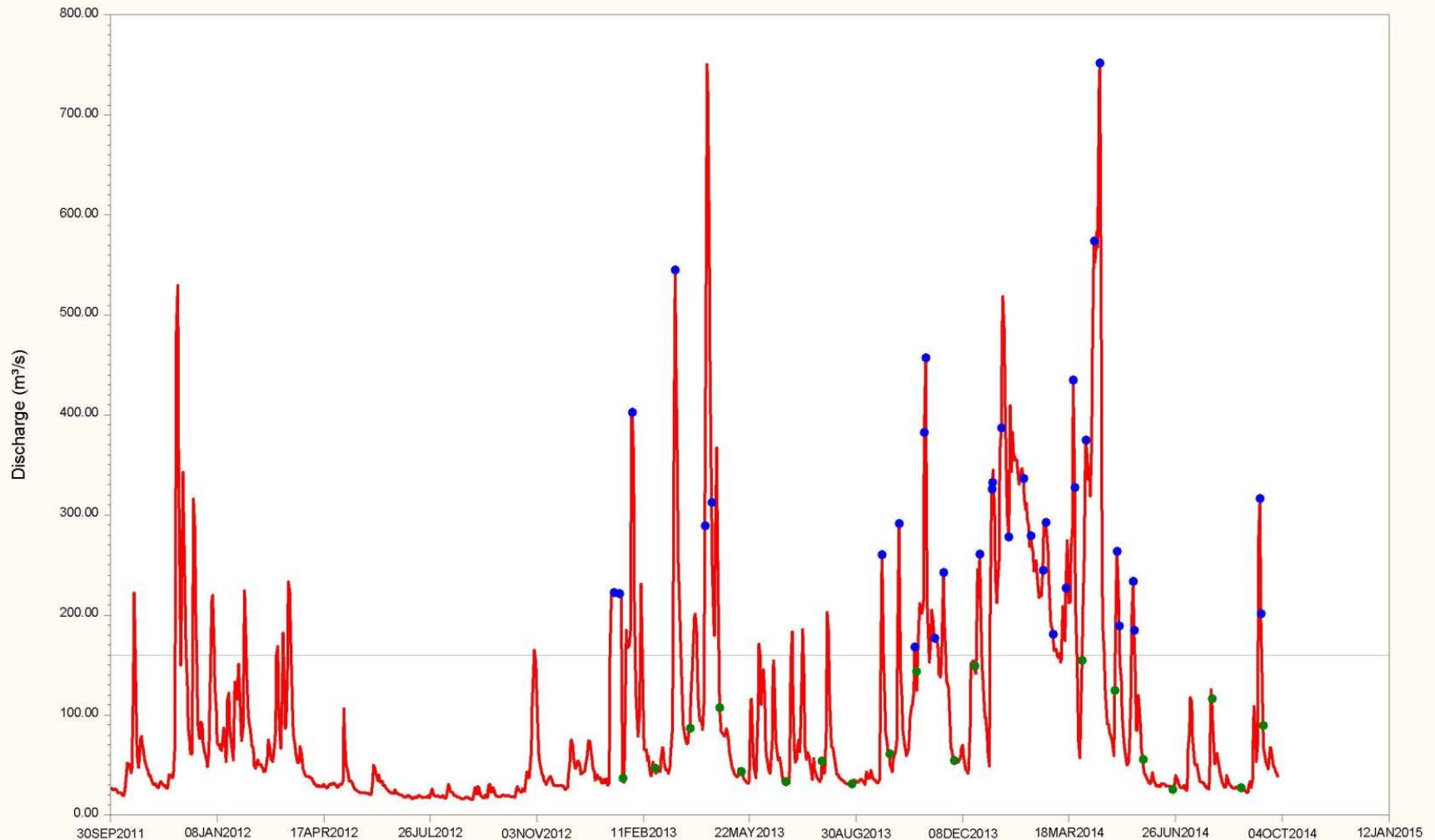
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Sufficient Samples?

Grand River At York



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Sample Selection Protocol

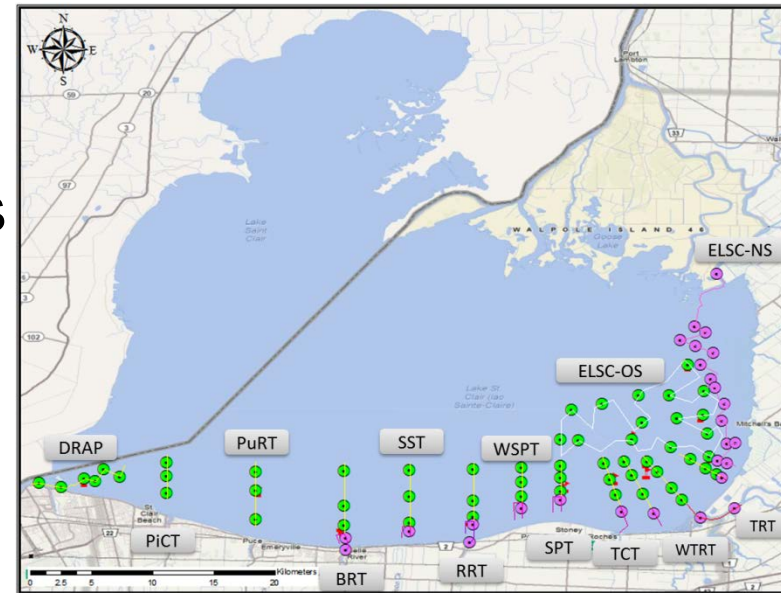
Example - Thames River at Thamesville:

- For runoff events $>200 \text{ m}^3/\text{s}$ – three samples will be analyzed (rising limb, peak, falling limb)
- For runoff events $>100 \text{ m}^3/\text{s}$ up to $200 \text{ m}^3/\text{s}$ – two samples will be analyzed (rising limb, peak)
- For runoff events $>80 \text{ m}^3/\text{s}$ up to $100 \text{ m}^3/\text{s}$ – one sample will be analyzed (peak)
- If no runoff events (flow $<80 \text{ m}^3/\text{s}$) – one sample will be analyzed every two weeks (most recent sample)
- One sample on each day of Lake St. Clair survey

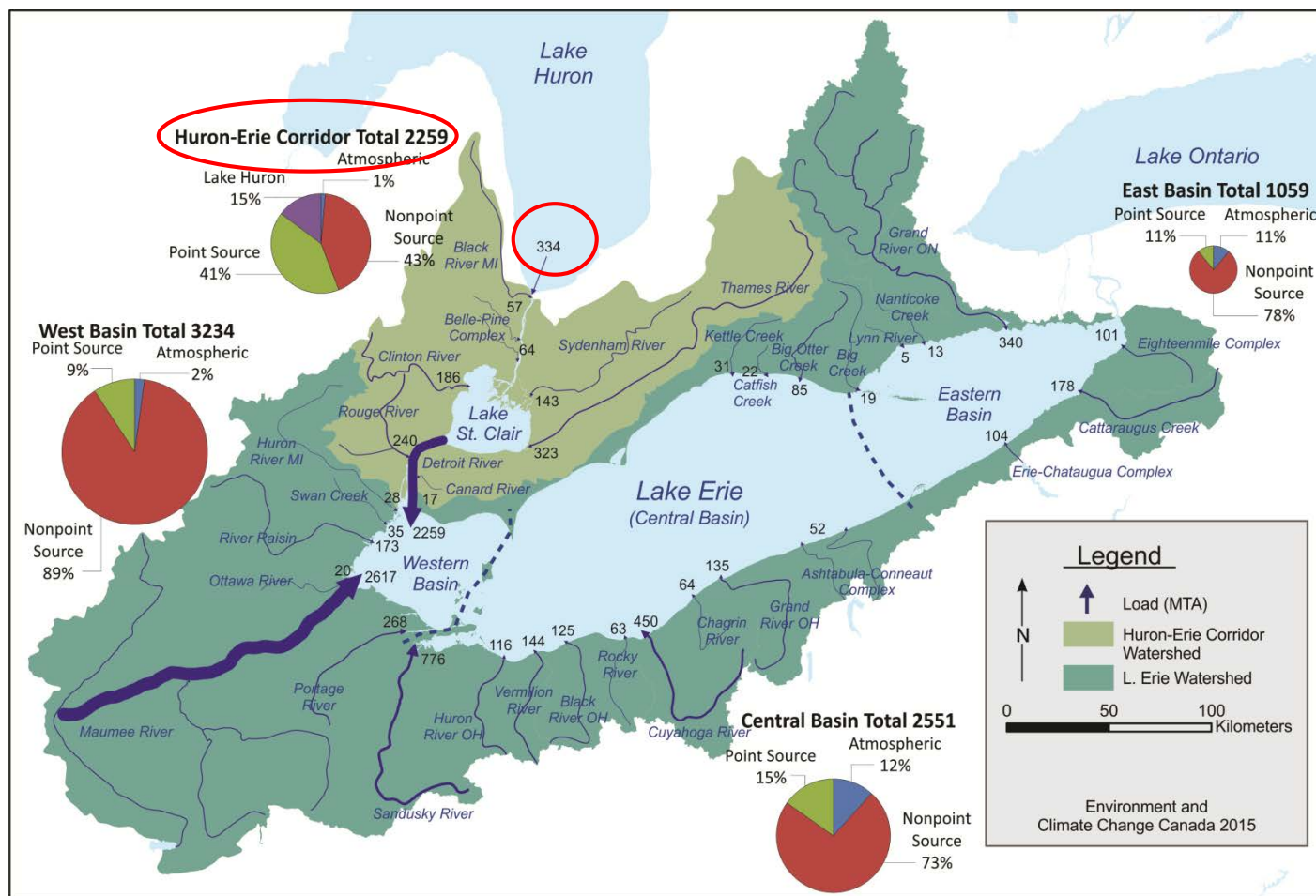


Current Activities – St. Clair Detroit Corridor

- Ongoing St. Clair River monitoring with enhancements
 - Increased frequency, SRP monitoring
- Ongoing Detroit River monitoring on the Canadian side *ONLY*
- Publication: *Nutrient Concentrations and Loadings from the St. Clair River (2001-2015) and the Detroit River (2014-2015)*
Debbie Burniston, Alice Dove, Sean Backus
- Thames River and Sydenham River monitoring for loadings
- Nested monitoring in the Thames River watershed - 12 locations
- Collaborative monitoring in Lake St. Clair with MOECC



