The Metropolitan

Water Reclamation District

of Greater Chicago

WELCOME

TO THE FEBRUARY EDITION

OF THE 2016

M&R SEMINAR SERIES

BEFORE WE BEGIN

- SAFETY PRECAUTIONS
  - PLEASE FOLLOW EXIT SIGN IN CASE OF EMERGENCY EVALUATION
  - AUTOMATED EXTERNAL DEFIBRILLATOR (AED) LOCATED OUTSIDE
- PLEASE SILENCE CELL PHONES OR SMART PHONES
- QUESTION AND ANSWER SESSION WILL FOLLOW PRESENTATION
- PLEASE FILL EVALUATION FORM
- SEMINAR SLIDES WILL BE POSTED ON MWRD WEBSITE (www.MWRD.org: Home Page ⇒ Reports ⇒ M&R Data and Reports ⇒ M&R Seminar Series ⇒ 2016 Seminar Series)
- STREAM VIDEO WILL BE AVAILABLE ON MWRD WEBSITE (www.MWRD.org: Home Page ⇒ MWRDGC RSS Feeds)

Mr. Thomas A. Minarik Jr.

Current: **Senior Aquatic Biologist**, Aquatic Ecology and Water Quality Section, Environmental Monitoring and Research Division (EM&RD), Monitoring and Research Department (M&R), MWRD

Experience:

- Since 2001, Water Quality Monitoring in the Chicago Area Waterways
  - Continuous Dissolved Oxygen Monitoring
  - Ambient Biological Monitoring
  - Ambient Water Quality Monitoring
- From 2008 to present, Project manager for Collaborative Research on Endocrine Active Compounds in the Chicago Area Waterways
- From 2010 to present, Project manager for Continuous Dissolved Oxygen Monitoring Program

Education: B.S. Environmental Science from DePaul University, Chicago, IL

Overview of the Metropolitan Water Reclamation District of Greater Chicago's Illinois Waterway Monitoring Program

February 2016 M&R Seminar

Thomas A. Minarik, Jr. Senior Aquatic Biologist

Outline

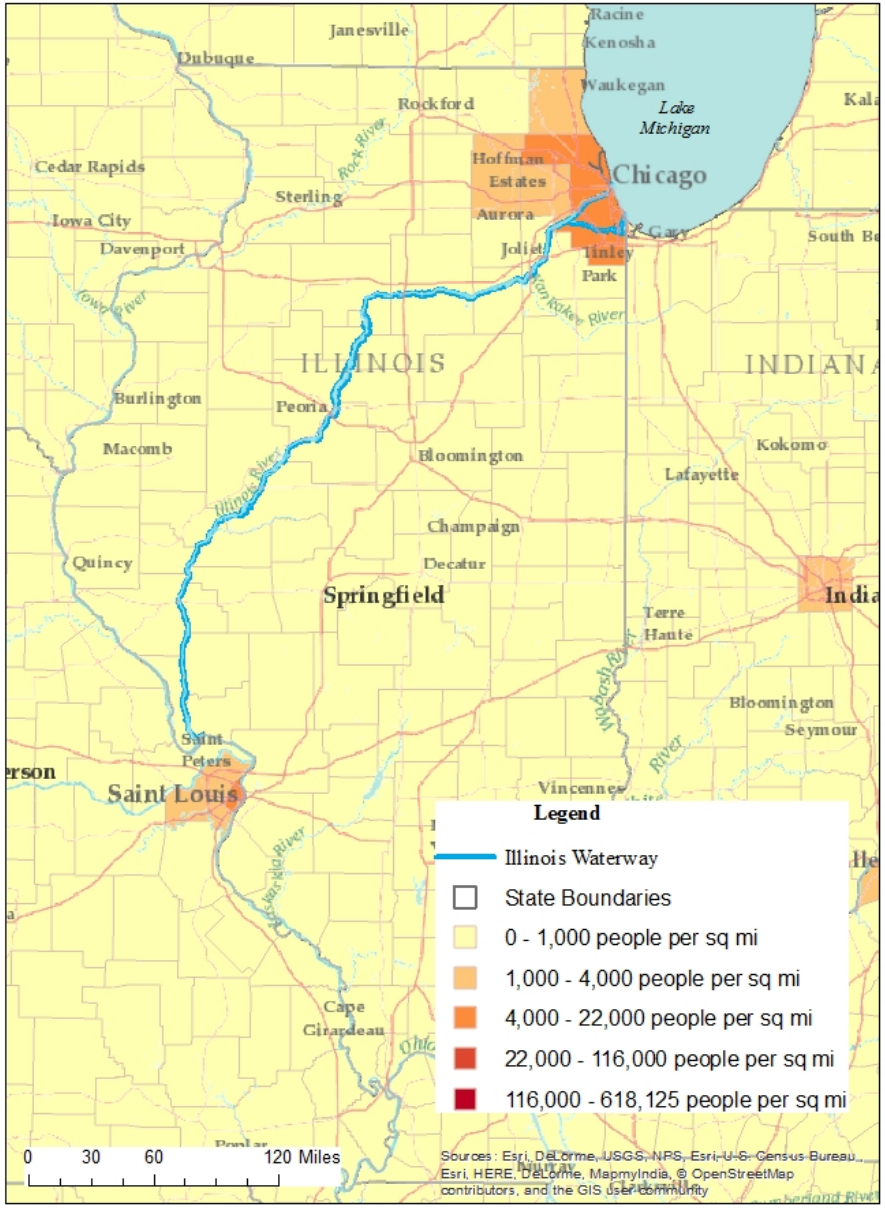
- What is the ILWW
- What is the ILWW Monitoring Program
- History of the ILWW Monitoring Program
- Water Quality Improvement Efforts
- Significant Findings
- Biological Improvements in the ILWW
- Future ILWW Monitoring Program Considerations

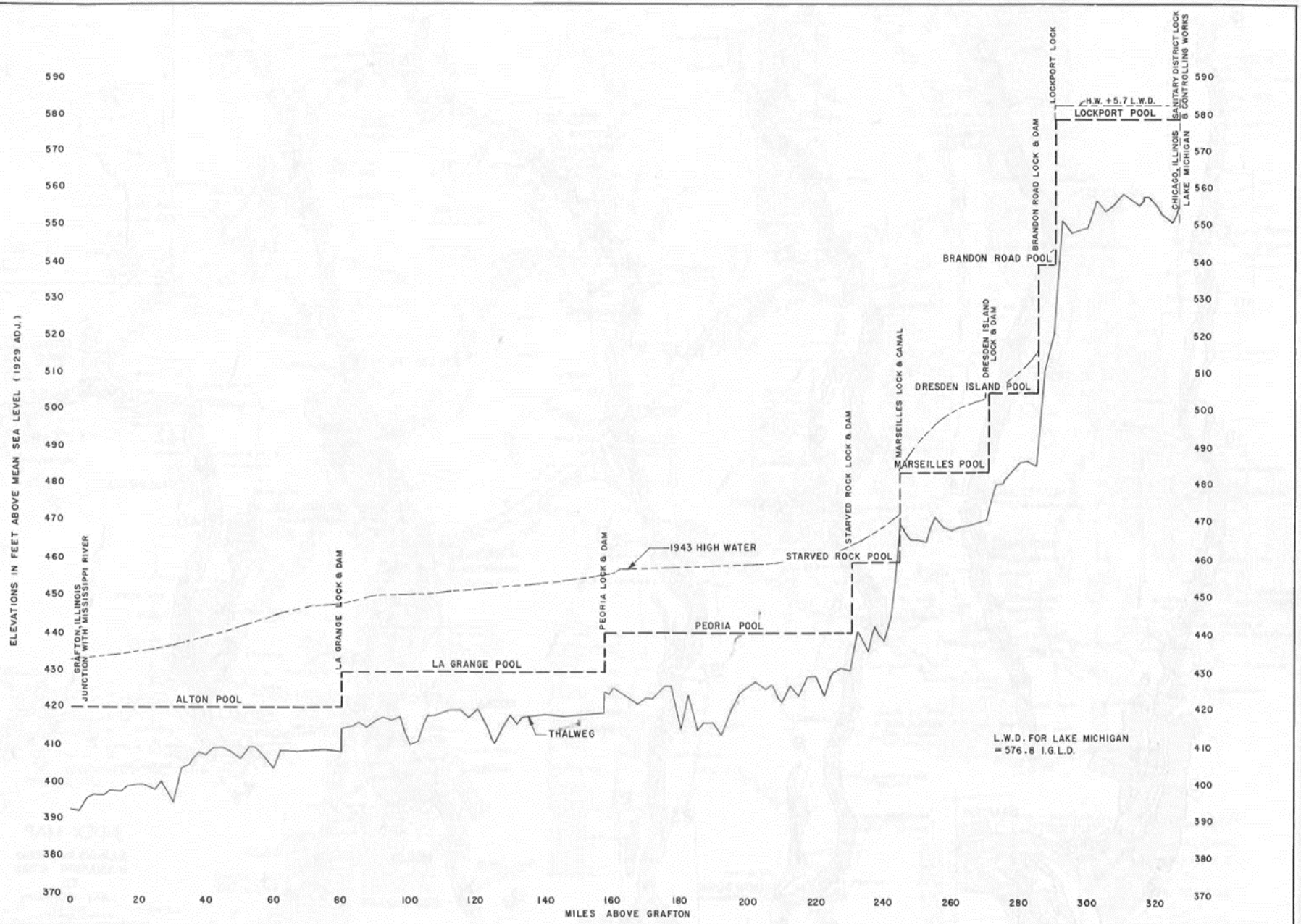
The Illinois Waterway (ILWW)

