The Grand River

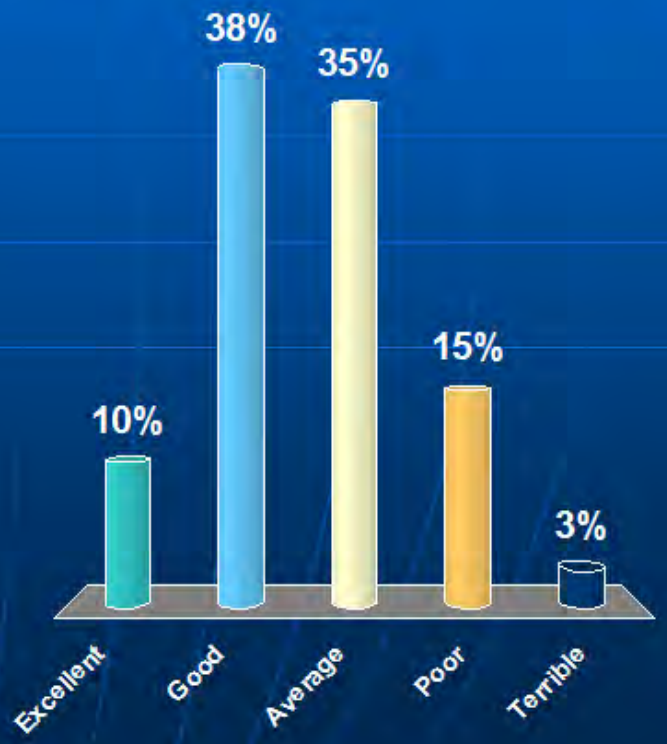
Overview of Water Quality and Ecological Health

Daniel M. O'Keefe, Ph.D.
Michigan Sea Grant
MSU Extension

How does surface water quality in Ottawa County compare to other areas of the state?

How would you rate Ottawa County's surface water quality in relation to other areas of the state?

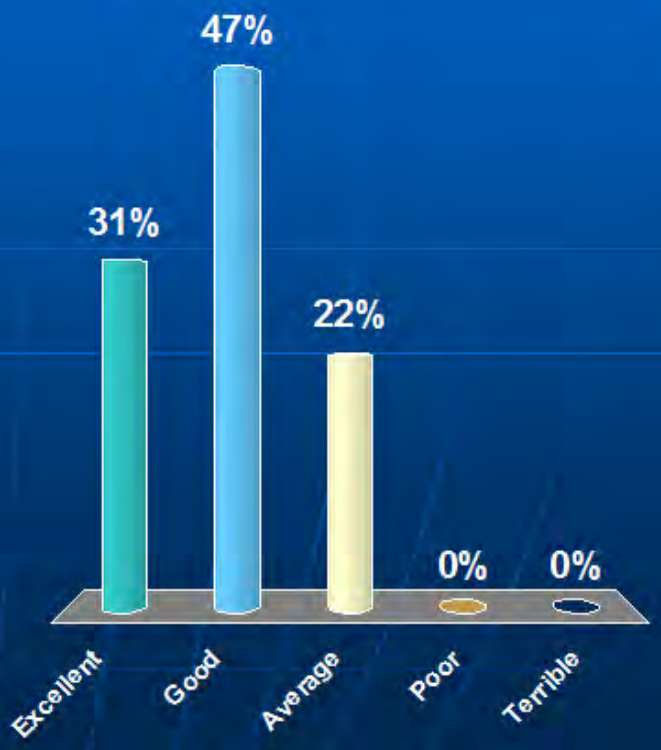
1. Excellent
2. Good
3. Average
4. Poor
5. Terrible



Audience Polling Results from
4th Annual Ottawa County WQF - 2009

How would you rate Ottawa County's surface water quality in relation to other areas of the state?

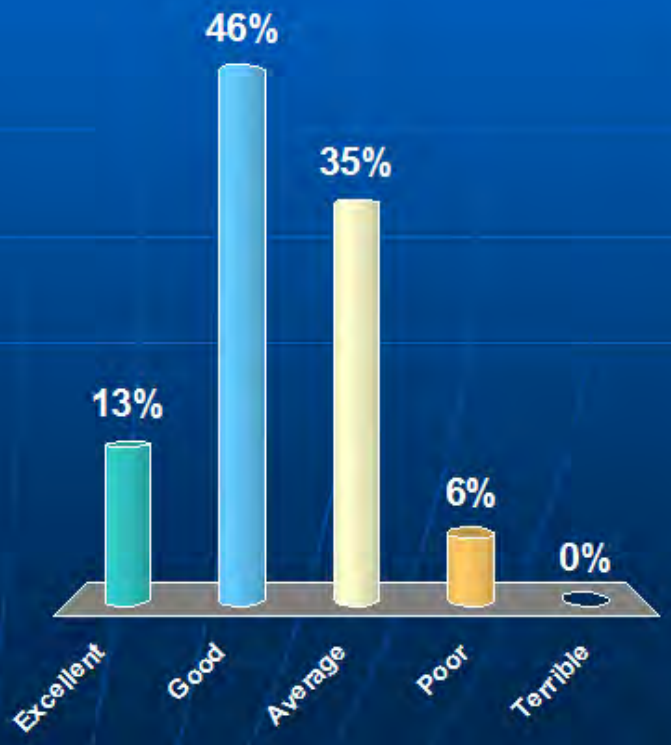
1. Excellent
2. Good
3. Average
4. Poor
5. Terrible



Audience Polling Results from
6th Annual Ottawa County WQF - 2011

How would you rate Ottawa County's surface water quality in relation to other areas of the state?