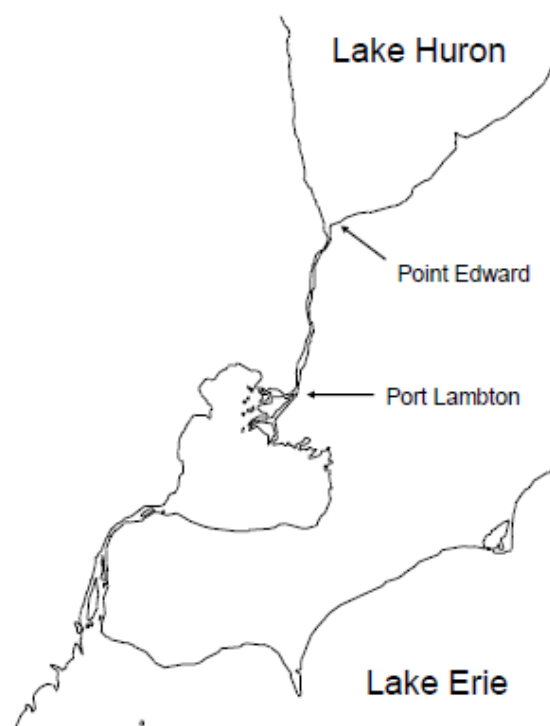
Mean TP Loads to Lake Erie, 2003-2013 (MTA)



St. Clair River Upstream-Downstream Program

Year-round (all season) monitoring

- Every 2 weeks from 2001 – 2012
- Every 4 weeks 2012 to present

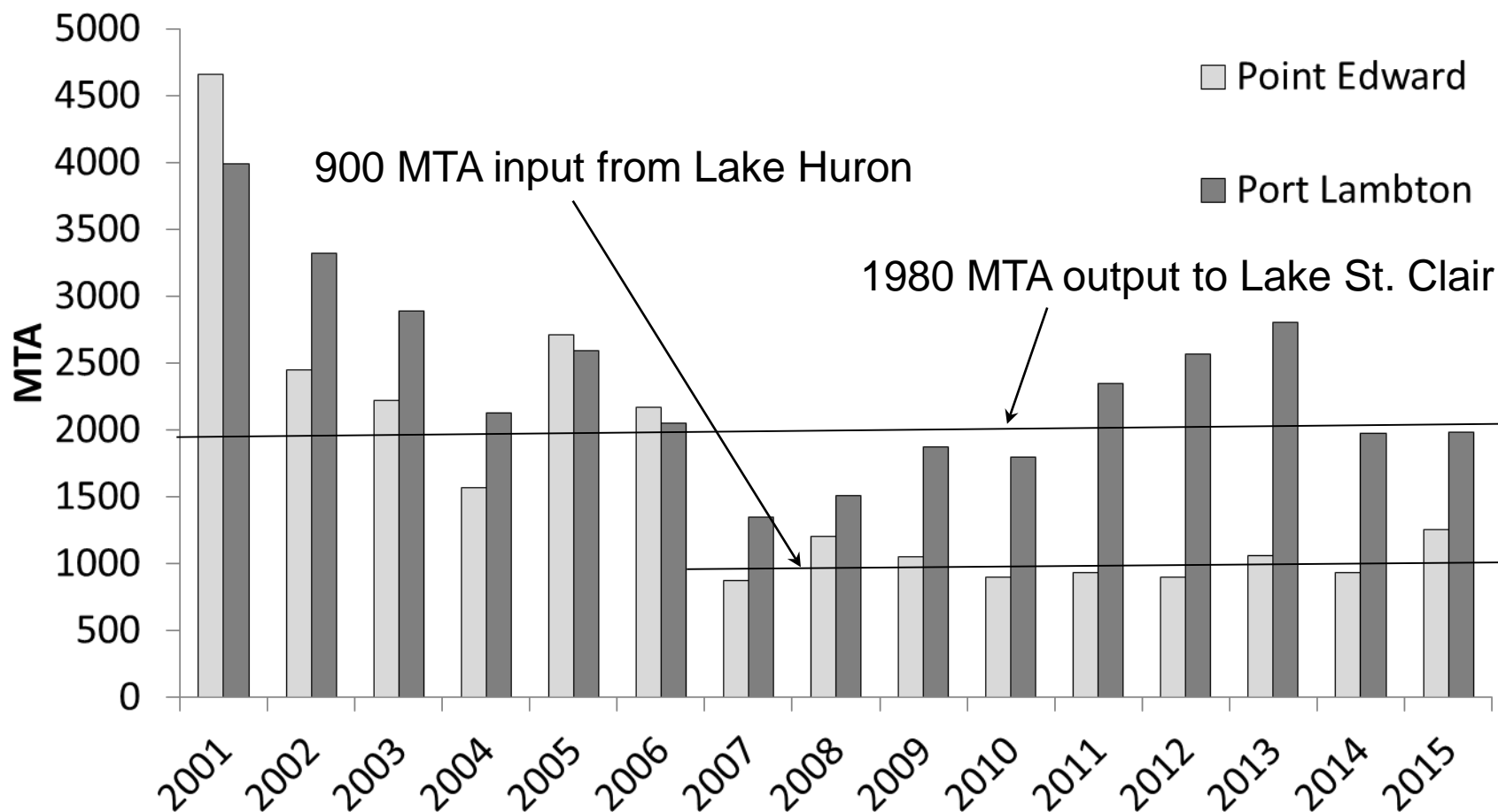


Nutrients (TP, TDP, $\text{NO}_3 + \text{NO}_2$, TN, TDN, NH_3)
Major Ions (Ca, Cl, Mg, K, Na, SO_4 , SiO_2)
Organic Contaminants
Trace Metals

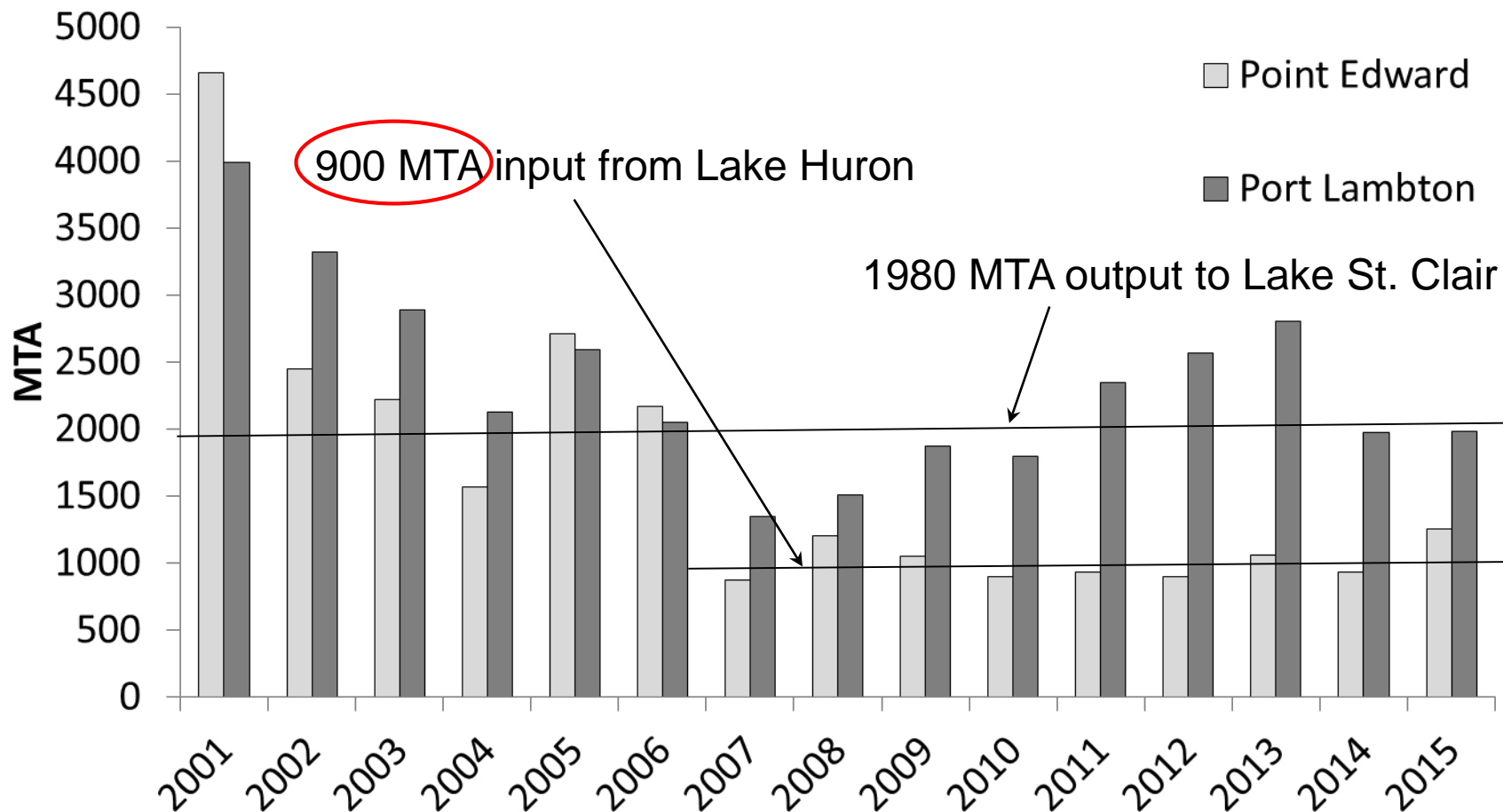
} In water and
suspended sediment



Total Phosphorus Loads - LOADEST



Total Phosphorus Loads - LOADEST



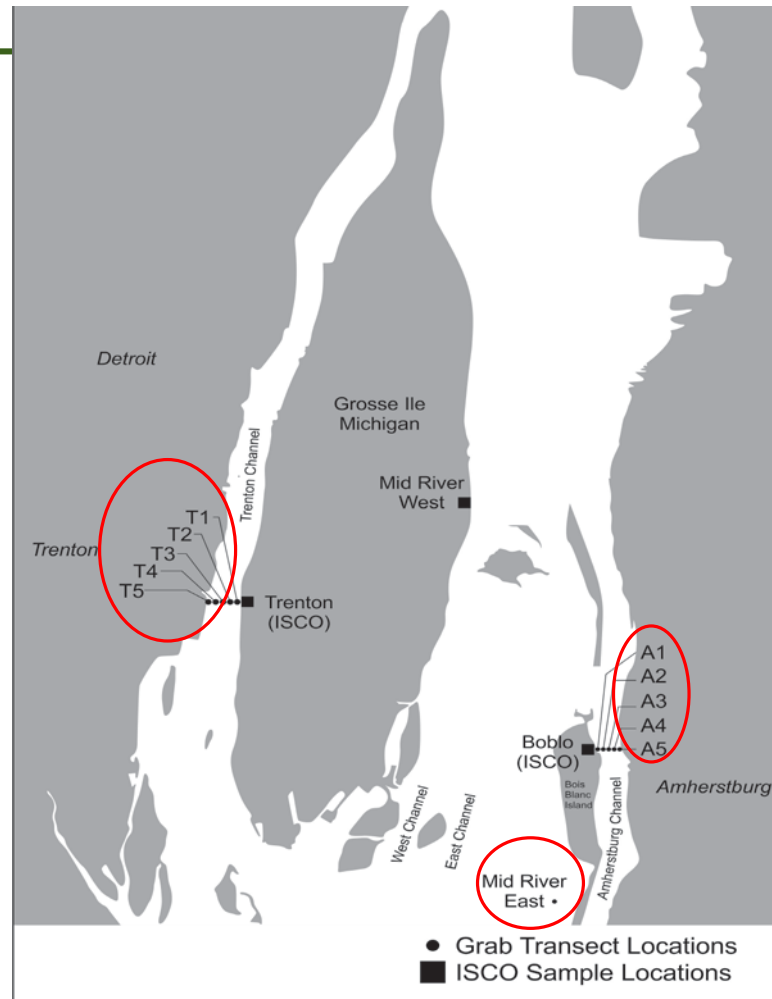
Detroit River 2014 and 2015 (2004 and 2007)