- A 327 mile waterway from Grafton, IL to Chicago, IL
- Connecting the Mississippi River with Lake Michigan
- Composed of a series of 8 navigational pools
- Created in the 1930's by lock and dam structures
- Heavily impacted by Anthropogenic factors

Illinois Waterway Navigational Pools

Navigational Pool	Inclusive Waterway Mile-Points	Length (Miles)
Lockport	327.2 - 291.0	36.2
Brandon Road	291.0 - 286.0	5.0
Dresden Island	286.0 - 271.5	14.5
Marseilles	271.5 – 244.5	27.0
Starved Rock	244.5 - 231.0	13.5
Peoria	231.0 - 157.6	73.4
LaGrange	157.6 - 80.2	77.4
Alton	80.2 - 0.0	80.2


Janesville
Racine
Kenosha
Dubuque
Waukegan
Rockford
Lake Michigan
Hoffman Estates
Chicago
Cedar Rapids
Sterling
Aurora
Iowa City
Davenport
Joliet
Tinley Park
Gary
ILLINOIS
INDIANA
Burlington
Peoria
Macomb
Bloomington
Kokomo
Lafayette
Champaign
Quincy
Decatur
Springfield
Terre Haute
Bloomington
Seymour
Saint Peters
Saint Louis
Vincennes
Cape Girardeau
Legend
Illinois Waterway
State Boundaries
0 - 1,000 people per sq mi
1,000 - 4,000 people per sq mi
4,000 - 22,000 people per sq mi
22,000 - 116,000 people per sq mi
116,000 - 618,125 people per sq mi
0 30 60 120 Miles
Sources: Esri, DeLorme, USGS, NPS, Esri, U.S. Census Bureau, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



ILLINOIS WATERWAY, ILLINOIS
PROFILE
MILE 0.0 TO MILE 327.2


7668
JULY 7 20

ILWW Resources

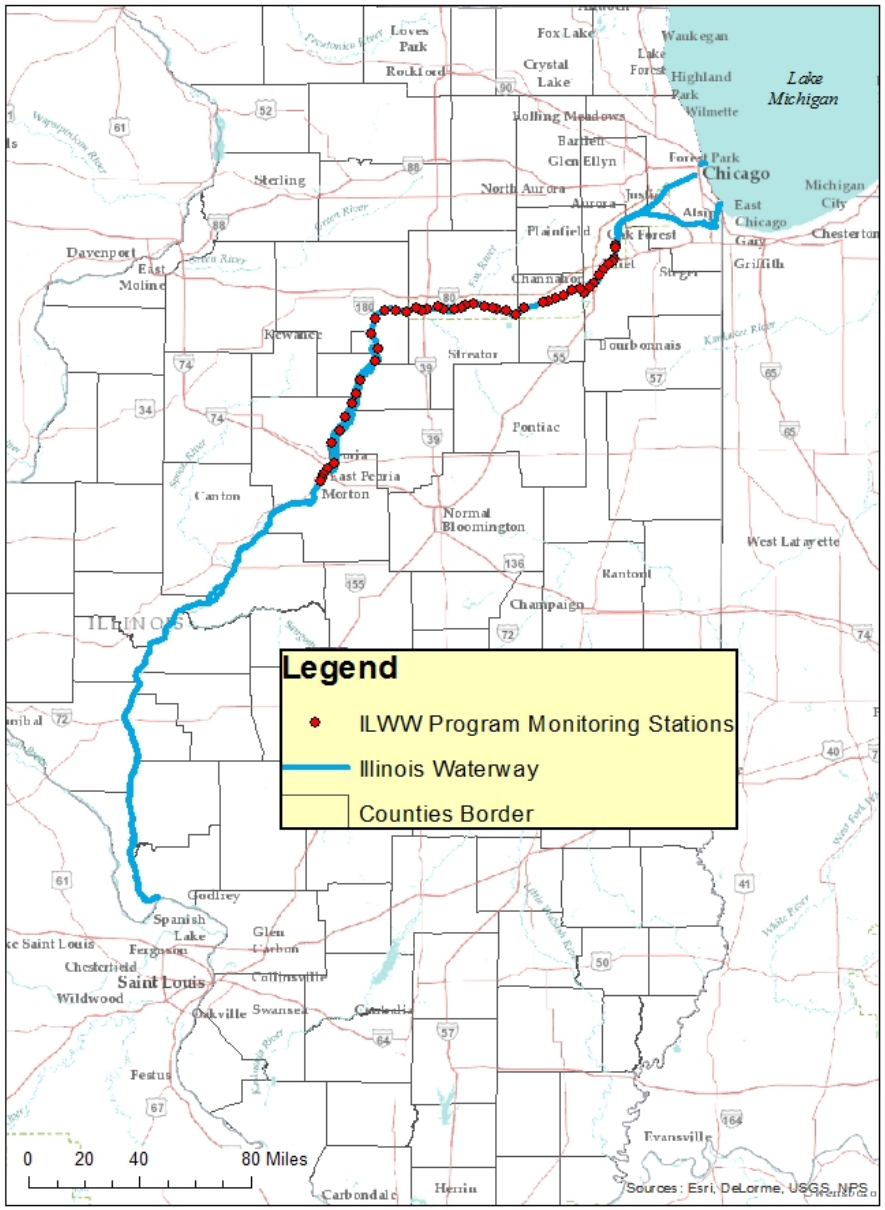
- Agricultural and urban drainage
- Commercial and recreational navigation
- Electric power generation
- Treated wastewater conveyance
- Fishing and other recreational activities
- Industrial and public water supply

The ILWW Monitoring Program

- A monitoring program designed by the District to assess water quality and sediment quality in the Illinois waterway downstream of the District's discharges
- Important times for water quality
  - 1972 Passage of the Clean Water Act
  - 1974 Illinois Pollution Control Board amends water quality standards for Chicago area waterways
  - The District invested in improvements in operations and to its infrastructure to achieve water quality improvements

ILWW Program Design

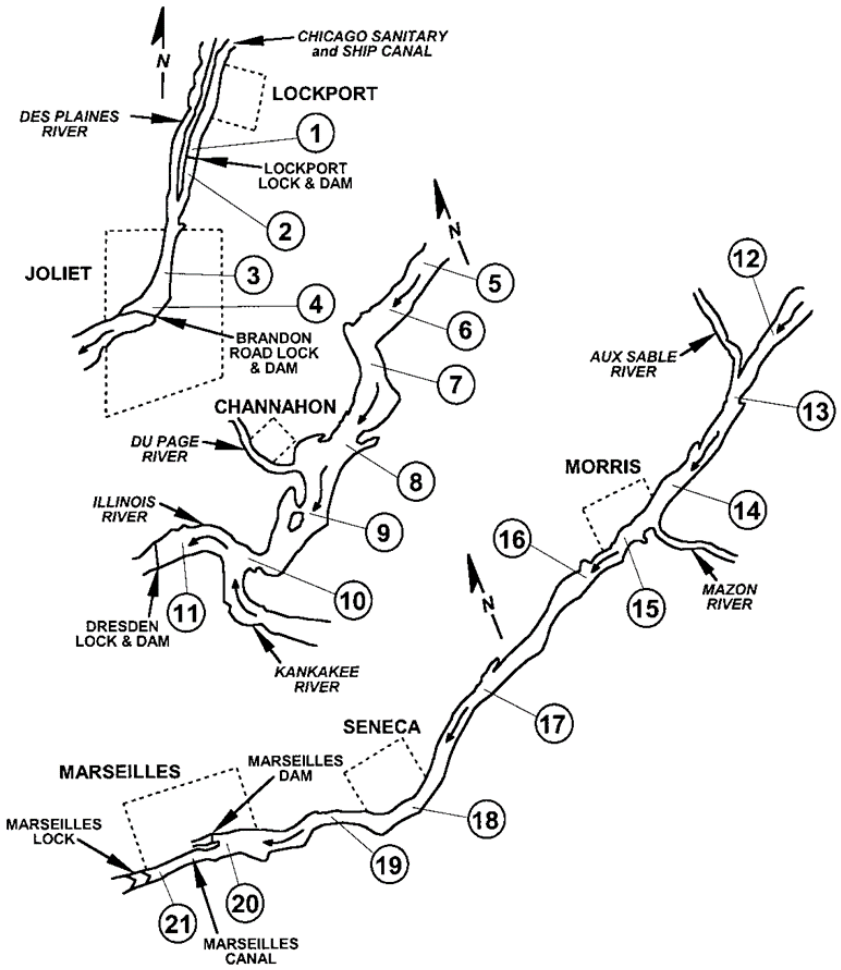
- The study area covered 133 river miles within the ILWW
- Six navigational pools were monitored
  - Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria
- Forty-nine stations were selected for water sampling
- Fourteen of the 49 stations were selected for sediment sampling
- Seasonal monitoring trips involved a 4-day downstream trip followed by a 4-day upstream trip
- The ILWW program was managed under the guidance of a quality assurance project plan


Legend
ILWW Program Monitoring Stations
Illinois Waterway
Counties Border
0 20 40 80 Miles
Sources: Esri, DeLorme, USGS, NPS
Lake Michigan
Chicago
Rockford
Sterling
Davenport
Peoria
Pontiac
Champaign
Saint Louis
Carbondale
Evansville
ILLINOIS