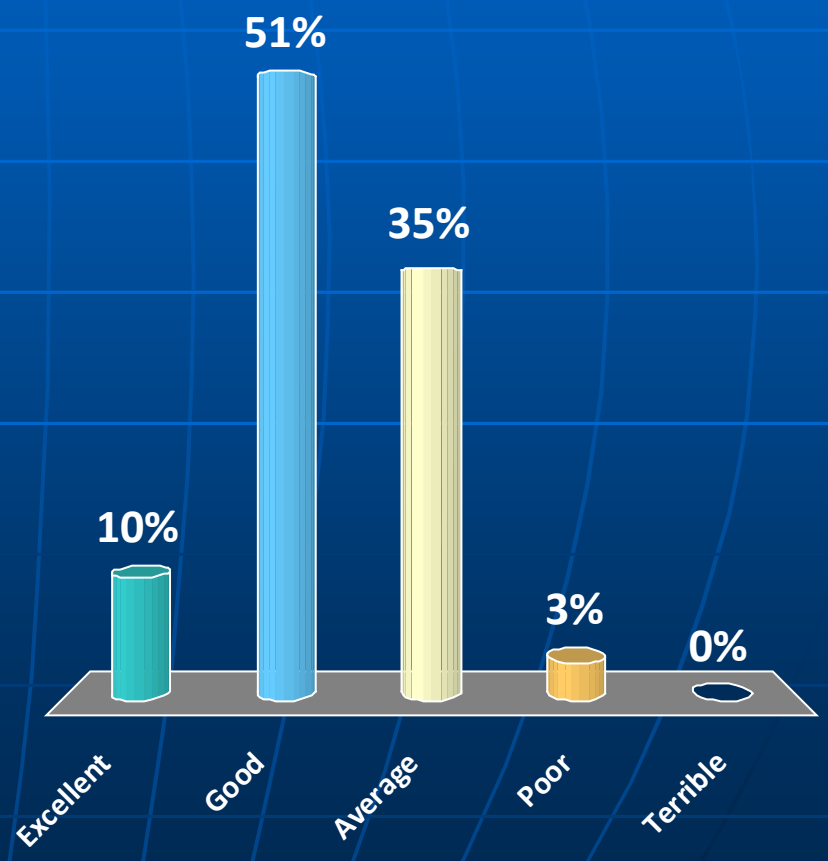
1. Excellent
2. Good
3. Average
4. Poor
5. Terrible



Audience Polling Results from
7th Annual Ottawa County WQF - 2012

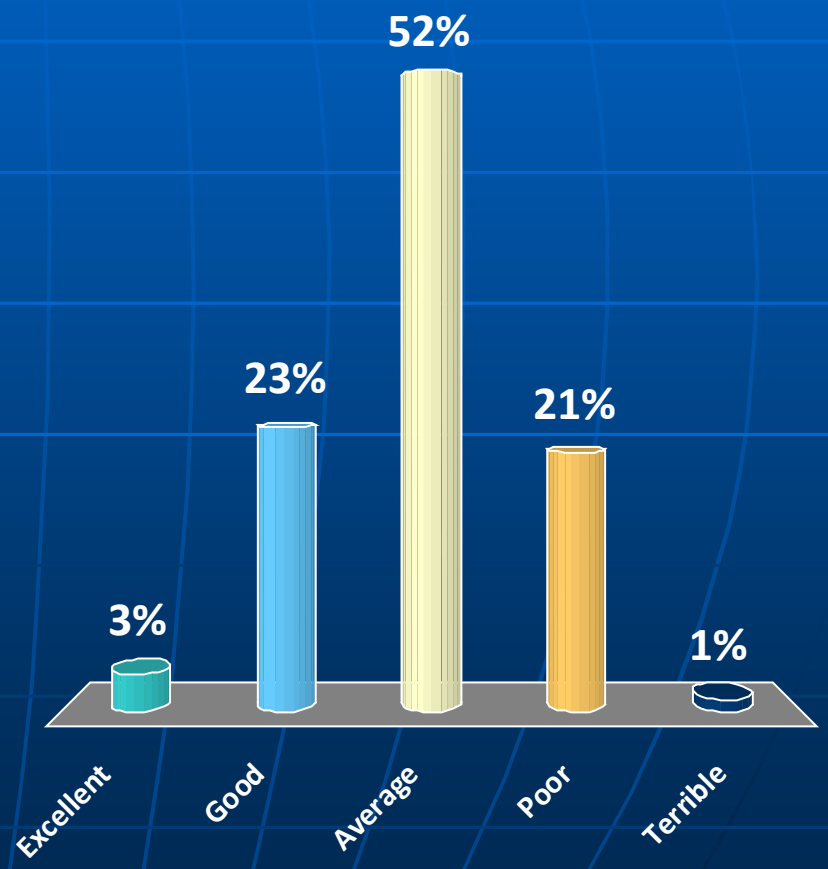
How would you rate Ottawa County's surface water quality in relation to other areas of the state?

1. Excellent
2. Good
3. Average
4. Poor
5. Terrible



How would you rate surface water quality in the Grand River in relation to other areas of the state?

1. Excellent
2. Good
3. Average
4. Poor
5. Terrible



How ‘healthy’ is the Grand River?