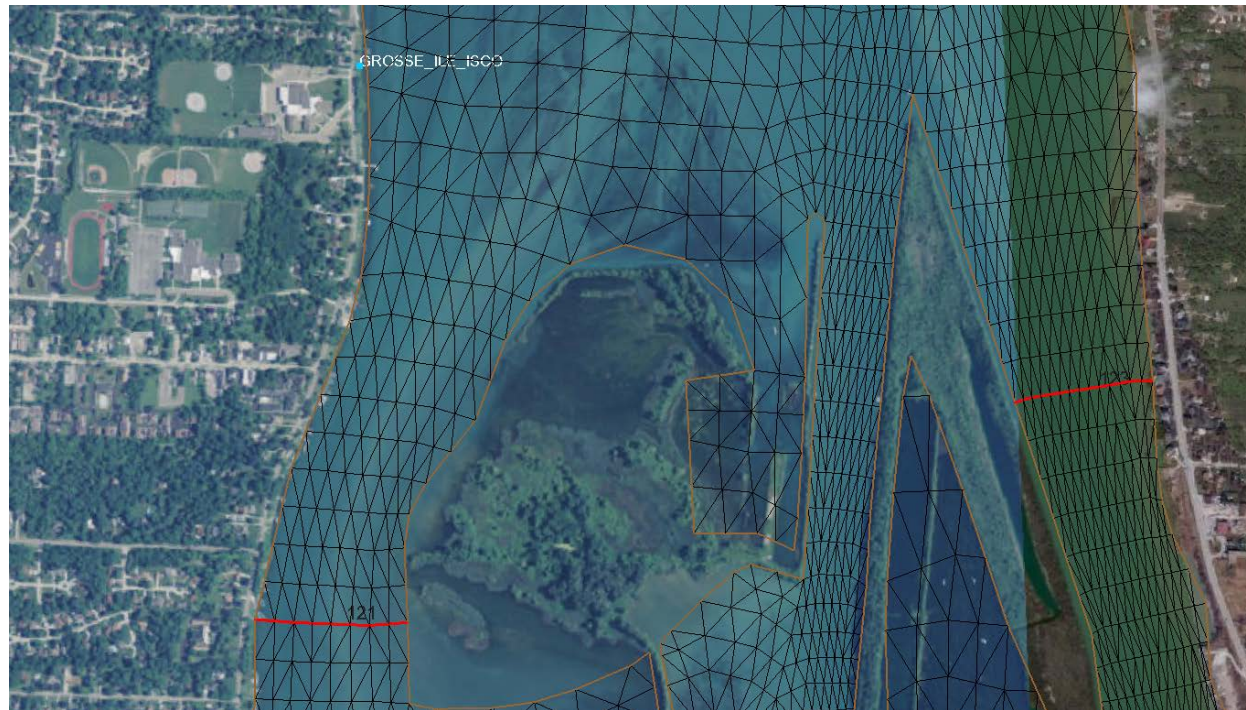
Detroit River 2014 and 2015 (2004 and 2007)



Detroit River 2014 and 2015 (2004 and 2007)



Hydrosim 2d and Dispersim 2d Model



Boundary Waters Issues, Meteorological Survey of Canada



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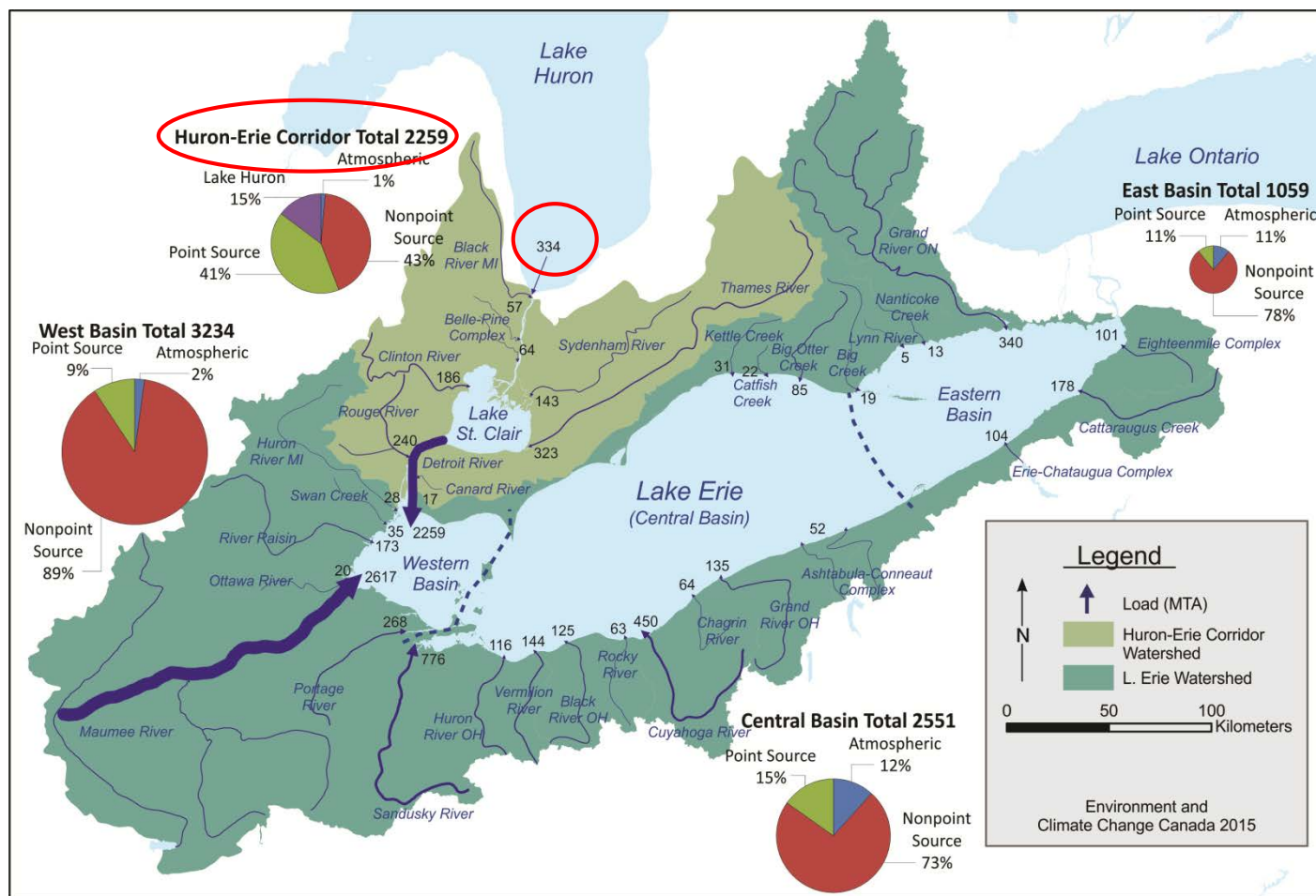
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Corridor Total Phosphorus Loads

Water year, MTA	2007	2014	2015
Lake Huron	877	933	1250
St. Clair River	1350	1970	1980
Trenton Channel	2000-2500	718	584
Mid River	810	1580	837
Amherstburg Channel	870-1010	1250	1190
Total Load, Detroit River	3680-4320	3550	2610



Mean TP Loads to Lake Erie, 2003-2013 (MTA)