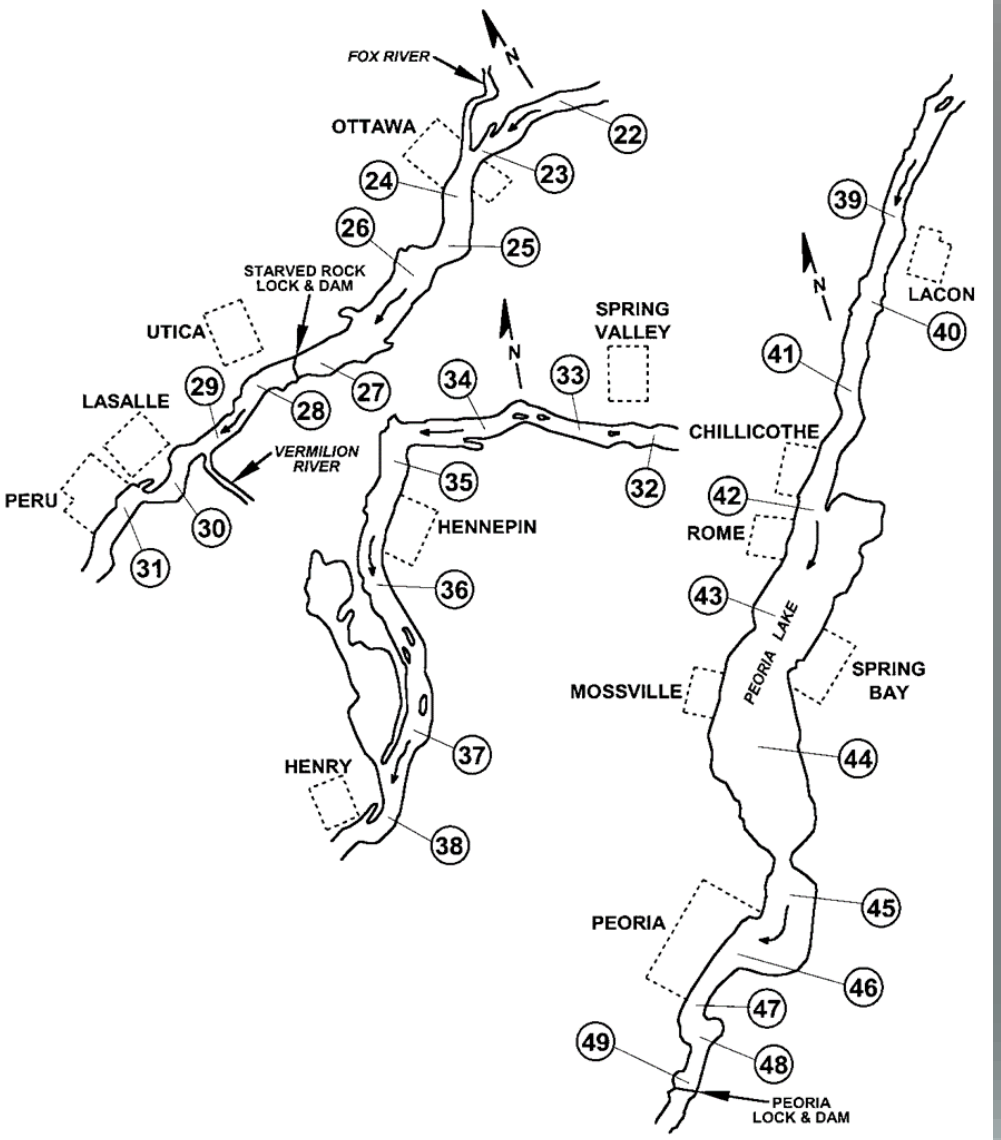
ILWW Monitoring Station Locations

Pool	# of Stations	Waterway Name
Lockport	1	Chicago Sanitary & Ship Canal
Brandon Road	3	Chicago Sanitary & Ship Canal, Des Plaines River
Dresden Island	7	Des Plaines River, Illinois River
Marseilles	10	Illinois River
Starved Rock	6	Illinois River
Upper Peoria	14	Illinois River
Lower Peoria	8	Illinois River

MAP OF THE ILLINOIS WATERWAY FROM LOCKPORT TO MARSEILLES SHOWING SAMPLING STATIONS 1 TO 21



MAP OF THE ILLINOIS WATERWAY FROM OTTAWA TO PEORIA SHOWING SAMPLING STATIONS 22 TO 49



ILWW Program History

- The first monitoring trips occurred in 1977
- From 1983 – 2011 seasonal monitoring continued with the exception of 1998 (29 total individual years)
- Each station was typically sampled 6 times per year for water quality
- More frequent monitoring occurred for the years 1989 – 1991
  - Mandated by the Illinois Pollution Control Board (R1987 - 027)

List of Water Quality Parameters Measured for the ILWW Monitoring Program

- Water Temperature, Total Suspended Solids, Total Organic Carbon, Turbidity, Conductivity, Five-Day Biochemical Oxygen Demand, Dissolved Oxygen, pH, Ammonia Nitrogen, Un-ionized Ammonia, Total Kjeldahl Nitrogen, Nitrite plus Nitrate Nitrogen, Total Nitrogen, Nitrite Nitrogen, Nitrate Nitrogen, Total Phosphorus, Chlorophyll a, Total Cyanide, Phenols, FOG, Hardness, Total Calcium, Total Magnesium, Fecal Coliform, *E. Coli*
- Total and Soluble Metals
  - Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Silver, and Zinc

List of Sediment Chemistry Parameters Measured for the ILWW Monitoring Program

- Total Solids, Total Volatile Solids, Chemical Oxygen Demand, Ammonia Nitrogen, Total Kjeldahl Nitrogen, Nitrite plus Nitrate Nitrogen, Total Phosphorus, Total Cyanide, Phenols
- Total Metals
  - Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Silver, and Zinc

Description of sampling processes

- Sample stations were marked with GPS and river mile markers
- Water samples were collected from a boat in the center of the waterway at a 3 foot depth with a submersible drainage pump

Description of sampling processes (continued)

- Sediment samples were collected with a Ponar grab sampler
- Water and sediment samples were transported to the District laboratory within 24 hours of collection for analysis
- Water samples for bacteria analysis were transported to a contractor laboratory to meet holding time requirements

Description of data management

- The results from each analysis were entered into the District's laboratory information management system
- The data was saved in excel spreadsheets
- The data was submitted to the IEPA for use in water quality reports required by section 305(b) of the Clean Water Act
- Some of the data is posted on the District website at mwrd.org
- District reports were done for some individual years and are also available on the District website

Asian carp video

Water Quality Improvement Efforts

- Regulatory / Permits
- WWTP upgrades
- Infrastructure Improvements

MWRDGC Infrastructure and Operations Improvements

1979	User Charge Ordinance Implemented
	In-stream Aeration on North Shore Channel
1980	In-stream Aeration on North Branch Chicago River
1985	Mainstream TARP Tunnel System Completed
	Mainstream and Calumet TARP Pump Station On-line
	Expanded Secondary Treatment Capacity at Calumet WRP
	USEPA Approval of Pretreatment Program
1986	Calumet-Sag Leg TARP Tunnel Completed

Deep Tunnel

Devon Aeration Station

MWRDGC Infrastructure and Operations Improvements (continued)