Stream Order

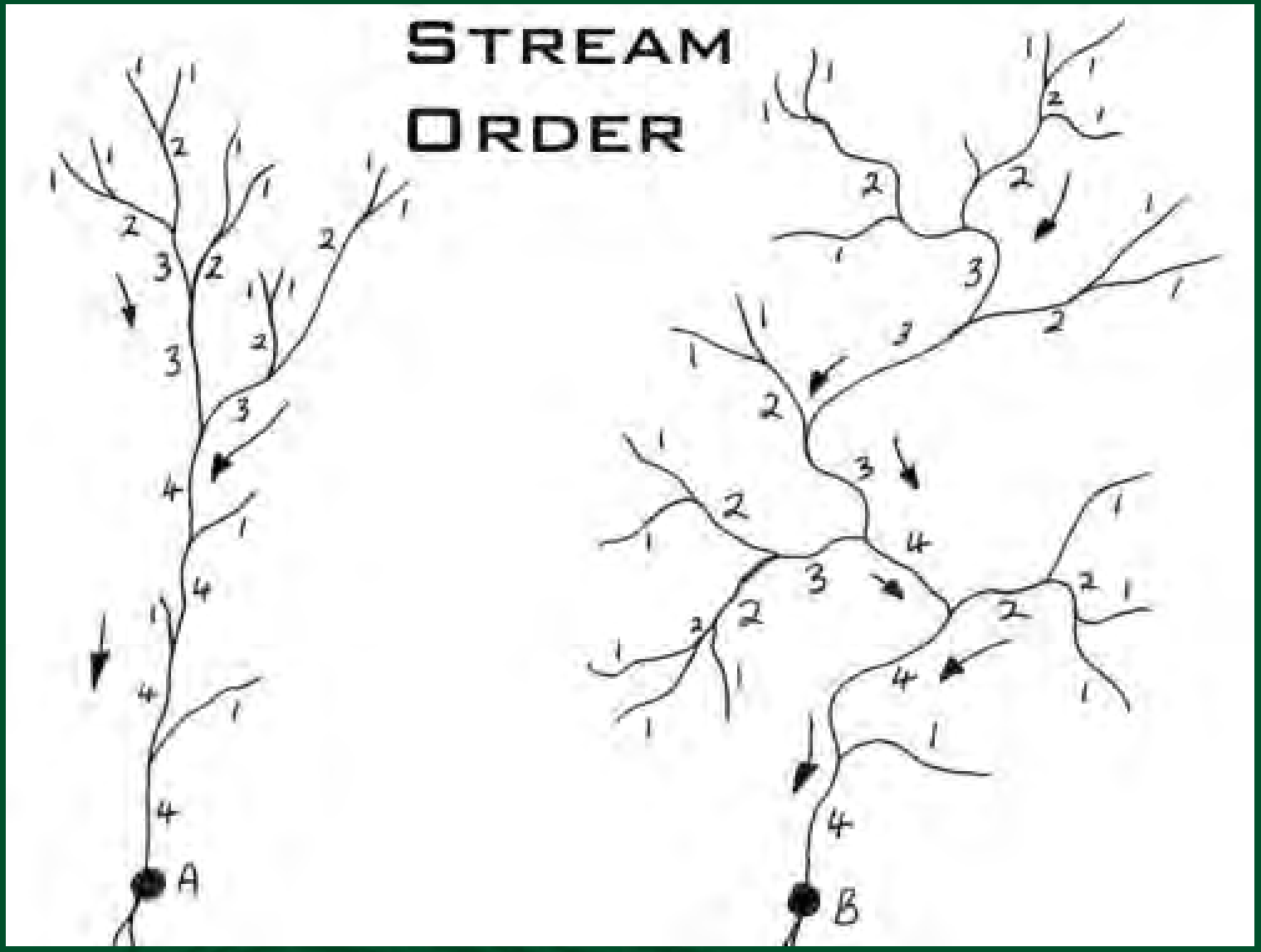
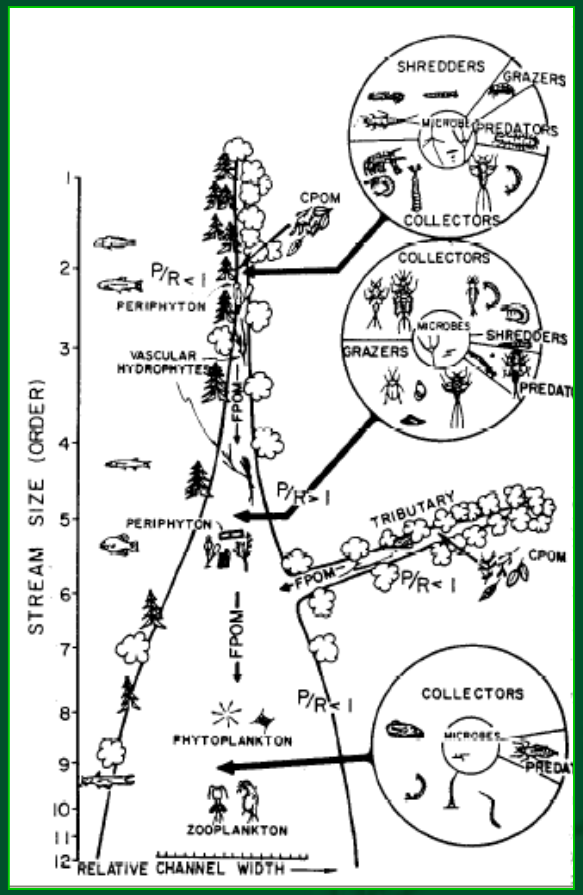


Image from lifeinfreshwater.org.uk

The River Continuum



Vannote et al. 1980

Headwater Creeks

Low Fish Diversity

Trout, Sculpin

Midreach Streams

Balanced Energy Inputs

Suckers, Sm. Bass

Large Rivers

Backwaters Important

Highly Productive

Diverse Fish Species

How ‘healthy’ is the Grand River?