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2859

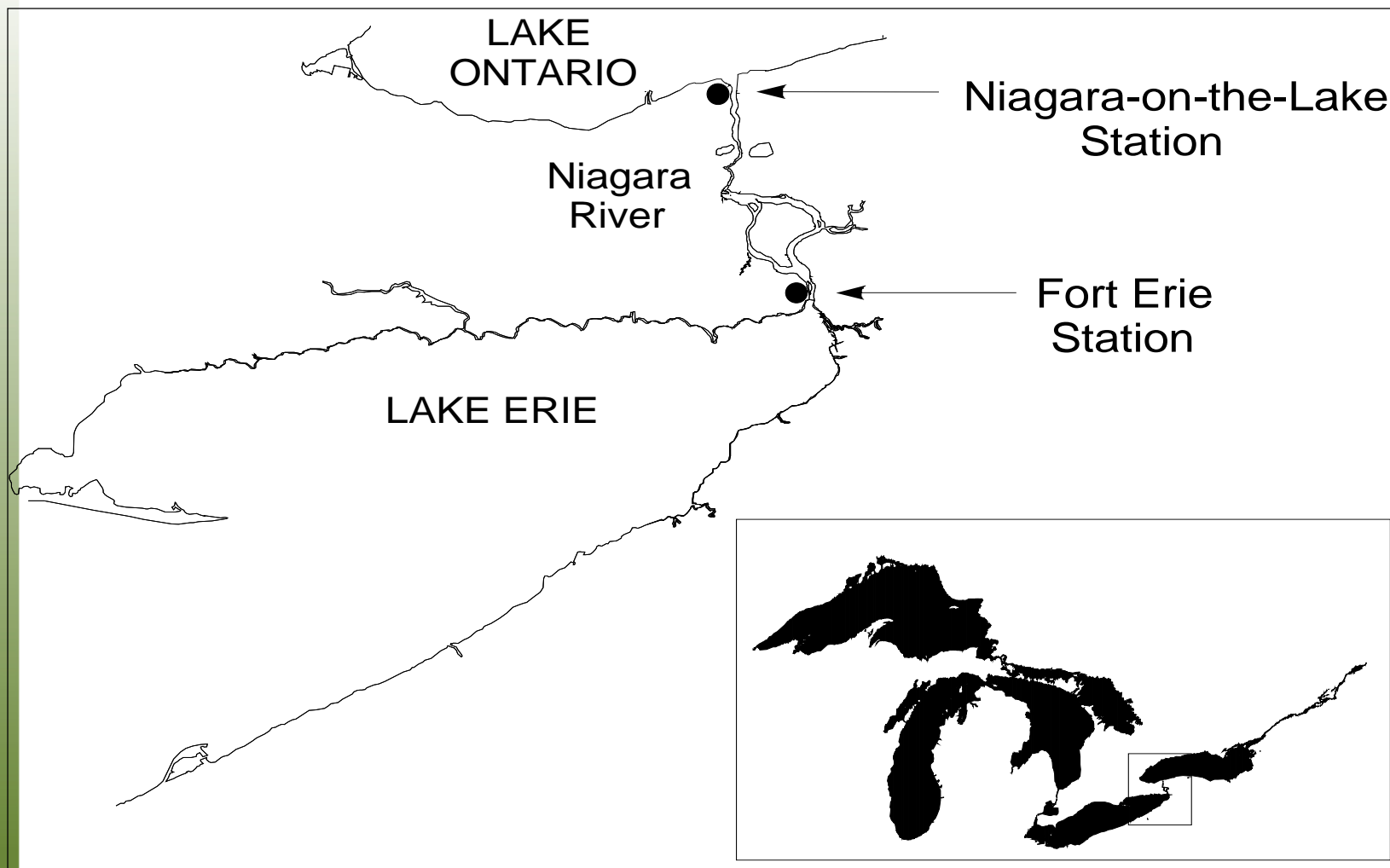


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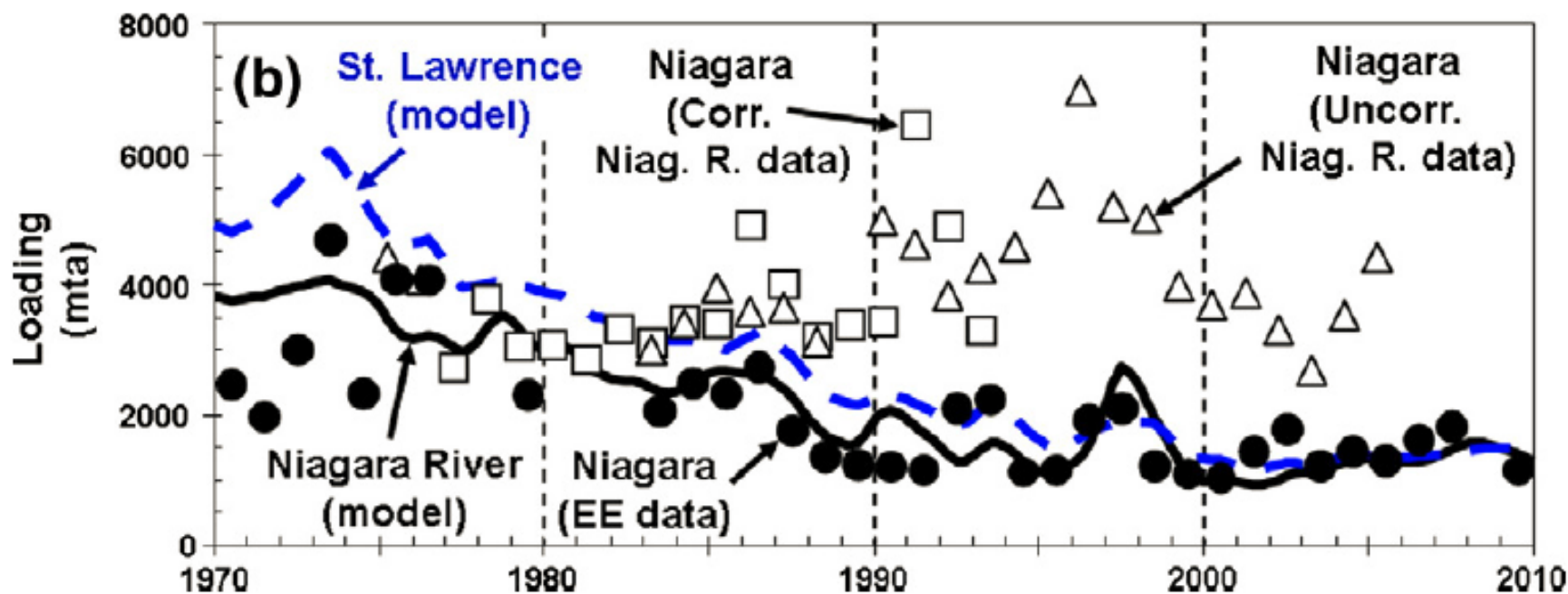
Canada

Niagara River Upstream-Downstream

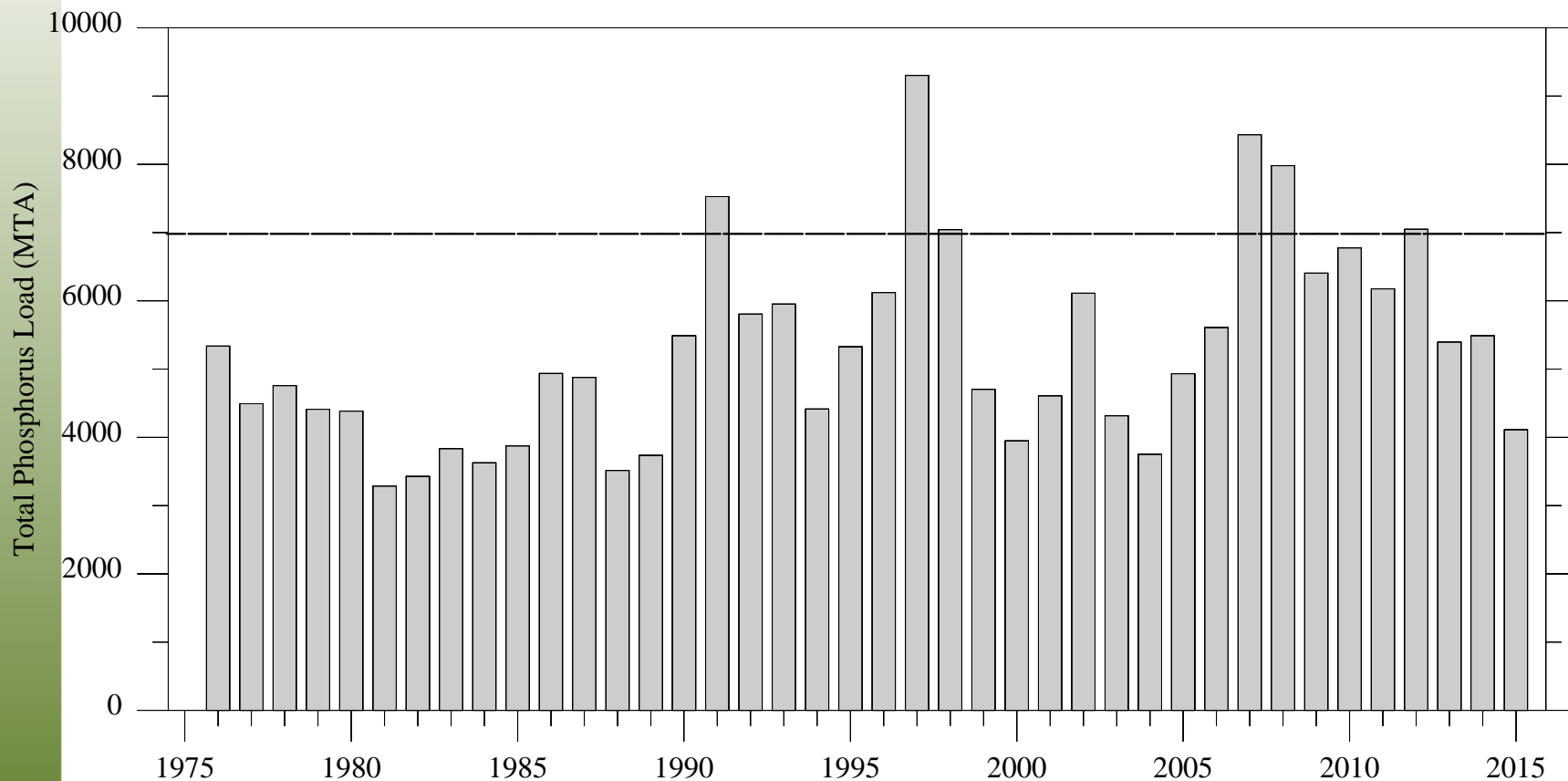


What we thought we knew

S.C. Chapra, D.M. Dolan / Journal of Great Lakes Research 38 (2012) 741–754



Total Phosphorus Loads at Niagara-on-the-Lake



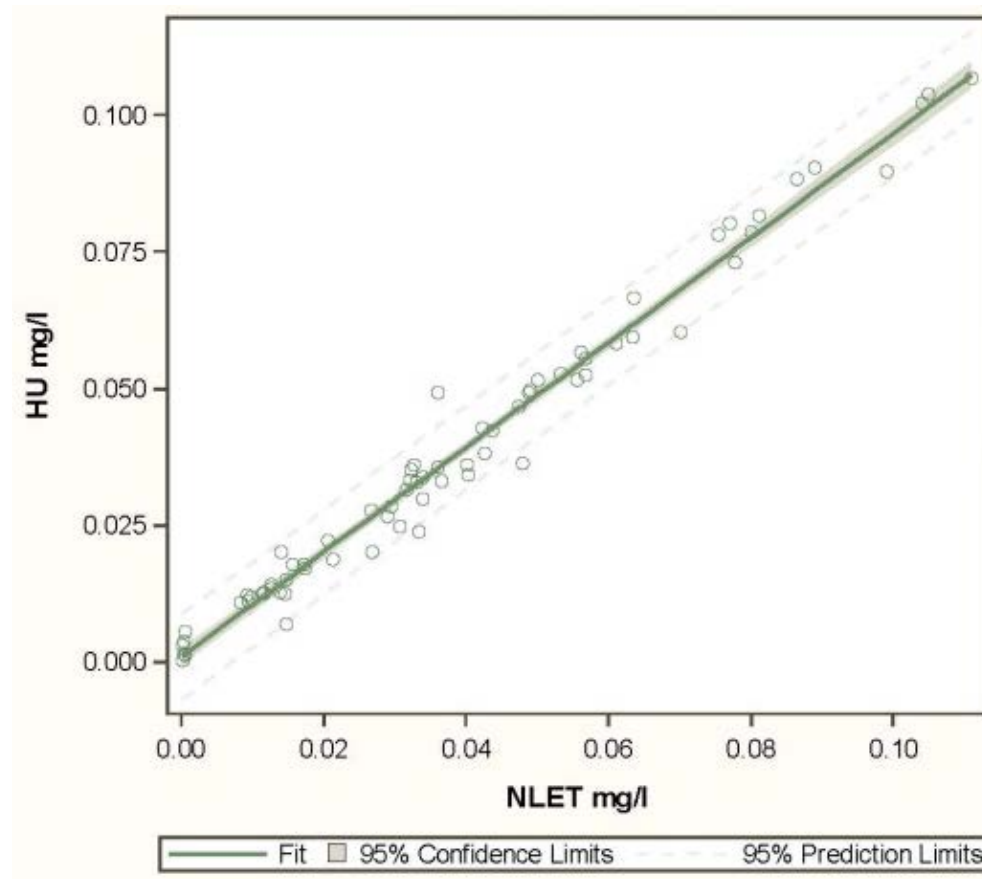
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Interlaboratory Comparison Heidelberg University and ECCCC NLET