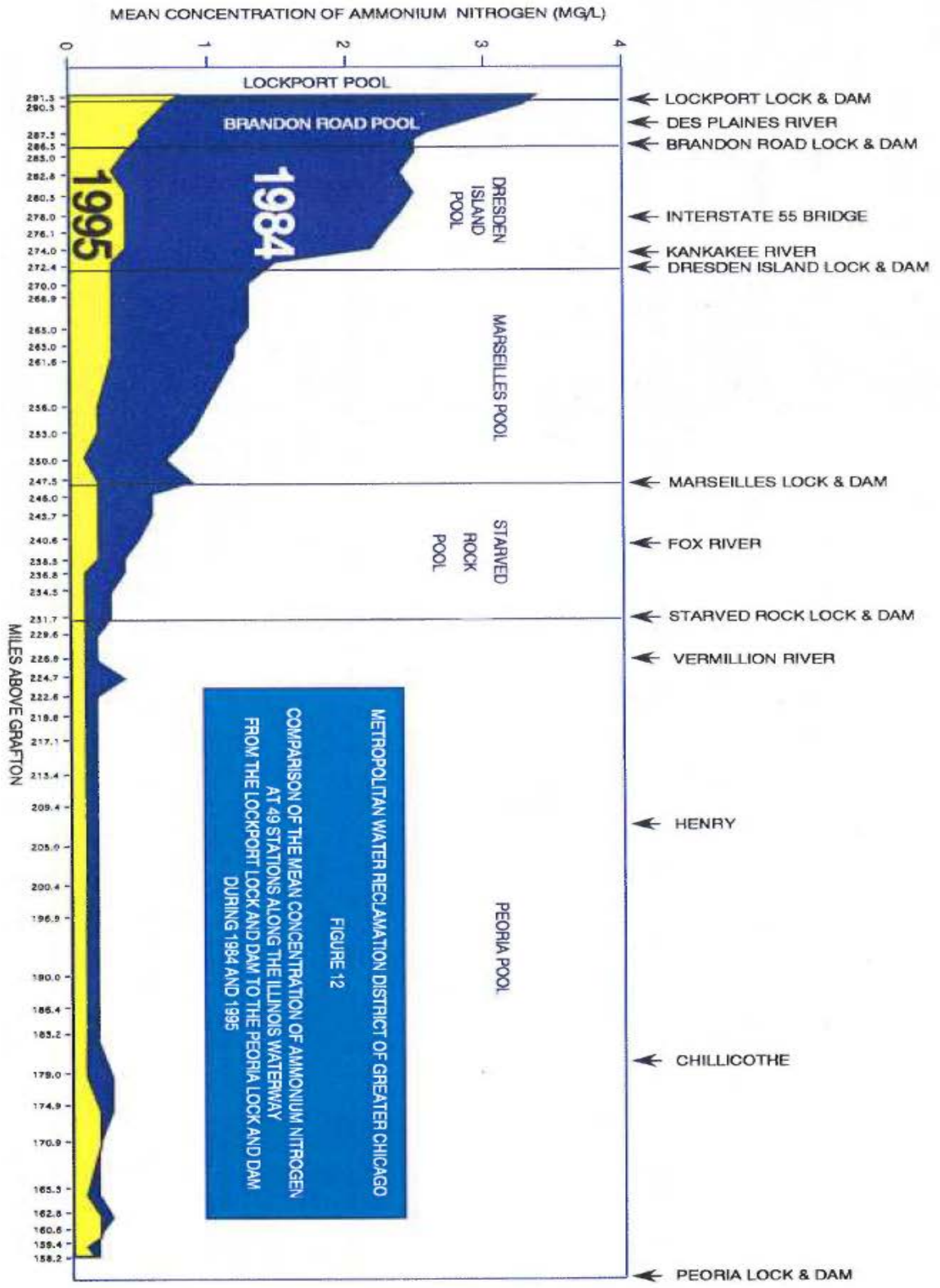
1990	Improved Nitrification at Stickney, Calumet, and O'Brien WRPs
1992	Side-stream Aeration Along Calumet-Sag Channel
1993	Implementation of Part 503 Biosolids Regulations
1994	Side-stream Aeration Along Calumet and Little Calumet Rivers
	Additional Side-stream Aeration Along Calumet-Sag Channel
1998	Majewski Reservoir Completed
1999	DesPlaines TARP Tunnel System Completed
2003	Thornton Transitional Reservoir On-line
2006	Phase 1 TARP, Pollution Control Tunnels Completed

SEPA 4

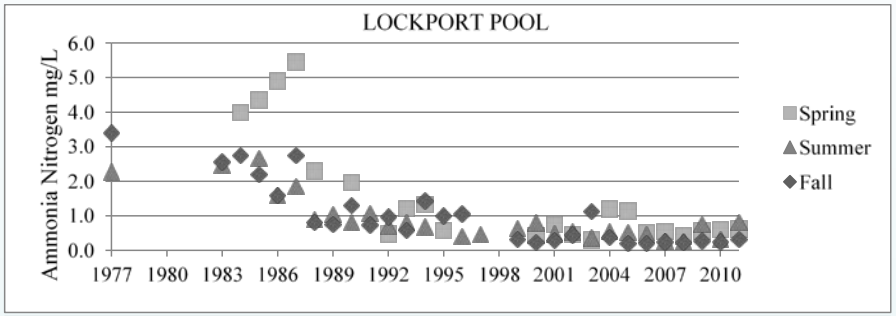
Thornton Reservoir

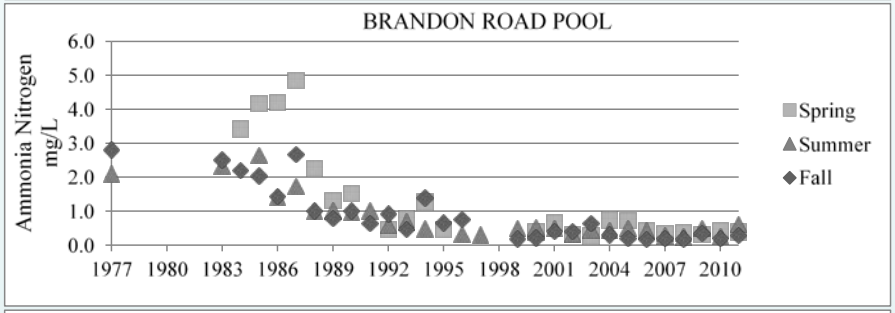
Water Quality Results

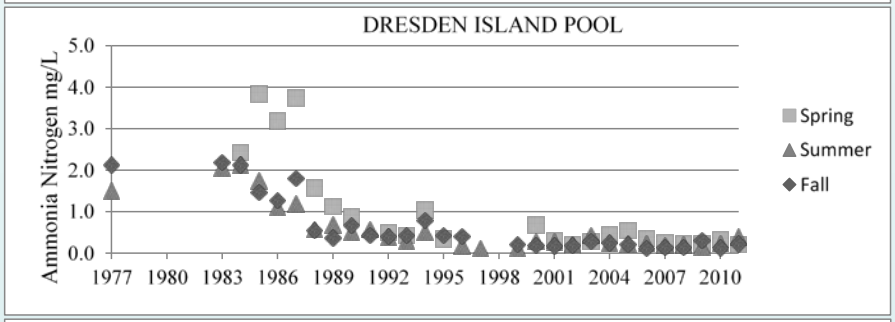
- Analysis of yearly ILWW program data found some spatial patterns in the water quality data
  - Increases in the downstream direction are noticeable for
    - *Dissolved Oxygen, pH, Total Suspended Solids, Turbidity, Chlorophyll a*
  - Decreases in the downstream direction are noticeable for
    - *Ammonia Nitrogen, Temperature, Fecal Coliform, Total Nitrogen, Total Phosphorus*

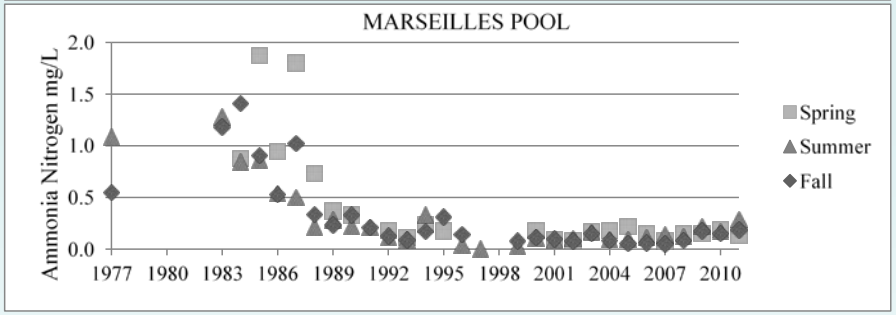

MEAN CONCENTRATION OF AMMONIUM NITROGEN (MG/L)
0
1
2
3
4
LOCKPORT POOL
BRANDON ROAD POOL
DRESDEN ISLAND POOL
MARSEILLES POOL
STARVED ROCK POOL
PEORIA POOL
1984
1995
MILES ABOVE GRAFTON
291.5
290.3
287.5
286.5
285.0
282.8
280.5
278.0
276.1
274.0
272.4
270.0
268.9
265.0
263.0
261.6
256.0
253.0
250.0
247.5
246.0
243.7
240.6
238.3
236.8
234.5
231.7
229.6
226.8
224.7
222.6
219.8
217.1
213.4
209.4
205.0
200.4
196.9
190.0
186.4
183.2
179.0
174.9
170.9
165.3
162.8
160.6
159.4
158.2
LOCKPORT LOCK & DAM
DES PLAINES RIVER
BRANDON ROAD LOCK & DAM
INTERSTATE 55 BRIDGE
KANKAKEE RIVER
DRESDEN ISLAND LOCK & DAM
MARSEILLES LOCK & DAM
FOX RIVER
STARVED ROCK LOCK & DAM
VERMILLION RIVER
HENRY
CHILLICOTHE
PEORIA LOCK & DAM
METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO
FIGURE 12
COMPARISON OF THE MEAN CONCENTRATION OF AMMONIUM NITROGEN
AT 49 STATIONS ALONG THE ILLINOIS WATERWAY
FROM THE LOCKPORT LOCK AND DAM TO THE PEORIA LOCK AND DAM
DURING 1984 AND 1995