Elements of Water Quality

- Physical – temperature, conductivity, turbidity
- Chemical – oxygen, nutrients, toxics, pharmaceuticals
- Biological – fecal indicators, pathogens, BOD
- These factors are often interrelated

Other Components of Ecological Health

- Biological Communities – fish, invertebrates
- Contaminants in Fish – PCBs, mercury
- Stream Hydrology – patterns of stream flow over time
- Watershed – soils, land use, BMPs, nutrient sources
- Habitat – riparian vegetation, substrate, sinuosity

How ‘healthy’ is the Grand River?

Can we reduce this to a single number?

City of Grand Rapids
Environmental Services

Grand River Monitoring

by

Mike Lunn

Environmental Services Department Manager

Presented at 9th Annual
Ottawa County WQF

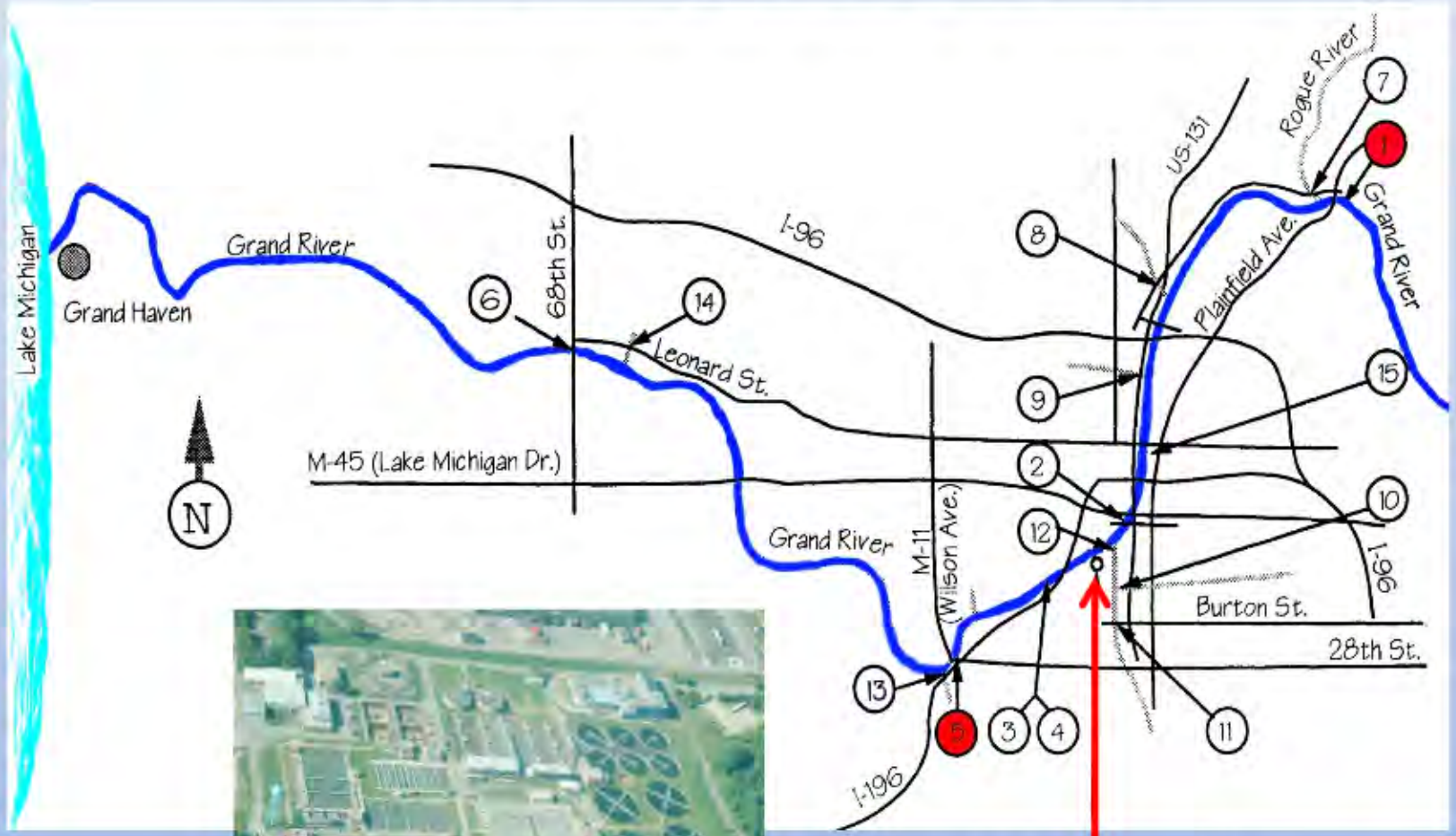
Grand Rapids Modified Water Quality Index

Parameter	Weight
Dissolved oxygen	0.18
Fecal coliform	0.17
pH	0.12
Biochemical oxygen demand	0.12
Temperature change	0.11
Total phosphate	0.11
Nitrates	0.11
Turbidity – Not Measured	-
Total Suspended Solids + Chlorides instead of Total solids	0.08