SRP



Loading Estimate Decision Support System

- Collaborative Project between Water Quality Monitoring and Research Divisions
- Purpose: an updated, more highly automated tool to estimate annual TP and SRP loadings using Dolan Method
 - Monitored tributaries, unmonitored watershed areas, point sources (municipal and industrial), atmospheric deposition, upstream Great Lakes (i.e. Lake Huron)
 - Loadings calculated on a water year basis
 - Standard errors are provided for each estimate
- Project timeline:
 - April 2016: Start project
 - June 2016: Receive data files for Lake Erie loads
 - July 2016: Develop system design of loading estimate decision support system
 - September 2016: Began implementation of Dolan Method in decision support system (DSS)
 - March 2017 - present: In process of beta testing, bug fixing and verifying results

Maccoux, M.J., Dove, A., Backus, S.M., Dolan, D.M., 2016. Total and soluble reactive phosphorus loadings to Lake Erie, J. Great Lakes Res., <http://dx.doi.org/10.1016/j.jglr.2016.08.005>



Loading Estimate Decision Support System (DSS) Overview

- Initial beta implementation of Dolan Method
- DSS is a Windows application with a graphical user interface
- Input data (tributary flows and concentrations, point source effluent, atmospheric deposition, etc.) are stored in multiple csv-formatted text files
 - Data import function for point source data
- A “project” file is used to organize data and information
- Output results are saved in multiple csv-formatted text files
- Some input data and outputs are viewable within the DSS, others require external application (e.g., Excel)
 - Graphs generated by R software with EGRET library (Exploration and Graphics for RivEr Trends) from USGS



Data Sources (for Lake Erie Loadings)

Data	Agency
Tributary Flow	<u>Canada</u> Water Survey of Canada (Environment and Climate Change Canada)
	<u>U.S.</u> Water Resources Division (U.S. Geological Service)
Tributary Water Quality	<u>Canada</u> Water Quality and Monitoring and Surveillance Division (Environment and Climate Change Canada) Provincial Water Quality Monitoring Network (Ontario Ministry of Environment and Climate Change)
	<u>U.S.</u> National Center for Water Quality Research (Heidelberg University) Water Resources Division (Michigan Department of Environmental Quality) Division of Surface Water (Ohio Environmental Protection Agency) STORET (U.S. Environmental Protection Agency) Water Resources Division (U.S. Geological Survey)
Point Source	<u>Canada</u> MISA (Ontario Ministry of Environment and Climate Change)
	<u>U.S.</u> Water Division-PCS/ICIS (U.S. Environment Protection Agency)
Atmospheric Deposition	<u>Canada</u> Water Quality and Monitoring and Surveillance Division (Environment and Climate Change Canada)

Loading Estimate Decision Support System Project File

Project File: general information for tributary

Tributaries	Basin	Country	Watershed Area (km2)
Black-MI	Huron-Erie Corridor	US	1800
Belle-Pine Complex	Huron-Erie Corridor	US	1550
Clinton	Huron-Erie Corridor	US	1901
Rouge	Huron-Erie Corridor	US	1890
Thames	Huron-Erie Corridor	CAN	5706
Sydenham	Huron-Erie Corridor	CAN	3038
Canard	Huron-Erie Corridor	CAN	347
Turkey	Huron-Erie Corridor	CAN	28

Example of tributary sections in project file

Concentration Data for Black-MI

Date	TP (mg/L)
21/10/2008	0.046
14/04/2009	0.035
15/06/2009	0.071
05/08/2009	0.059
06/10/2009	0.035
21/05/2010	0.076
19/07/2010	0.08
11/08/2010	0.055
12/10/2010	0.042
29/03/2011	0.06
20/06/2011	0.047
01/08/2011	0.059

Flow Data for Black-MI

DATE	Flow (cfs)
01/10/2008	449.4
02/10/2008	407.456
03/10/2008	331.058
04/10/2008	281.624
05/10/2008	229.194
06/10/2008	191.744
07/10/2008	164.78
08/10/2008	164.78
09/10/2008	187.25
10/10/2008	203.728
11/10/2008	185.752
12/10/2008	167.776
13/10/2008	142.31
14/10/2008	137.816
15/10/2008	130.326
16/10/2008	134.82
17/10/2008	146.804
18/10/2008	133.322
19/10/2008	127.33
20/10/2008	122.836
21/10/2008	115.346

Project File: monitored tributary data

	Parameter	Flow Data File	Concentration Data File	Loading Estimate Method
Mon Tributary Loads				
Black-MI	TP	Inputs\Black-MI flow.csv	Inputs\Black-MI TP.csv	Beale
Black-MI	SRP	Inputs\Black-MI flow.csv	Inputs\Black-MI SRP.csv	Beale
Clinton	TP	Inputs\Clinton flow.csv	Inputs\Clinton TP.csv	Beale
Clinton	SRP	Inputs\Clinton flow.csv	Inputs\Clinton SRP.csv	Beale
Rouge	TP	Inputs\Rouge flow.csv	Inputs\Rouge TP.csv	Beale
Rouge	SRP	Inputs\Rouge flow.csv	Inputs\Rouge SRP.csv	Beale
Huron-MI	TP	Inputs\Huron-MI flow.csv	Inputs\Huron-MI TP.csv	Beale
Huron-MI	SRP	Inputs\Huron-MI flow.csv	Inputs\Huron-MI SRP.csv	Beale

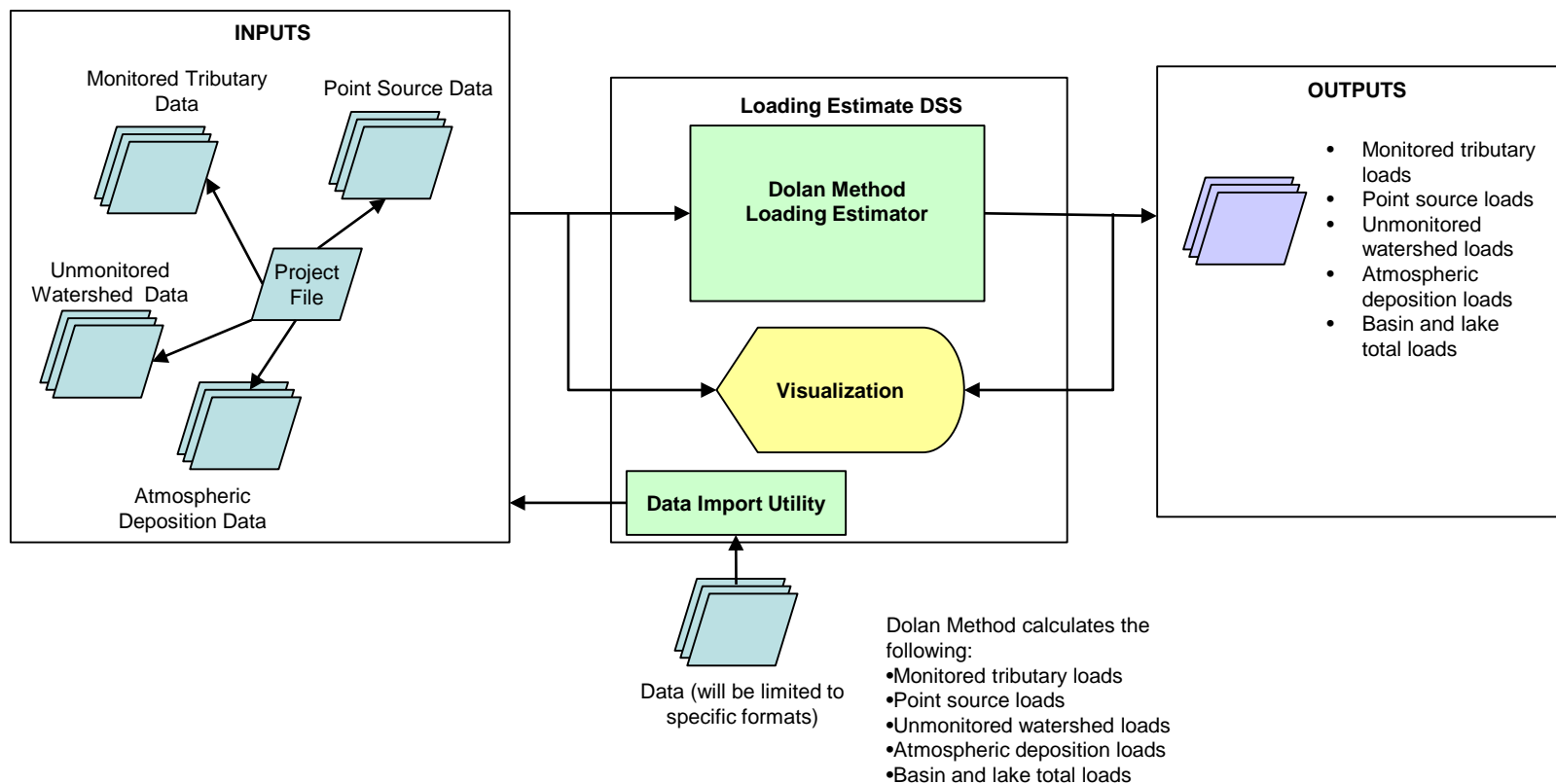


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Loading Estimate Decision Support System Schematic Diagram