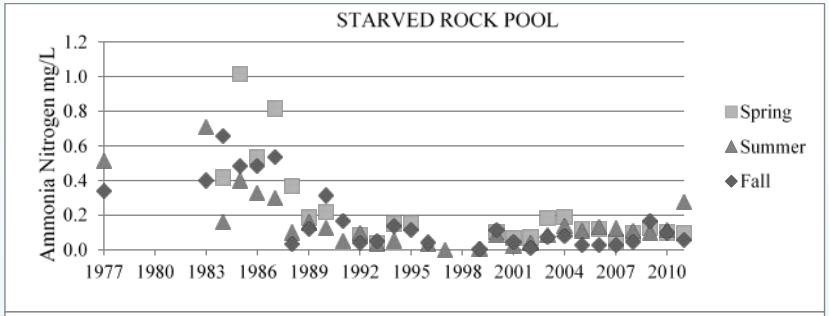
Ammonia Nitrogen in the ILWW

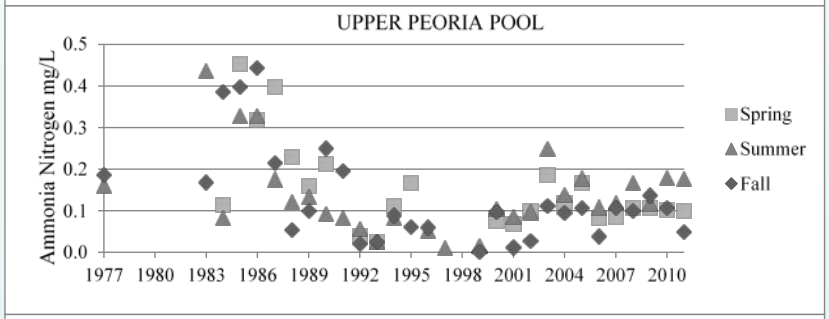


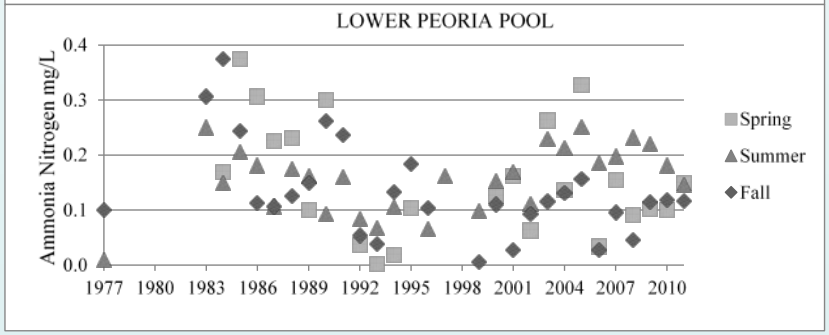






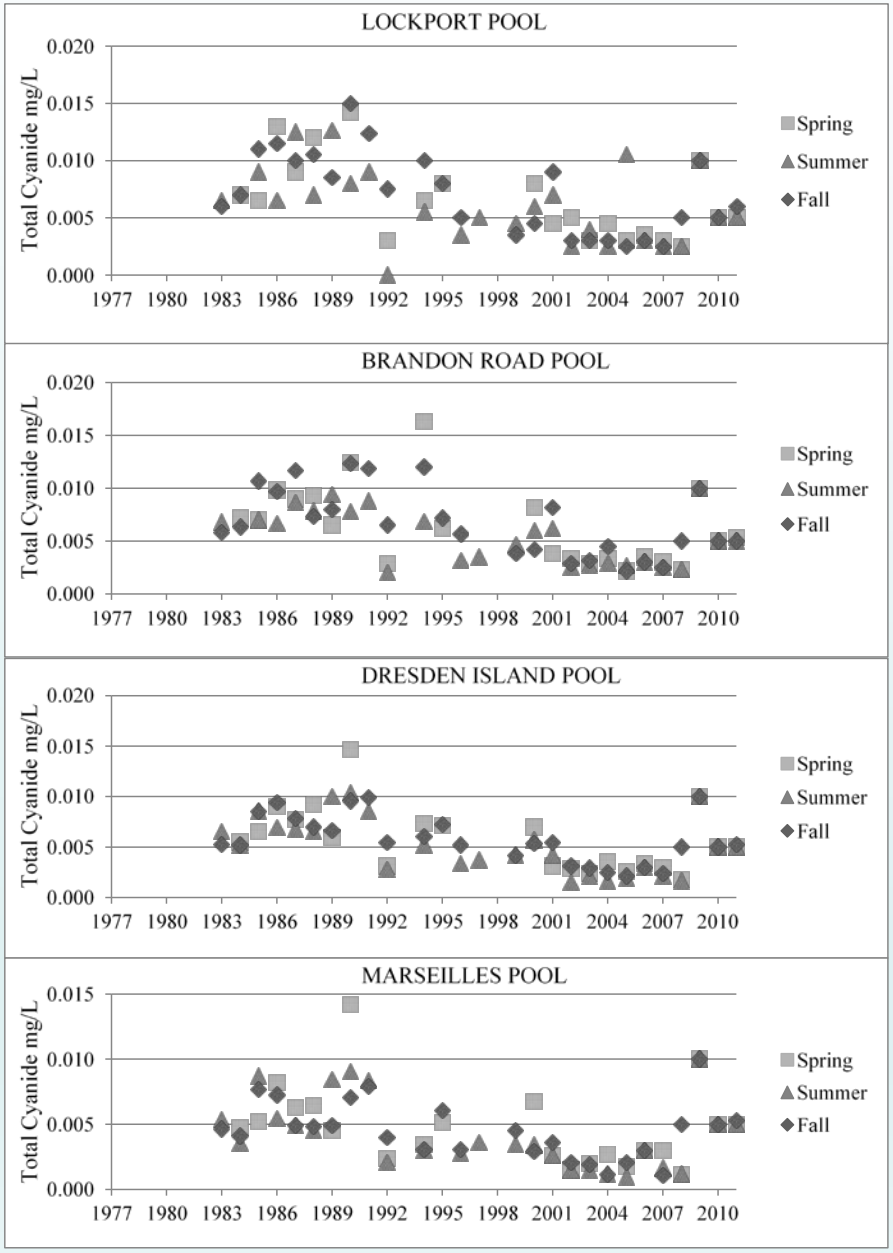


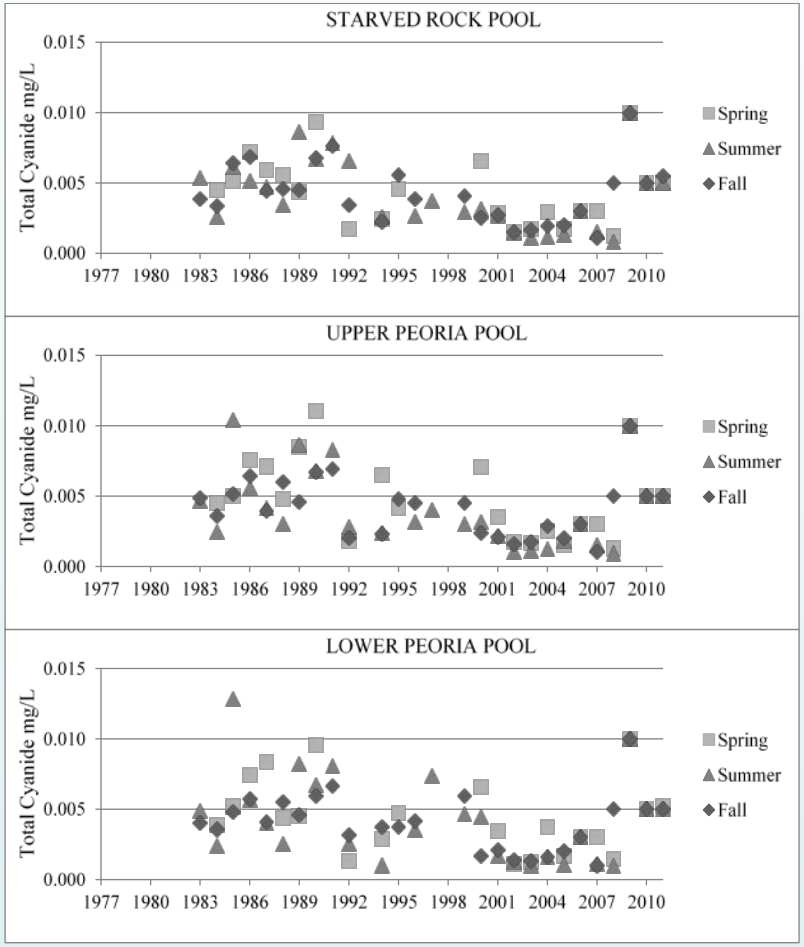




[1] Points on graph represent the yearly seasonal average.