Water Quality Index Legend

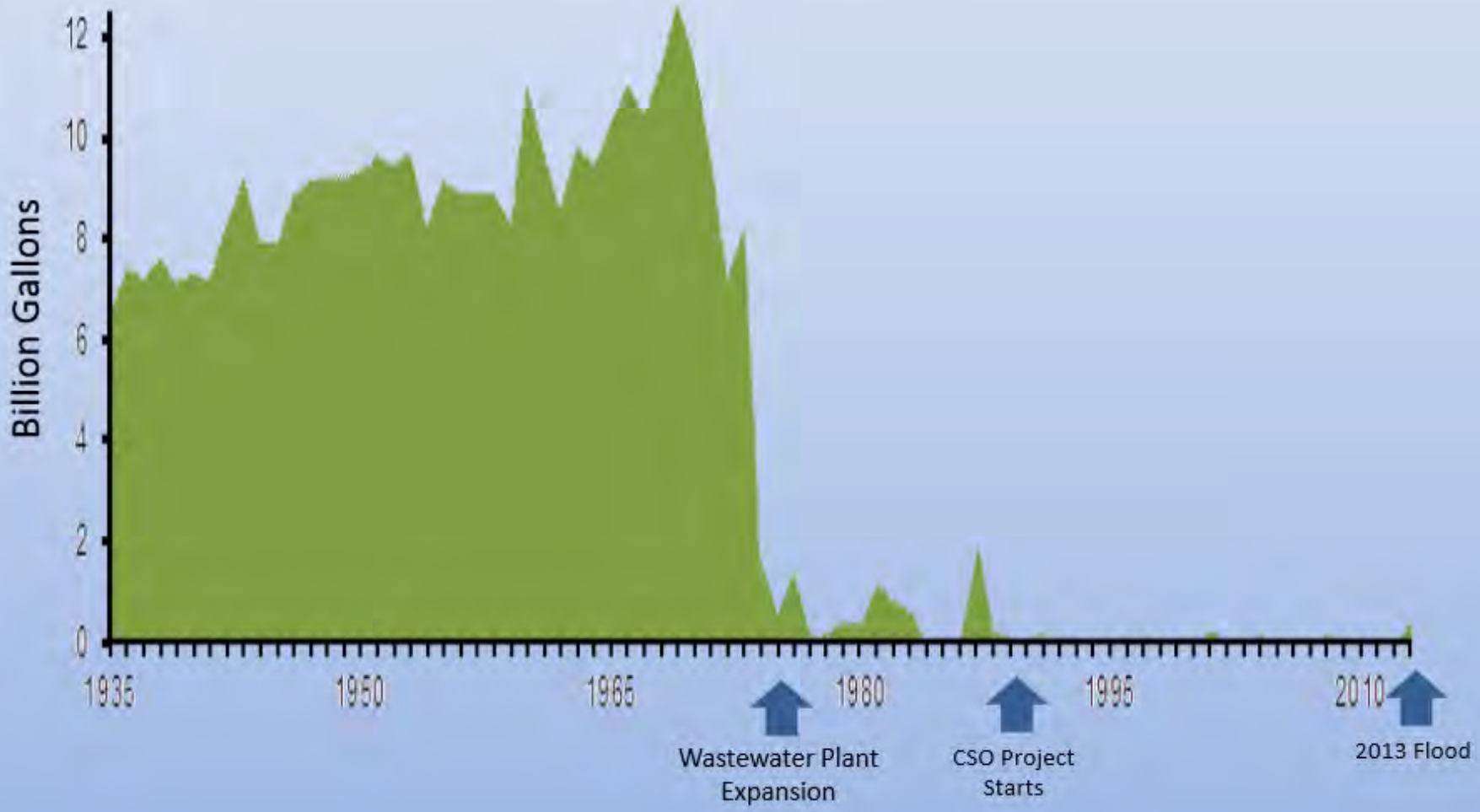
Range	Quality
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very bad