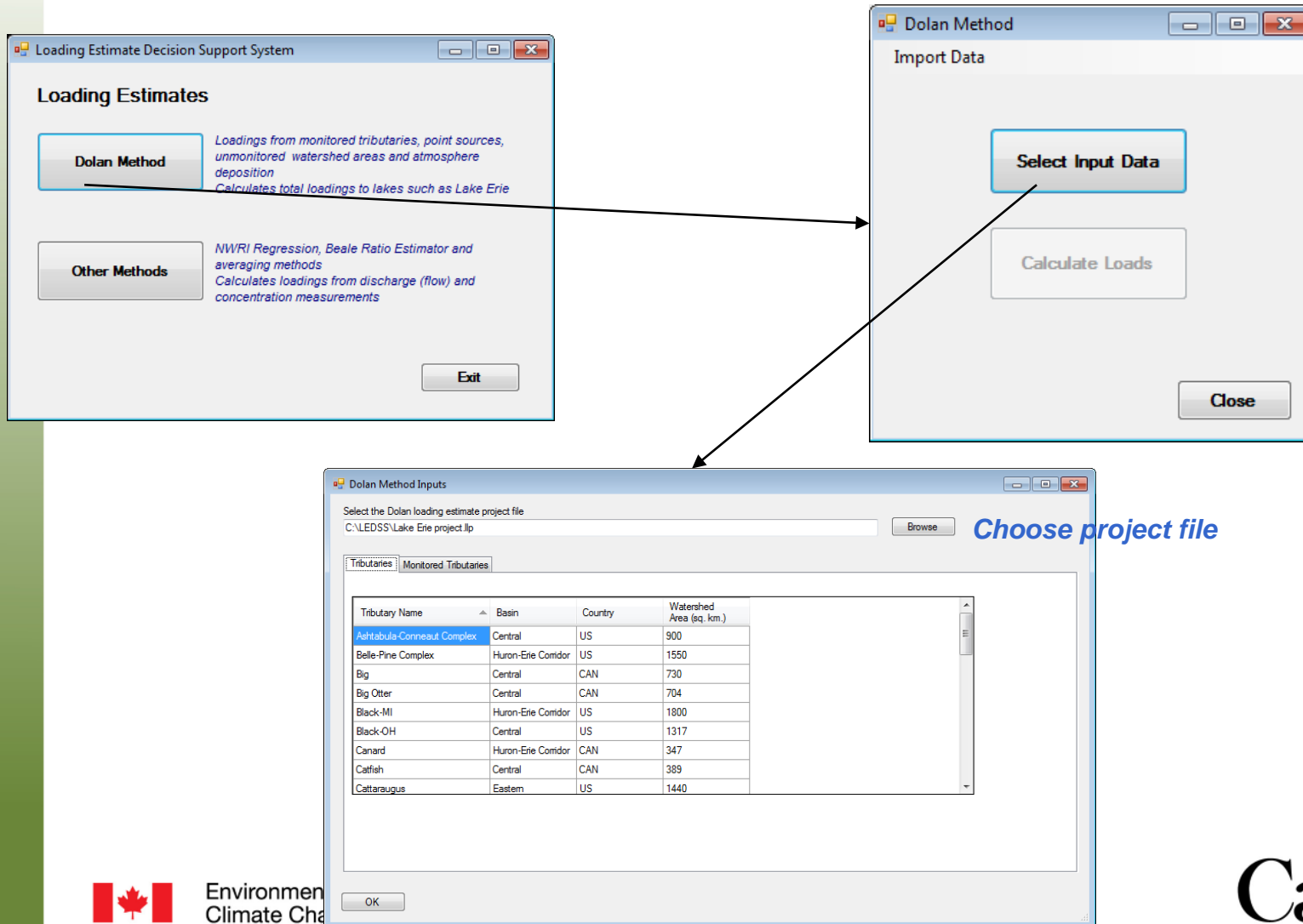
Loading Estimate Decision Support System

Current Status

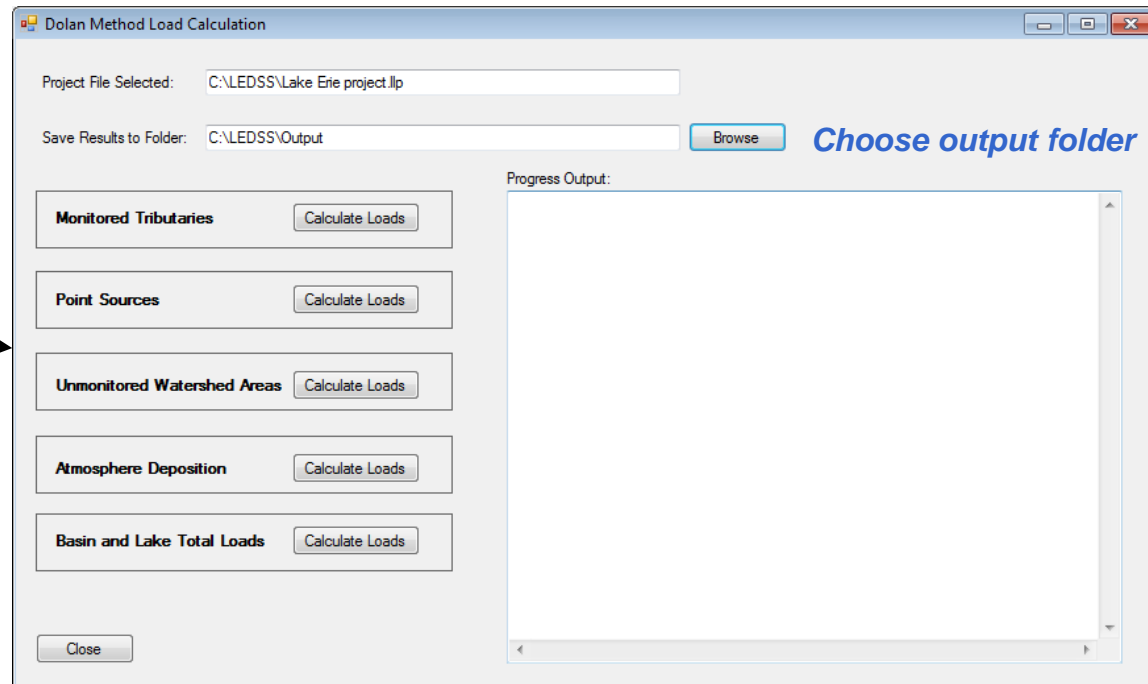
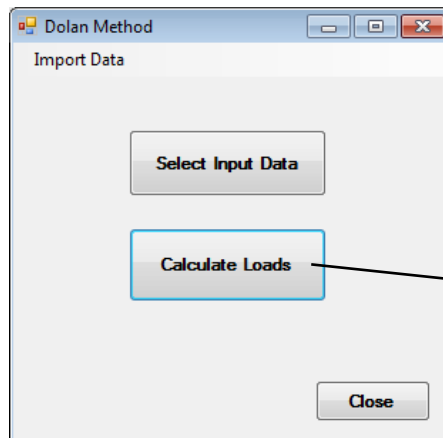
- Implemented loading calculations for:
 - monitored tributaries (Stratified Beale Ratio Estimator, Heidelberg data)
 - unmonitored watershed areas
 - point sources
 - atmospheric deposition
 - basin, country and lake totals
- In the process of beta testing, bug fixing and verifying results



Loading Estimate Decision Support System Demo



Loading Estimate Decision Support System Demo



Loading Estimate Decision Support System Monitored Tributaries (Stratified Beale Ratio)

Inputs — Program Execution — Outputs

Grand-ON flow data

Original data file

DATE	A	B	C	D	E
01/01/1993	228	19.6	12.9	322	
02/01/1993	332	15.9	11.8	240.64	
03/01/1993	111	13.2	10.3	186.2	
04/01/1993	201	20.6	12.9	308.2	
05/01/1993	653	56	25.3	913.16	
06/01/1993	667	63.2	26.9	955.32	
07/01/1993	413	37.6	19.7	590.36	
08/01/1993	266	19	12.1	365.52	
09/01/1993	206	10.1	6.7	259.76	
10/01/1993	170	8.11	4.08	200.008	
11/01/1993	247	7.4	3.33	181.336	
12/01/1993	138	6.52	2.79	159.792	
13/01/1993	112	6.23	2.46	139.808	

convert

csv file for DSS

```
DATE,Flow (m3/s)
01/01/1993,322
02/01/1993,240.64
03/01/1993,186.2
04/01/1993,308.2
05/01/1993,913.16
06/01/1993,955.32
07/01/1993,590.36
08/01/1993,365.52
09/01/1993,259.76
10/01/1993,200.008
11/01/1993,181.336
12/01/1993,159.792
13/01/1993,139.808
```

Grand-ON concentration data

Original data file

DATE	A	B	C	D	E	F
10/11/2008	2.77	0.74	0.004	0.057		
09/12/2008	4.2	0.84	0.0275	0.045		
10/02/2009	3.59	1.28	0.0544	0.087		
16/02/2009	2.78	1.1	0.087	0.193		
30/03/2009	3.3	1.07	0.0175	0.073		
21/04/2009	3.04	0.66	0.0038	0.054		
31/05/2009	3.19	0.9	0.0034	0.094		
28/06/2009	1.9	0.93	0.0096	0.091		
27/07/2009	2	0.67	0.0087	0.072		
11/08/2009	1.33	0.91	0.0025	0.09		
20/09/2009	1.78	0.77	0.004	0.066		
18/10/2009	2.42	0.75	0.0051	0.037		

convert

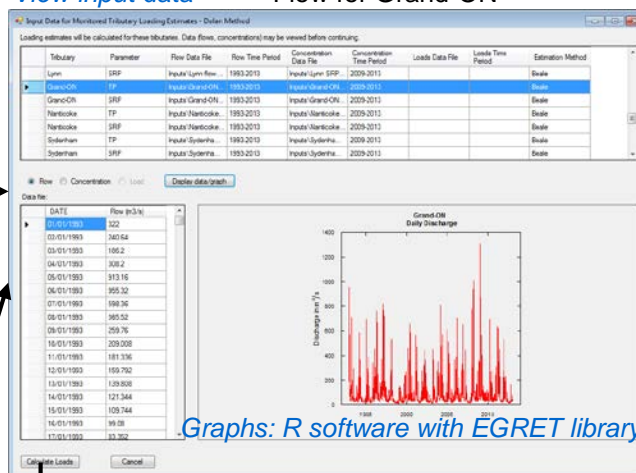
csv file for DSS

TP

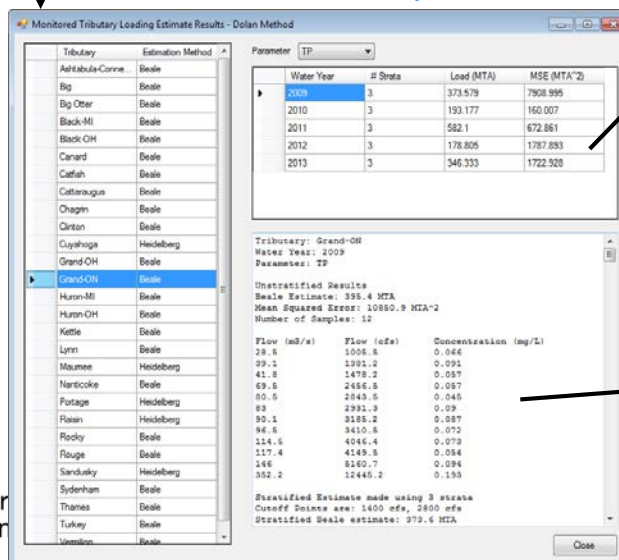
```
Date,TP (mg/L)
13/10/2008,0.057
09/12/2008,0.045
10/02/2009,0.087
16/02/2009,0.193
30/03/2009,0.073
21/04/2009,0.054
31/05/2009,0.094
28/06/2009,0.091
27/07/2009,0.072
11/08/2009,0.09
20/09/2009,0.066
18/10/2009,0.037
```

View input data

Flow for Grand-ON



Calculate monitored tributary loads and view results



Annual loads for tributaries (csv file)

```
Monitored Tributary loads.csv - Notepad
Tributary,Parameter,Water Year,#Strata,Loading (MTA),MSE (MTA^2),
Grand-ON,TP,2009,3,373.579,7908.995,
Grand-ON,TP,2010,3,193.177,160.007,
Grand-ON,TP,2011,3,582.1,672.861,
Grand-ON,TP,2012,3,178.805,1787.893,
Grand-ON,TP,2013,3,346.333,1722.928,
```