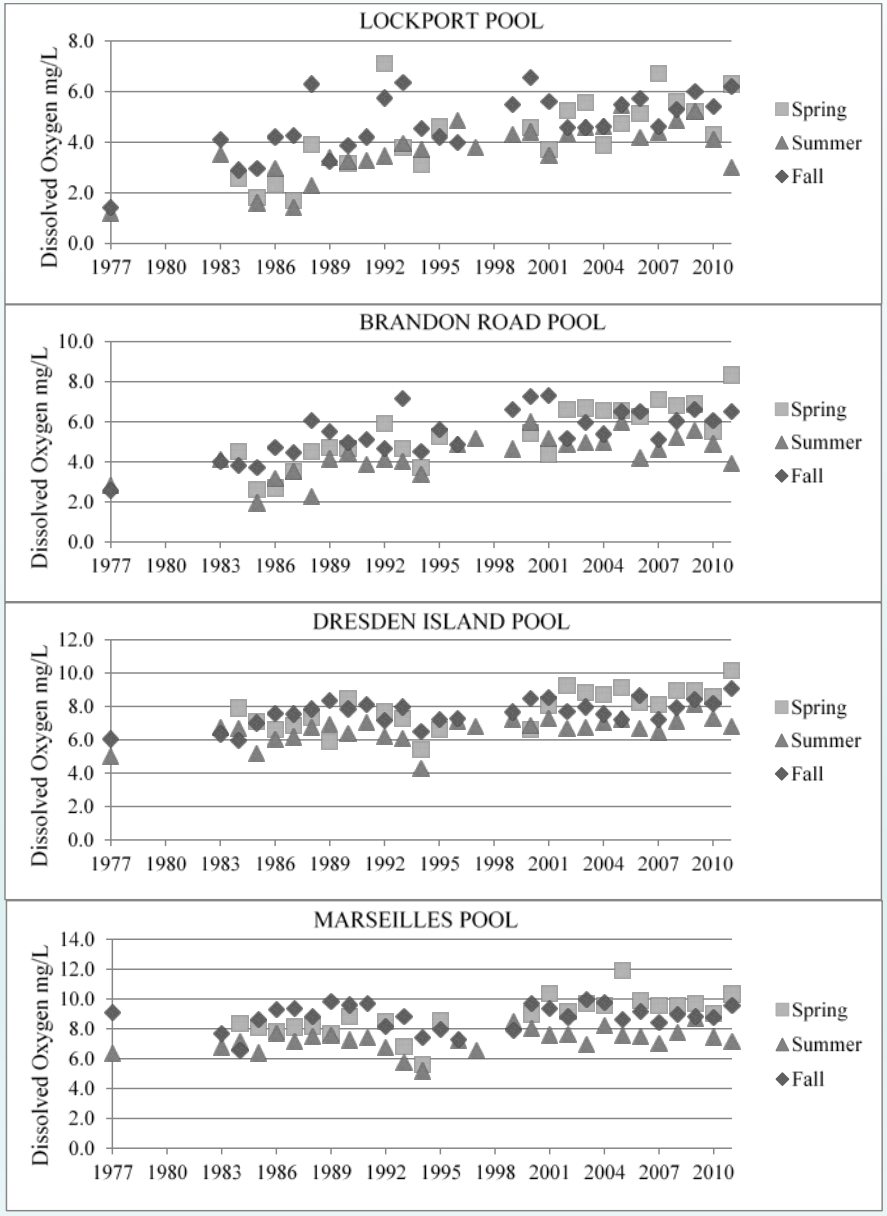
Total Cyanide in the ILWW

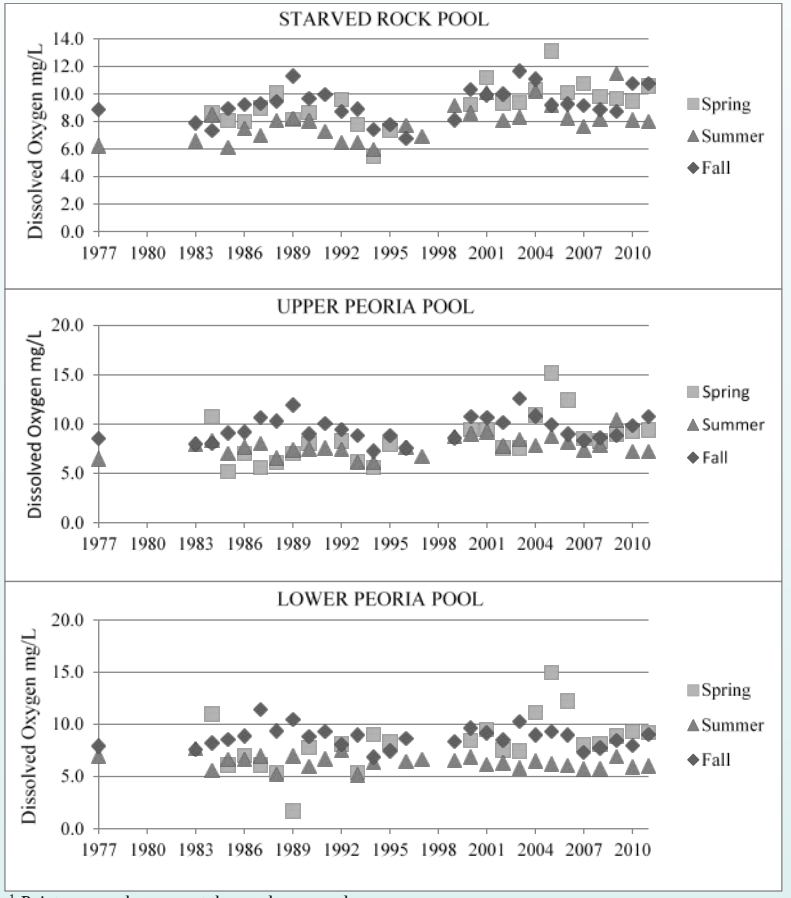




[1] Points on graph represent the yearly seasonal average.

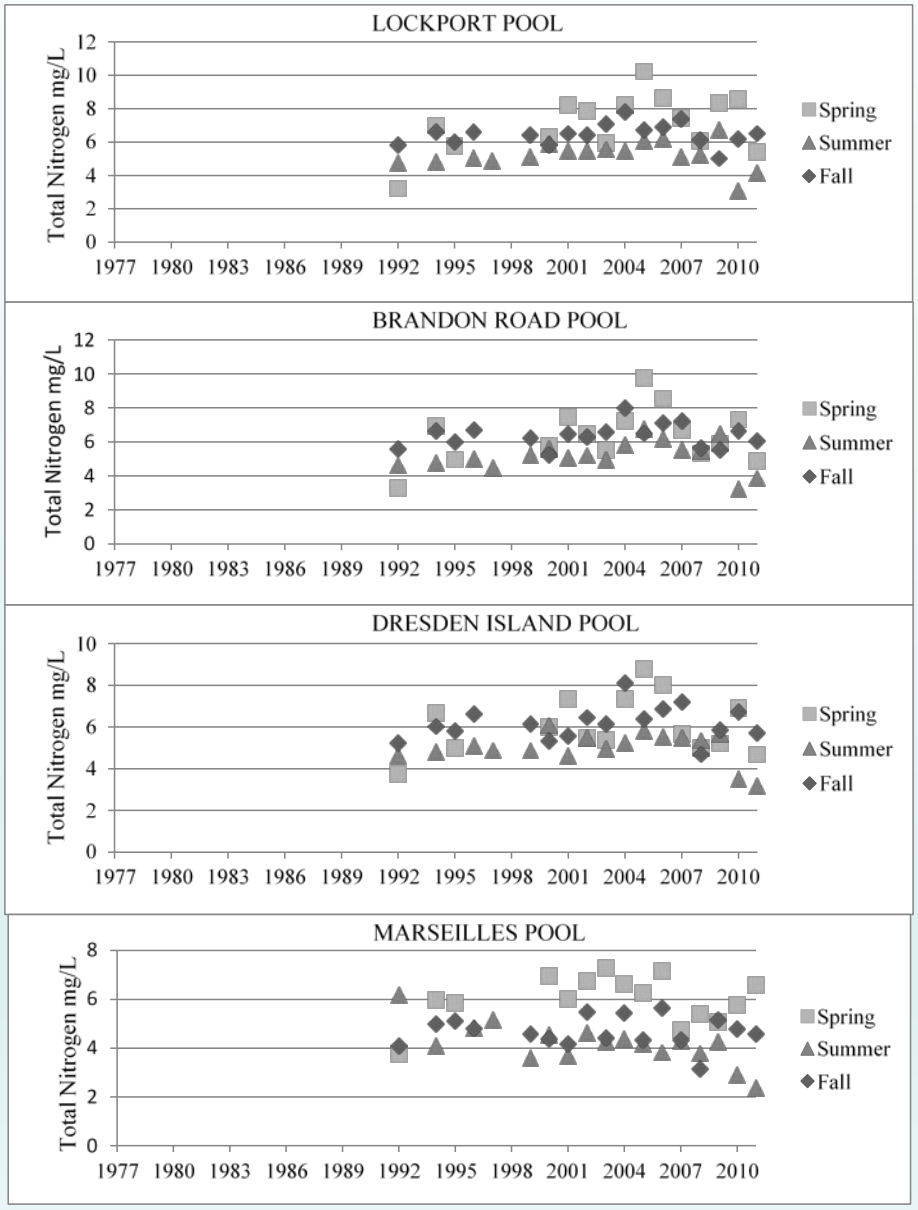
Dissolved Oxygen in the ILWW

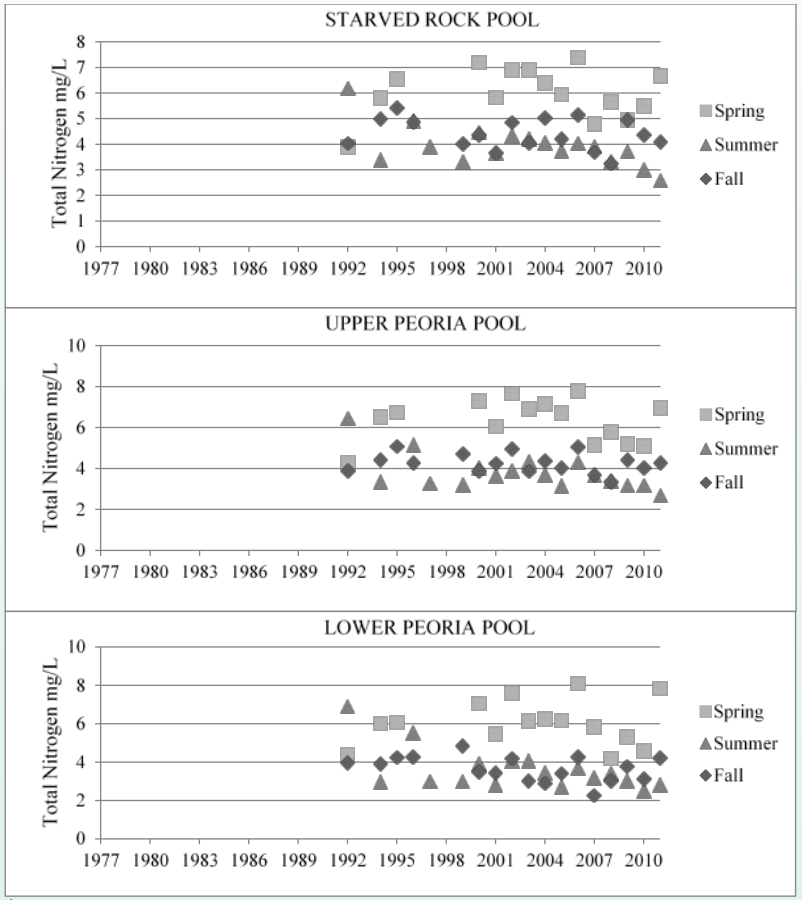




[1] Points on graph represent the yearly seasonal average.