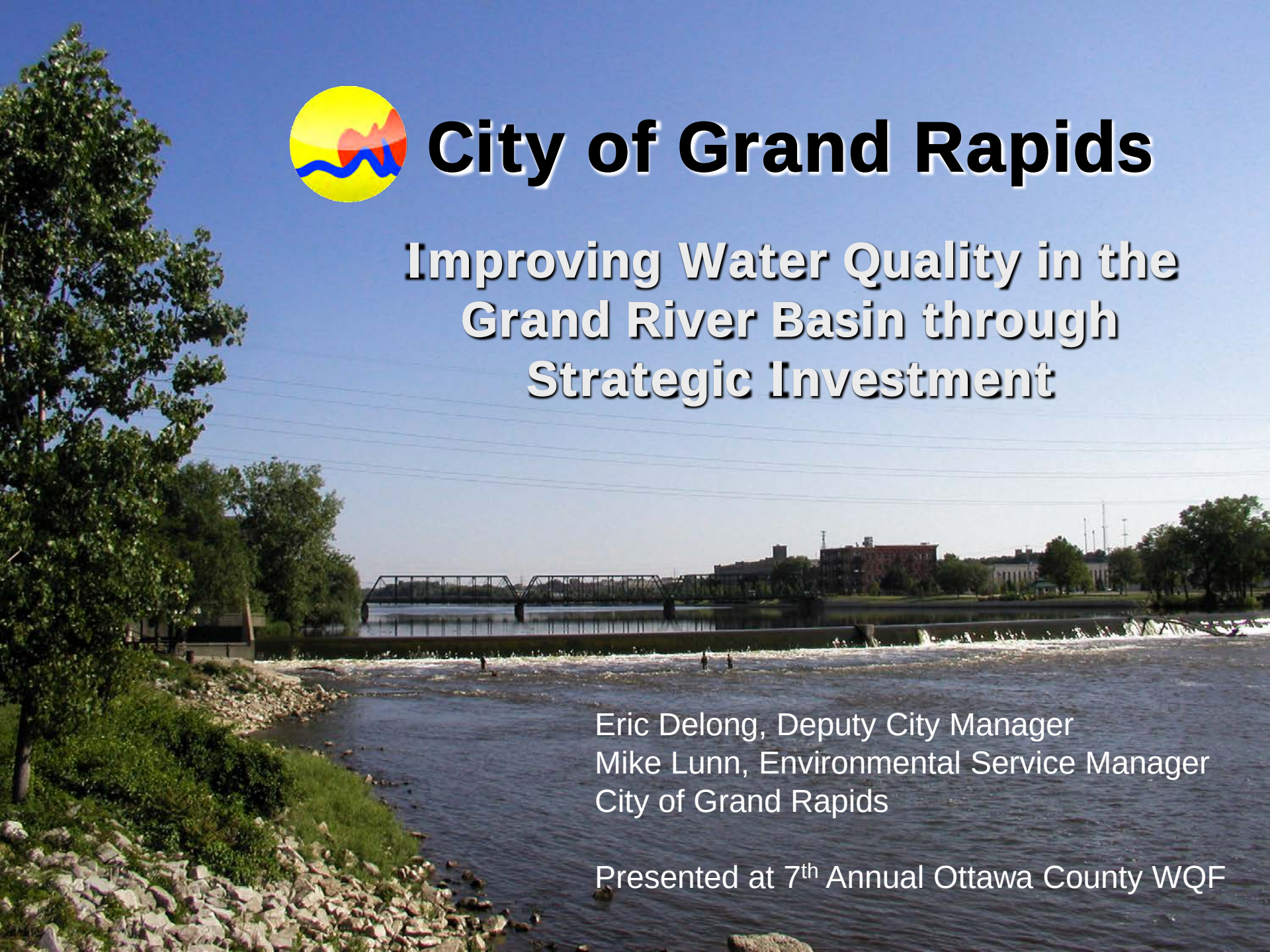
Monitoring Locations



Grand Rapids WWTP

Grand Rapids Combined Sewer Overflow History (Billion Gallons)





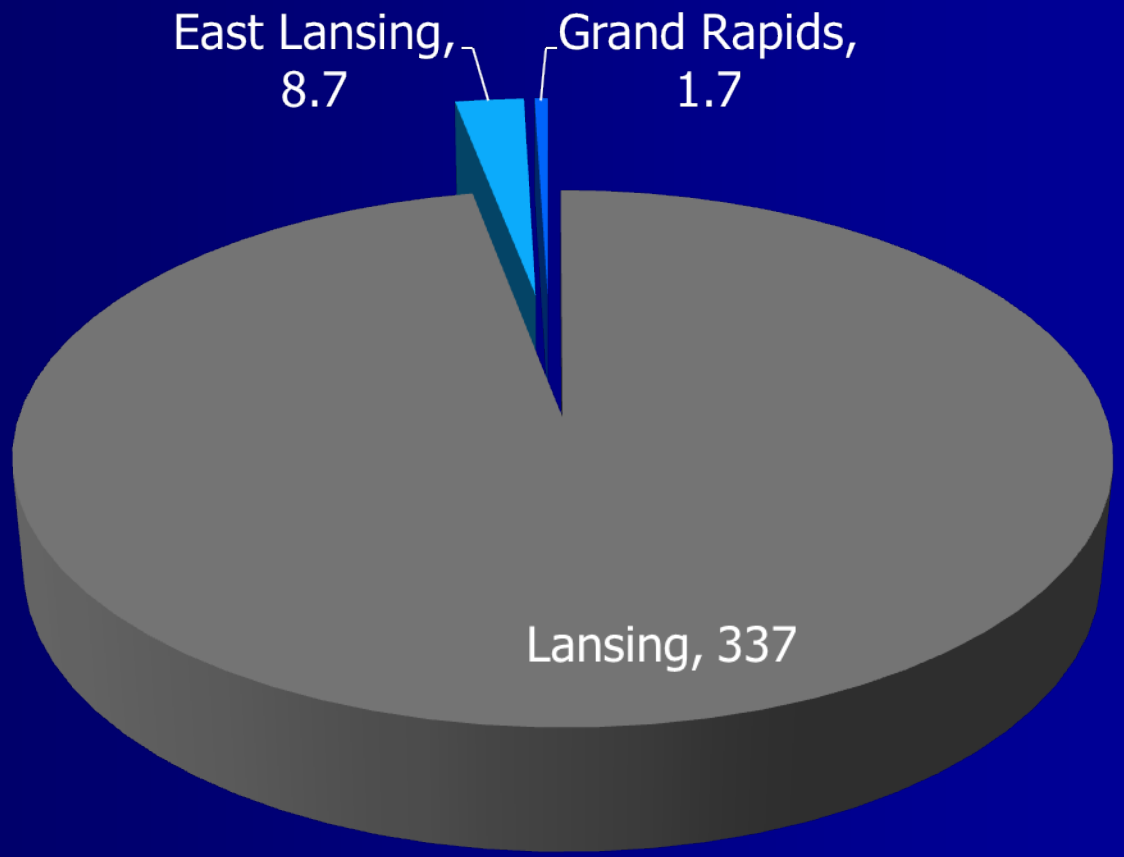
City of Grand Rapids

Improving Water Quality in the Grand River Basin through Strategic Investment

Eric Delong, Deputy City Manager
Mike Lunn, Environmental Service Manager
City of Grand Rapids