Grand-ON

Details of results (free form text file)

```
Grand-ON TP.txt - Notepad
Tributary: Grand-ON
Water Year: 2009
Parameter: TP

Unstratified Results
Beale Estimate: 395.4 MTA
Mean Squared Error: 10850.9 MTA^2
Number of Samples: 12

Flow (m3/s) Flow (cfs) Concentration (mg/L)
28.5 1005.5 0.066
39.1 1381.2 0.091
41.8 1478.2 0.057
69.5 2456.5 0.057
80.5 2843.5 0.045
83 2931.3 0.09
98.1 3185.2 0.087
96.5 3410.5 0.072
114.5 4046.4 0.073
117.4 4149.5 0.054
146 5160.7 0.094
352.2 12445.2 0.193

Stratified Estimate made using 3 strata
Cutoff Points are: 1400 cfs, 2800 cfs
Stratified Beale estimate: 373.6 MTA
Mean Squared Error for Stratified Estimate: 7909 MTA^2
```



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Loading Estimate Decision Support System Monitored Tributaries (Heidelberg)

Inputs — Program Execution — Outputs

Original data file

Maumee daily loads

Maumee loads_updated to WY2013.xlsx

	A	B	C	D	E	F	G	H	I
	Date	Month	Date 2	Maumee discharge (million cubic meters)	Maumee SS Load (tonnes)	Maumee TP Load (tonnes)	TP Remark	Maumee SRP Load (tonnes)	
12421	10/01/2008	418	Oct-2008	0.861	21.3	0.109		0.004	
12422	10/02/2008	418	Oct-2008	0.651	16.0	0.071		0.004	
12423	10/03/2008	418	Oct-2008	0.487	8.6	0.043		0.002	
12424	10/04/2008	418	Oct-2008	0.619	10.8	0.051		0.002	
12425	10/05/2008	418	Oct-2008	0.663	12.4	0.055		0.002	
12426	10/06/2008	418	Oct-2008	0.587	17.9	0.061		0.004	
12427	10/07/2008	418	Oct-2008	0.565	15.2	0.055		0.005	
12428	10/08/2008	418	Oct-2008	0.817	16.0	0.076		0.007	
12429	10/09/2008	418	Oct-2008	0.810	16.7	0.082		0.005	
12430	10/10/2008	418	Oct-2008	0.568	9.8	0.046		0.002	
12431	10/11/2008	418	Oct-2008	0.553	15.2	0.060		0.002	
12432	10/12/2008	418	Oct-2008	0.710	19.9	0.087		0.003	
12433	10/13/2008	418	Oct-2008	0.673	15.0	0.073		0.005	
12434	10/14/2008	418	Oct-2008	0.673	16.9	0.078		0.005	
12435	10/15/2008	418	Oct-2008	0.548	14.2	0.075		0.003	
12436	10/16/2008	418	Oct-2008	1.030	26.6	0.138		0.004	
12437	10/17/2008	418	Oct-2008	1.084	27.9	0.142		0.004	
12438	10/18/2008	418	Oct-2008	0.986	21.9	0.121		0.003	
12439	10/19/2008	418	Oct-2008	1.311	53.2	0.173		0.003	
12440	10/20/2008	418	Oct-2008	1.006	27.2	0.126		0.005	
12441	10/21/2008	418	Oct-2008	1.050	24.0	0.104		0.005	

convert

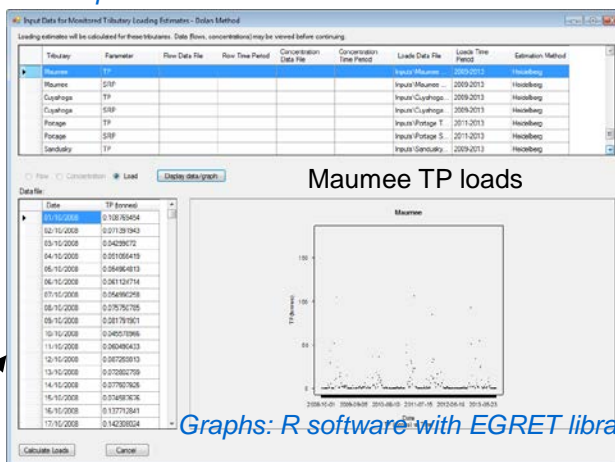
Maumee TP loads

Maumee TP loads.csv - Notepad

```
File Edit Format View Help
Date,TP (tonnes)
01/10/2008,0.108769454
02/10/2008,0.071391943
03/10/2008,0.04299072
04/10/2008,0.051066419
05/10/2008,0.054964813
06/10/2008,0.061124714
07/10/2008,0.054990258
08/10/2008,0.075750785
09/10/2008,0.081791901
10/10/2008,0.045578966
11/10/2008,0.060490433
12/10/2008,0.087269813
13/10/2008,0.072802799
14/10/2008,0.077507925
15/10/2008,0.074587676
16/10/2008,0.137712841
17/10/2008,0.142308024
18/10/2008,0.120880557
```

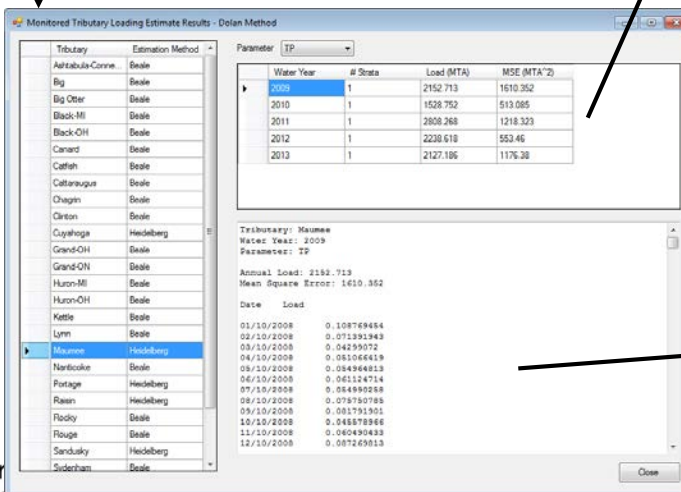
Data files converted into csv format using external program such as Excel

View input data



Graphs: R software with EGRET library

Sum up daily loads of monitored tributaries in water year and view results



Annual loads from tributaries (csv file)

Monitored Tributary loads.csv - Notepad

```
File Edit Format View Help
Tributary,Parameter,Water Year,#Strata,Loading (MTA),MSE (MTA^2)
.
.
.
Maumee,TP,2009,1,2152.713,1610.352,
Maumee,TP,2010,1,1528.752,513.085,
Maumee,TP,2011,1,2808.268,1218.323,
Maumee,TP,2012,1,2238.618,553.46,
Maumee,TP,2013,1,2127.186,1176.38,
.
.
.
```

Maumee

Details of results (free form text file)

Maumee TP.txt - Notepad

```
File Edit Format View Help
Tributary: Maumee
Water Year: 2009
Parameter: TP

Annual Load: 2152.713
Mean Square Error: 1610.352

Date Load
01/10/2008 0.108769454
02/10/2008 0.071391943
03/10/2008 0.04299072
04/10/2008 0.051066419
05/10/2008 0.054964813
06/10/2008 0.061124714
07/10/2008 0.054990258
08/10/2008 0.075750785
09/10/2008 0.081791901
10/10/2008 0.045578966
11/10/2008 0.060490433
12/10/2008 0.087269813
13/10/2008 0.072802799
14/10/2008 0.077507925
15/10/2008 0.074587676
```



Loading Estimate Decision Support System Point Sources

Inputs — Program Execution — Outputs

Point source effluents
(monthly average flows and concentrations or loads)

Original data file
(multiple facilities)

Industry: Sulco Chemicals Ltd.

convert

csv file for DSS
(multiple facilities)

Calculate point source loads and view results

Grand-ON TP loads

Annual loads from all point sources for
each tributary (csv file)

Grand-ON

Average daily loads at individual point
sources (csv file)

Sulco Chemicals

Function available in DSS to import point
source data into required csv format.

Loading Estimate Decision Support System Unmonitored Watershed Areas (Unit Area Load)



Annual loads for monitored tributaries
calculated by DSS

Black-MI TP loads

```
Monitored Tributary loads.csv - Notepad
File Edit Format View Help
Tributary,Parameter,Water Year,Estimate,Loading (MTA),MSE (MTA^2),
.
.
Black-MI,TP,2009,1,21.515,24.573,
Black-MI,TP,2010,1,10.787,1.78,
Black-MI,TP,2011,1,19.517,2.794,
Black-MI,TP,2012,2,21.331,17.429,
Black-MI,TP,2013,2,44.334,636.659,
.
.
```

Calculate unmonitored watershed area loads

Dolan Method Load Calculation

Project File Selected: C:\LEDSS\Lake Erie project.lp

Save Results to Folder: C:\LEDSS\Output

Monitored Tributaries [Calculate Loads]

Point Sources [Calculate Loads]

Unmonitored Watershed Areas [Calculate Loads]

Atmosphere Deposition [Calculate Loads]

Basin and Lake Total Loads [Calculate Loads]

Progress Output:

Unmonitored Tributary loading estimate
25/03/2017 10:51:07 PM

Project File: C:\LEDSS\Lake Erie project.lp

Calculating Black-MI
Monitored Tributary:
Parameter: TP
Results file: C:\LEDSS\Output\Unmonitored Tributary Loads.csv
Water Year: 2009,2010,2011,2012,2013.

Calculating Belle-Pine Complex
Monitored Tributary: Clinton
Parameter: TP
Results file: C:\LEDSS\Output\Unmonitored Tributary Loads.csv
Water Year: 2009,2010,2011,2012,2013.