Total Nitrogen in the ILWW





[1] Points on graph represent the yearly seasonal average.

Description of approach for data analysis

- What would we like to know about this long term data set
  - Were there changes in water and sediment quality throughout the waterway over time?
  - Was there any seasonal differences in water quality?
  - Were there any relationships between nutrients and other water quality parameters?
  - Were there any trends in water quality or sediment quality?
- What are the limitations for both water and sediment data
  - Is the quality and quantity of data adequate for statistical analysis?
- What can we do statistically to answer our questions

Water Quality Data Review

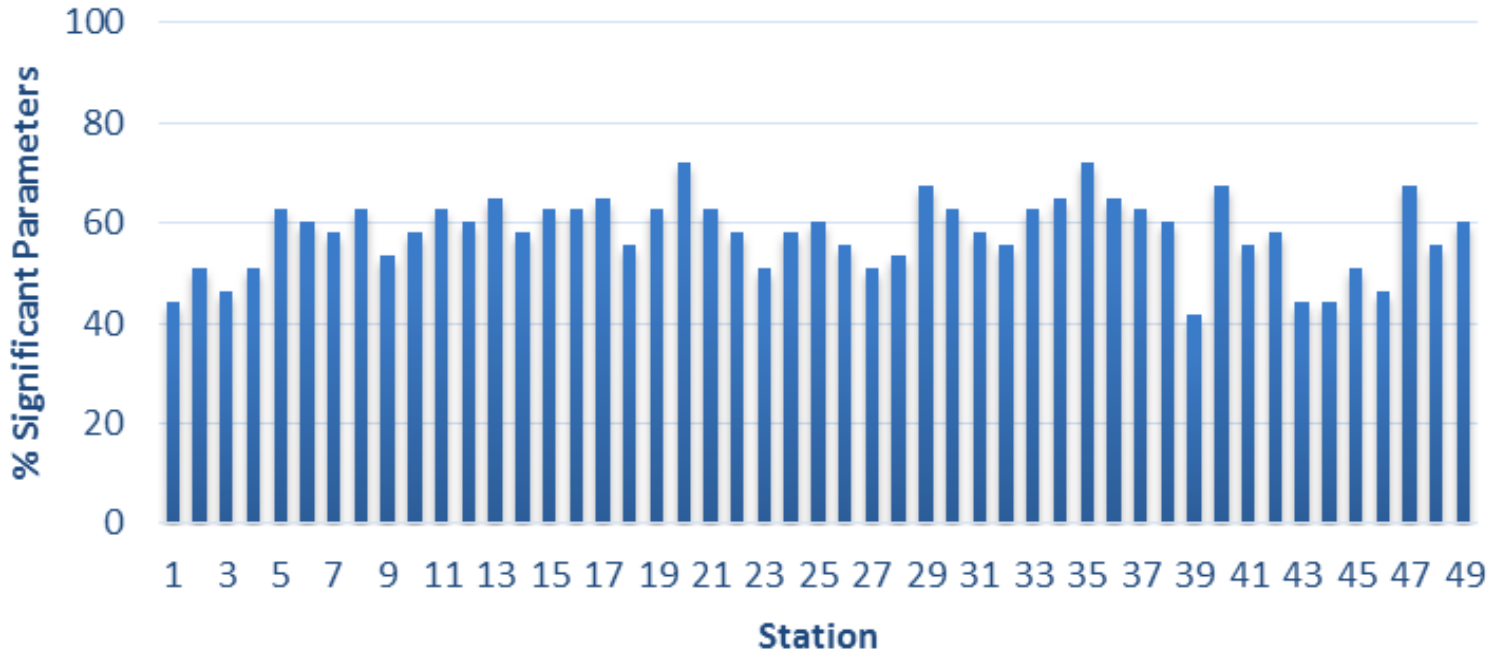
- Before doing any statistical analysis we reviewed the available water quality data and developed some quality control measures
  - We removed outliers when the result was +/- five times the standard deviation
  - We removed all observations of any parameter whose standard deviation was zero or near zero
  - We removed all observations of any parameter if the number of samples in a year was less than 5
  - 43 parameters qualified for statistical analysis

Results of ANOVA data analysis

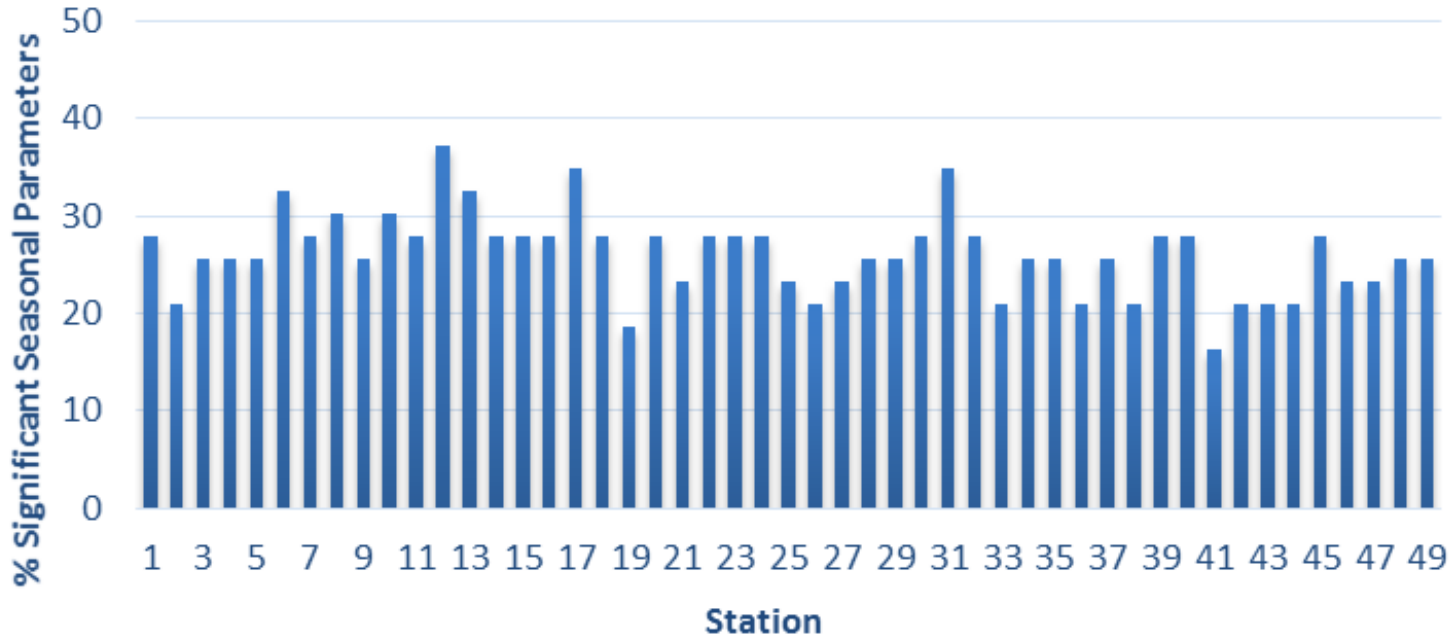
- Temporal Differences
  - There were significant differences in water quality parameters at each station over time
  - Not for every parameter but for 42% - 72% of them

- Seasonal Differences
  - There were significant seasonal differences in water quality parameters at each station
  - Not for every parameter but for 16% - 37% of them