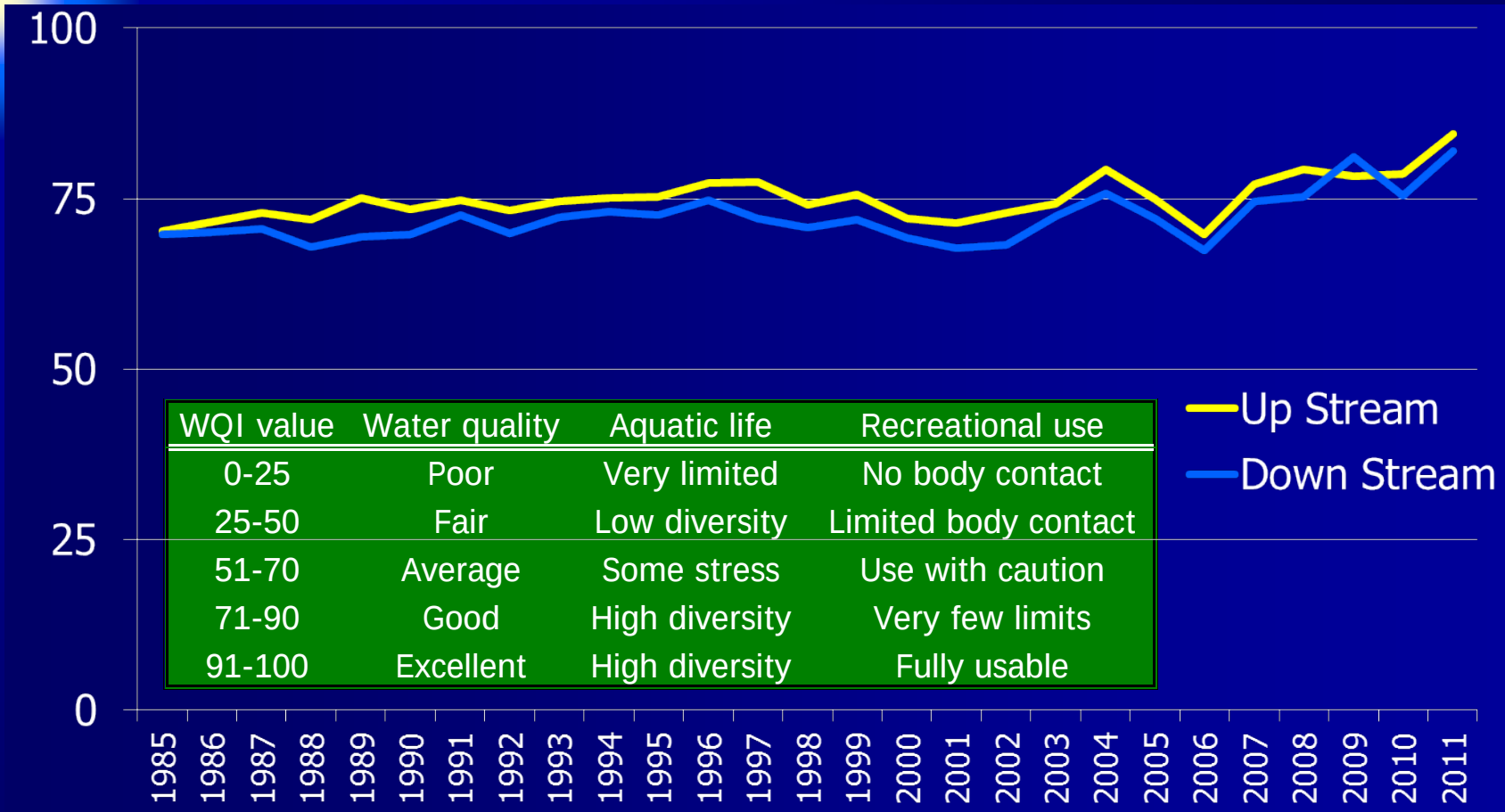
Presented at 7th Annual Ottawa County WQF

Grand River CSO's 2010
Million Gallons



Source: Michigan Department of Environmental Quality
Combined Sewer Overflow (CSO) Sanitary Sewer Overflow (SSO) and Retention Treatment Basin (RTB) Discharge 2010 Annual Report
(January 1, 2010 - December 31, 2010)

Grand Rapids Region
Upstream (Yellow) / Downstream (Blue)
Water Quality Index (WQI)