Calculating Clinton
Monitored Tributary:
Parameter: TP
Results file: C:\LEDSS\Output\Unmonitored Tributary Loads.csv
Water Year:

Calculating Rouge
Monitored Tributary:

Annual loads for unmonitored watershed
areas (csv file)

```
Unmonitored Tributary Loads.csv - Notepad
File Edit Format View Help
Tributary, Parameter, Water Year, Loading (MTA), MSE (MTA^2), Country
.
.
Black-MI,TP,2009,9.234,6.894,
Black-MI,TP,2010,0.165,0.441,
Black-MI,TP,2011,4.935,0.683,
Black-MI,TP,2012,3.248,4.322,
Black-MI,TP,2013,12.078,157.894,
.
.
```

Black-MI

Annual loads from indirect point sources
calculated by DSS

TP point source loads for Black-MI

```
Point Source Outputs.csv - Notepad
File Edit Format View Help
Water Body,Parameter,Water Year,Indirect Municipal (MTA),SE,Indirect Industrial (MTA),SE,Indirect Municipal (P
.
.
Black-MI,TP,2009,7.545,6.887,1.631,8.429,,0.333,0.132,
Black-MI,TP,2011,8.445,6.351,1.042,8.237,,0.153,0.082,
Black-MI,TP,2009,8.755,6.382,1.081,8.133,,0.284,0.116,
Black-MI,TP,2012,12.568,8.188,2.244,8.282,,0.12,0.071,
Black-MI,TP,2013,18.820,8.387,0.246,8.833,,0.155,
.
.
```

Areas of monitored and unmonitored
watersheds



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Canada

Loading Estimate Decision Support System Atmospheric Deposition

Inputs — Program Execution — Outputs

Monthly precipitation volumes
and TP concentrations

Annual loads for basins (csv file)

Original data file Point Pelee

AE	C	D	E	F	G	H	I	J	R
1	Sample Number	ENV Project	ENV Station	Start Date	End Date	Days	volume L	A0073 MGL TP-PJF N015413 total phosphorus	
2									
3									
4									
5									
6									
180	200811461	OH0709	OH02GH0701	PE0101	01/02/09	02/02/09	31	1.056	0.0102
181	200812255	OH0709	OH02GH0701	PE0201	02/02/09	03/02/09	28	1.902	0.0057
182	200900513	OH0709	OH02GH0701	PE0301	03/02/09	04/01/09	30	3.092	0.0504
183	200901500	OH0709	OH02GH0701	PE0401	01/04/2009	01/05/2009	30	2.83	0.0714
184	200905247	OH0709	OH02GH0701	PE0501	01/05/2009	01/06/2009	31	1.343	0.0535
185	200906110	OH0709	OH02GH0701	PE0601	01/06/2009	01/07/2009	30	2.624	0.0093
186	200906365	OH0709	OH02GH0701	PE0701	01/07/2009	01/08/2009	31	0.829	0.0029
187	200907796	OH0709	OH02GH0701	PE0801	01/08/2009	01/09/2009	31	4.028	0.0094
188	200909948	OH0709	OH02GH0701	PE0901	01/09/2009	01/10/2009	30	1.36	0.014
189	200911344	OH0709	OH02GH0701	PE1001	01/10/2009	02/11/2009	32	1.608	0.0081
190	200912222	OH0709	OH02GH0701	PE1101	02/11/2009	30/11/2009	28	0.471	0.0104
191	200913476	OH0709	OH02GH0701	PE1201	30/11/2009	01/01/2010	32	2.468	0.0034
192	200914110	OH0709	OH02GH0701	PE1301	01/01/2010	01/02/2010	31	0.76	0.0049
193	200915004	OH0709	OH02GH0701	PE1401	01/02/2010	01/03/2010	28	1.283	0.0057

convert

csv file for DSS

Point Pelee

File	Edit	Format	View	Help
Year,Month,Volume (L),TP (mg/L)				
2009,1,1.056,0.0102				
2009,2,1.902,0.0057				
2009,3,3.092,0.0504				
2009,4,2.83,0.0714				
2009,5,1.343,0.0535				
2009,6,2.624,0.0093				
2009,7,0.829,0.0029				
2009,8,4.028,0.0094				
2009,9,1.36,0.014				
2009,10,1.608,0.0081				
2009,11,0.471,0.0104				
2009,12,2.468,0.0034				
2010,1,0.76,0.0049				
2010,2,1.253,0.0057				
2010,3,1.38,0.002				
2010,4,3.349,0.0129				
2010,5,3.159,0.0091				

Calculate atmospheric deposition loads

Dolan Method Load Calculation

Project File Selected: C:\LEDSS\Lake Erie project.lp

Save Results to Folder: C:\LEDSS\Output

Monitored Tributaries

Point Sources

Unmonitored Watershed Areas

Atmosphere Deposition

Basin and Lake Total Loads

Close

Progress Output:

Atmospheric load estimation
29/03/2017 10:32:26 PM

Project File: C:\LEDSS\Lake Erie project.lp

Calculating: Point Pelee
Data File: Input\Point Pelee-TP.csv
Parameter: TP
Water Years: 2009,2010,2011,2012,2013
Station Report: C:\LEDSS\Output\Point Pelee

Calculating: Rock Point
Data File: Input\Rock Point-TP.csv
Parameter: TP
Water Years: 2009,2010,2011,2012,2013
Station Report: C:\LEDSS\Output\Rock Point

Calculating: St. Clair
Data File: Input\St. Clair-TP.csv
Parameter: TP
Water Years: 2009,2010,2011,2012,2013
Station Report: C:\LEDSS\Output\St. Clair

Summary Output File: C:\LEDSS\Output\Atmosphere Loads-station.csv
Basin Summary File: C:\LEDSS\Output\Atmosphere Loads-Basin.csv Estimate Completed

File	Edit	Format	View	Help
Basin,Year,Parameter,Load (MTA), Std Error (MTA)				
.				
.				
Huron-Erie Corridor,2009,TP,41.229,36.11				
Huron-Erie Corridor,2010,TP,26.1,21.04				
Huron-Erie Corridor,2011,TP,34.787,21.532				
Huron-Erie Corridor,2012,TP,19.463,12.092				
Huron-Erie Corridor,2013,TP,35.641,35.391				
Western,2009,TP,89.037,53.066				
Western,2010,TP,56.365,30.918				
Western,2011,TP,75.125,31.643				
Western,2012,TP,42.031,17.769				
Western,2013,TP,76.97,52.009				
Central,2009,TP,372.303,108.511				
Central,2010,TP,235.684,63.224				
Central,2011,TP,314.127,64.705				
Central,2012,TP,175.75,36.335				
Central,2013,TP,321.843,106.351				
Eastern,2009,TP,148.765,68.592				
.				
.				

Lake Erie basins

Annual loads at monitoring stations (csv file)

File	Edit	Format	View	Help
Station,Year,Parameter,Load (MTA), Std Error (MTA^2), # Samples				
.				
.				
Point Pelee,2009,TP,222.529,92.36,11				
Point Pelee,2010,TP,80.653,24.461,12				
Point Pelee,2011,TP,263.858,76.729,12				
Point Pelee,2012,TP,109.514,29.471,12				
Point Pelee,2013,TP,167.367,84.775,11				
.				
.				

Point Pelee

Data files converted into csv format using
external program such as Excel

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Loading Estimate Decision Support System Basin and Lake Total Loads

Inputs

Program Execution

Outputs

All annual loads calculated by DSS

Monitored tributaries

Unmonitored watershed areas

Atmospheric Deposition

Point sources

Loads from Upstream
Great Lakes

Sum up loads from all sources by basin, country, lake

Basin and lake total annual loads from all sources (csv file)

Basin and lake annual loads from each individual source (csv file)



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Loading Estimate Decision Support System Implementation Issues

- After initial round of beta testing of DSS, discrepancies in some results were discovered
 - Implementation is our interpretation of Dolan Method based on Maccoux *et al.*, (2016)
1. Monitored tributaries: When calculating loads using Stratified Beale Ratio Estimator, there were cases where the DSS used different flow cutoff values and/or number of strata compared to Maccoux *et al.*, (2016).

Examples: Black-Ml in 2013

	# of strata	TP Load (MTA)	MSE (MTA ²)
Maccoux	1	49	709
DSS	2	44 (-10%)	637 (-10%)

Sydenham in 2013

	# of strata	Flow cutoff (cfs)	TP Load (MTA)	MSE (MTA ²)
Maccoux	2	400	90	1100
DSS	2	300	88 (-2%)	1085 (-1%)

If we have detail information on the algorithms from Dolan program used by Maccoux *et al.*, (2016) to compute flow cutoff values and to choose number of strata, then issue can be resolved.



Loading Estimate Decision Support System Implementation Issues (continued)

2. Point sources: Differences in assigning point sources to tributaries and/or categorizing them as indirect or direct. This process was performed manually using a GIS by visual inspecting point source locations in relation to tributaries and water quality monitoring stations.

Example: Huron-MI in 2011

	Indirect Municipal (MTA)	Indirect Industrial (MTA)
Maccoux	27.95	0.17
DSS	33.06 (18%)	0.13 (-23%)

Note that differences in aggregated loads from multiple point sources can be large. If the same tributary and indirect/direct assignments from Maccoux *et al.*, (2016) were used, then differences can be resolved.

2. Heidelberg data: Annual mean square errors (MSEs) were not computed by DSS, but were obtained from Maccoux *et al.*, (2016) data files. For future years, MSEs need to be provided or calculation method needs to be known. Also for future years, daily loads need to be provided since these were not calculated by the DSS.



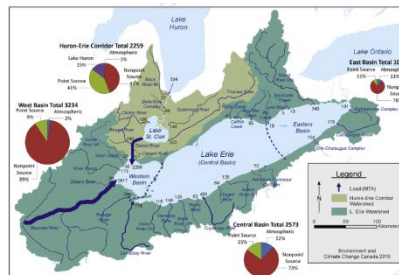
Loading Estimate Decision Support System

Next Steps

- Refine implementation of Dolan Method in DSS to reduce differences in results
- Implement visualization of results
 - Tables: annual loads from individual sources (or all aggregated) by tributary, basin, lake, country

	2003		2004		2005		2006	
	Load	S.E.	Load	S.E.	Load	S.E.	Load	S.E.
United States								
Municipal Wastewater	3870	65	3759	60	4087	143	3884	76
Adjustment for Unassimilated Area	1028	12	1314	60	1221	84	1179	39
Direct Industrial Point Source	7	0.6	8	0.7	7	0.5	7	0.8
Direct Municipal Point Source	1169	11	1321	40	1339	33	1339	33
Indirect Industrial Point Source ¹	93	3	27	2	25	2	31	2
Indirect Municipal Point Source ¹	314	12	372	7	351	6	366	8
U.S. Total	6972	83	6482	93	7271	176	6478	101
Canada								
Municipal Wastewater	572	84	1254	79	662	32	891	90
Adjustment for Unassimilated Area	122	20	363	35	158	14	219	43
Direct Industrial Point Source	27	3	28	2	23	1	24	0.9
Direct Municipal Point Source	53	3	54	2	63	3	56	2
Indirect Industrial Point Source ²	0	0	0	0	0	0	0	0
Indirect Municipal Point Source ²	88	2	87	2	90	2	96	2
Canadian Total	774	87	1648	87	904	35	1231	106
Atmospheric	813	150	511	78	363	62	452	140
Input from Lake Effect³	366		366		351		335	
Basin Total	8824	193	8056	150	8592	190	8417	206

- Maps and graphs



- Implement data import utilities as required



Summary

- ECCC is monitoring in the Huron-Erie corridor, priority Canadian tributaries to Lake Erie, nested monitoring in the Thames River watershed, Lake St. Clair with MOECC, and in the Great Lakes
- Loadings estimates based on Dolan approach, with 50-100 samples collected per location per water year
- LEDSS will be a publically available tool, modernizing the Dolan approach using AI and a user-friendly interface
- ECCC is working with partners to ensure data comparability and is supporting watershed and lake modeling initiatives with enhanced data