% of Significant Water Quality Parameters for Each Station Over 21 Years



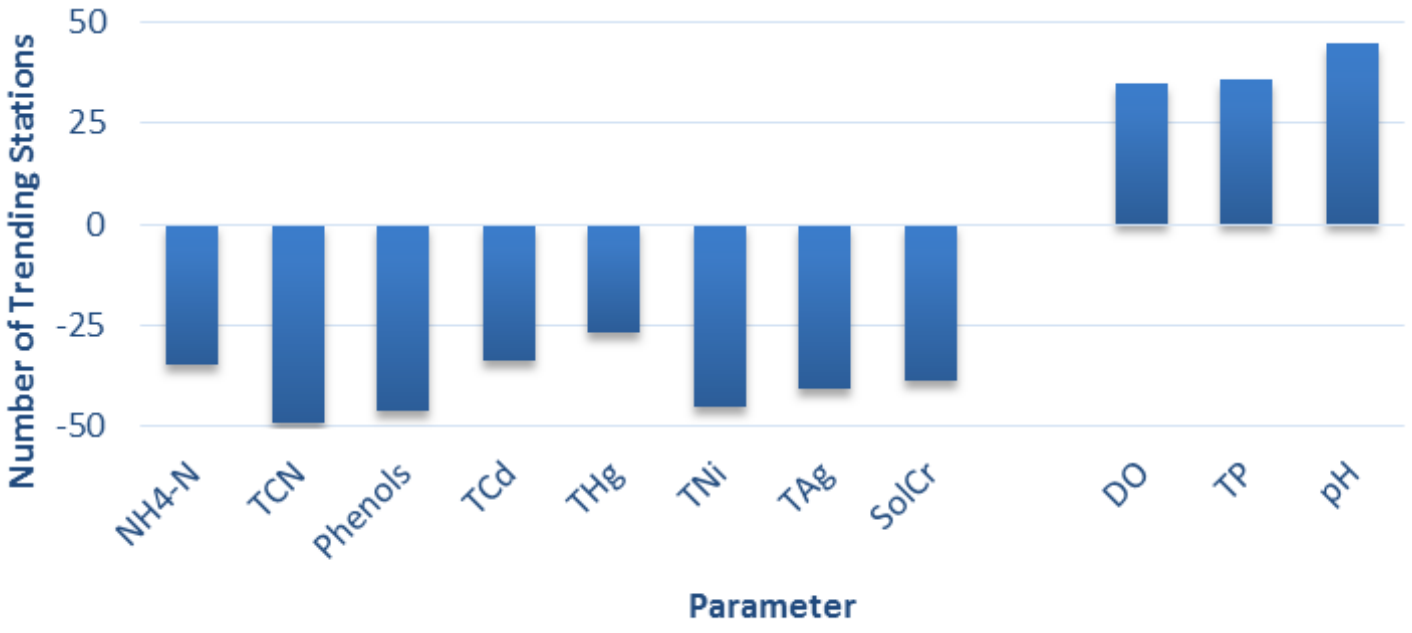
% of Signifcant Seasonal Parameters for Each Station



Water Quality Trend Analysis for the ILWW Monitoring Program using MANN-KENDALL

- There was varying results for each water quality parameter concentration when evaluating the annual mean for each station

ILWW Water Quality Annual Mean Concentration Trends



Special Nutrient Analysis 2002 - 2011

- Total Nitrogen and Total Phosphorus yearly means were analyzed to evaluate potential relationships between Dissolved Oxygen, Total Suspended Solids, Turbidity, and Chlorophyll a

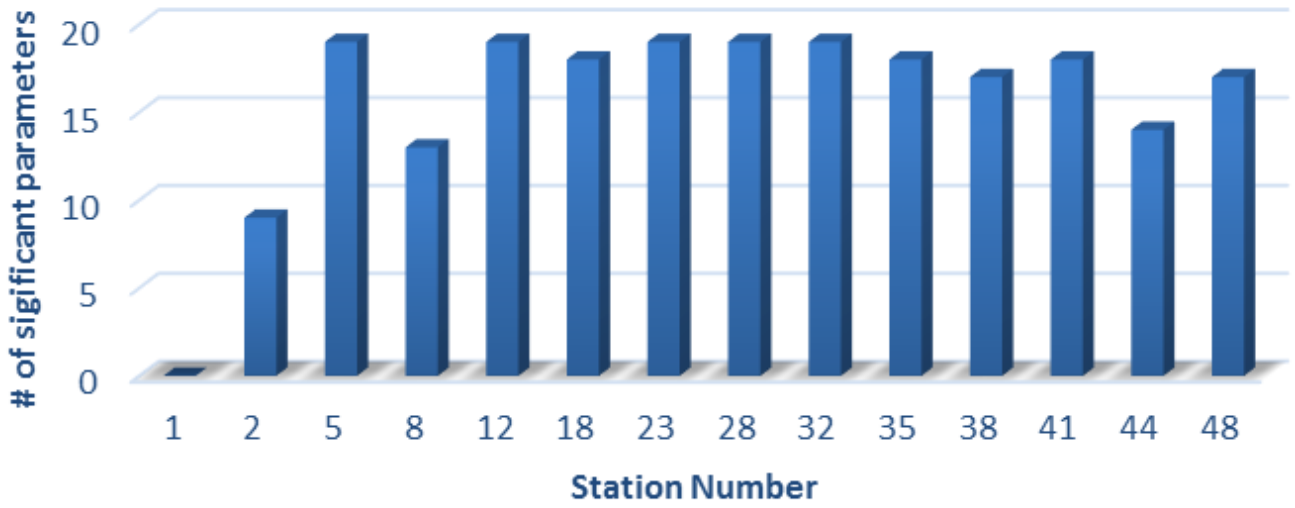
Simple Linear Regression for Selected Water Quality Parameters Assayed in the ILWW

Variable		Regression Result[1]		
Dependent (y)	Independent (x)	Intercept	Slope	R^2
Dissolved Oxygen	Total Nitrogen	14.93	-1.21	0.52
Total Suspended Solids	Total Nitrogen	120.36	-15.72	0.45
Turbidity	Total Nitrogen	151.34	-19.68	0.45
Chlorophyll a	Total Nitrogen	165.28	-24.68	0.76
Dissolved Oxygen	Total Phosphorus	11.95	-4.95	0.68
Total Suspended Solids	Total Phosphorus	70.16	-46.68	0.32
Turbidity	Total Phosphorus	88.44	-58.35	0.32
Chlorophyll a	Total Phosphorus	91.21	-81.09	0.71
Dissolved Oxygen	Chlorophyll a	-58.49	11.06	0.43
Turbidity	Chlorophyll a	6.43	0.60	0.47
[1]Log transformation taken for each variable				

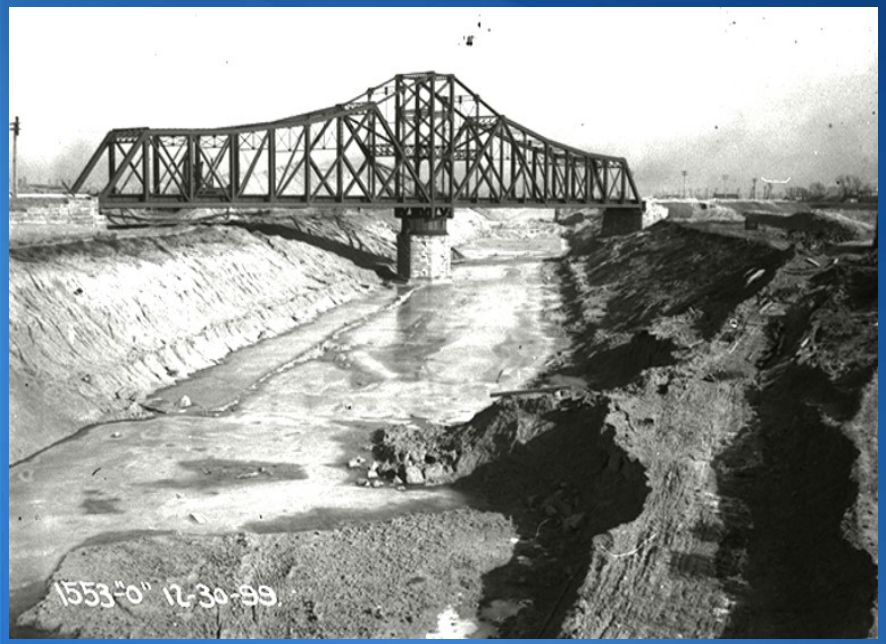
ILWW Sediment Chemistry Analysis

- Sediment data collected at 14 monitoring stations once per year over 26 years
- Meaningful statistical analysis is limited
  - ANOVA was done to look for temporal changes at each station
  - Mann-Kendall analyses was done to look for trends for each parameter over time

Significant Sediment Chemistry Parameters for Each ILWW Station Monitored Over 26 years



The Chicago Sanitary and Ship Canal near Lockport 1899



ILWW Sediment Chemistry Analysis cont.

- Trend analysis
  - No overall consistent trend for any parameter
  - Most parameters showed no trend
  - A few occurrences of positive or negative trends were found
  - Total cyanide had the highest number of occurrences for a negative trend at 7 out of 14 stations

Summary of Data Analysis for ILWW Monitoring Program

Water Quality

- Every station had some parameters with significant differences over the 21 years analyzed.
- Each station showed significant seasonal differences for some parameters.
- Some trends were found over time.

Sediment Quality

- Each station had some parameters with significant differences over the 26 years analyzed except for station 1.
- No clear trends were found over time.

Biological improvements in the ILWW

Fish (McClelland et al. 2012)

Increases in overall and native fish species richness.

Increases in relative abundance of native fishes. (1980s)

Mussels (Seitman et al. 2001)

Freshwater mussel recolonization of the upper ILWW. (1980s)

Future ILWW Monitoring Program Considerations

- Further investigations on water quality impacts from:
  - Phosphorus Reduction and Recovery
  - New Water Quality Standards in the CAWS
  - Thornton Composite Reservoir

Acknowledgments

- Thank you to: Jennifer Wasik, Dustin Gallagher, Justin Vick, Nick Kollias, Tom Granato, Heng Zhang, Albert Cox, Zainul Abedin, Justin Brown, Richard Lanyon, Angel Whitington, Greg Yarnik, Sharon Sopack-Phelan, Irwin Polls, Sam Dennison, Mary Hartford, Mike Sopcak
  - AND all of those in the Industrial Waste, Analytical Laboratories, and Environmental Monitoring and Research Divisions for their efforts in collecting and analyzing the samples

Questions?

“jointed river minnow”