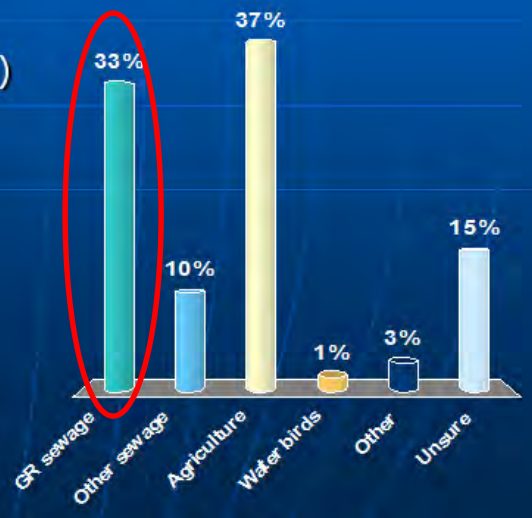


WQI value	Water quality	Aquatic life	Recreational use
0-25	Poor	Very limited	No body contact
25-50	Fair	Low diversity	Limited body contact
51-70	Average	Some stress	Use with caution
71-90	Good	High diversity	Very few limits
91-100	Excellent	High diversity	Fully usable

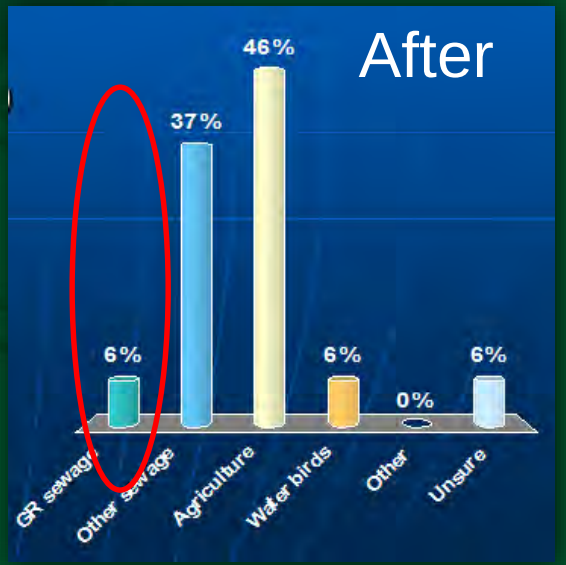
Before

In your opinion, what is the leading contributor of *E. coli* contamination in the Grand River watershed?

1. Urban sewage (Grand Rapids)
2. Urban sewage (Other)
3. Agriculture
4. Water birds
5. Other
6. Unsure



After



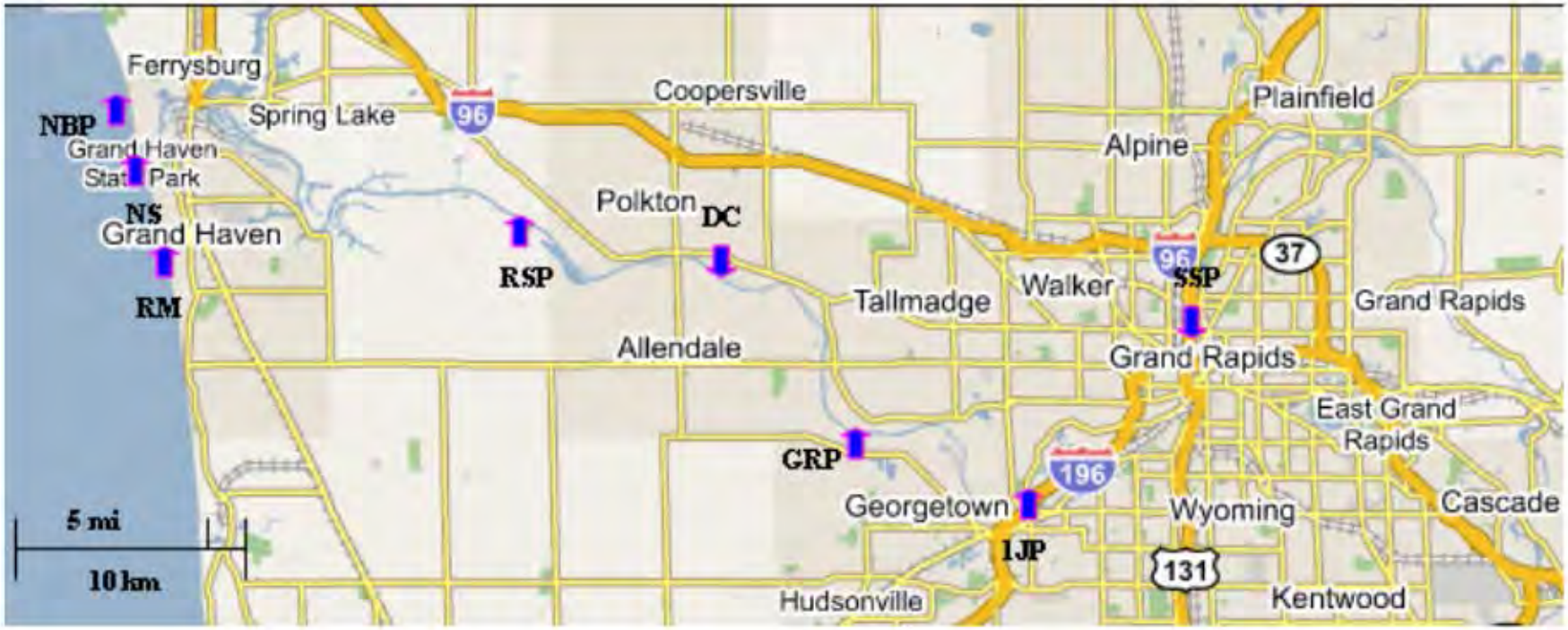
Polling at 7th Annual Ottawa County WQF - 2012

Water Pollution Studies for the Lower Grand River, Michigan

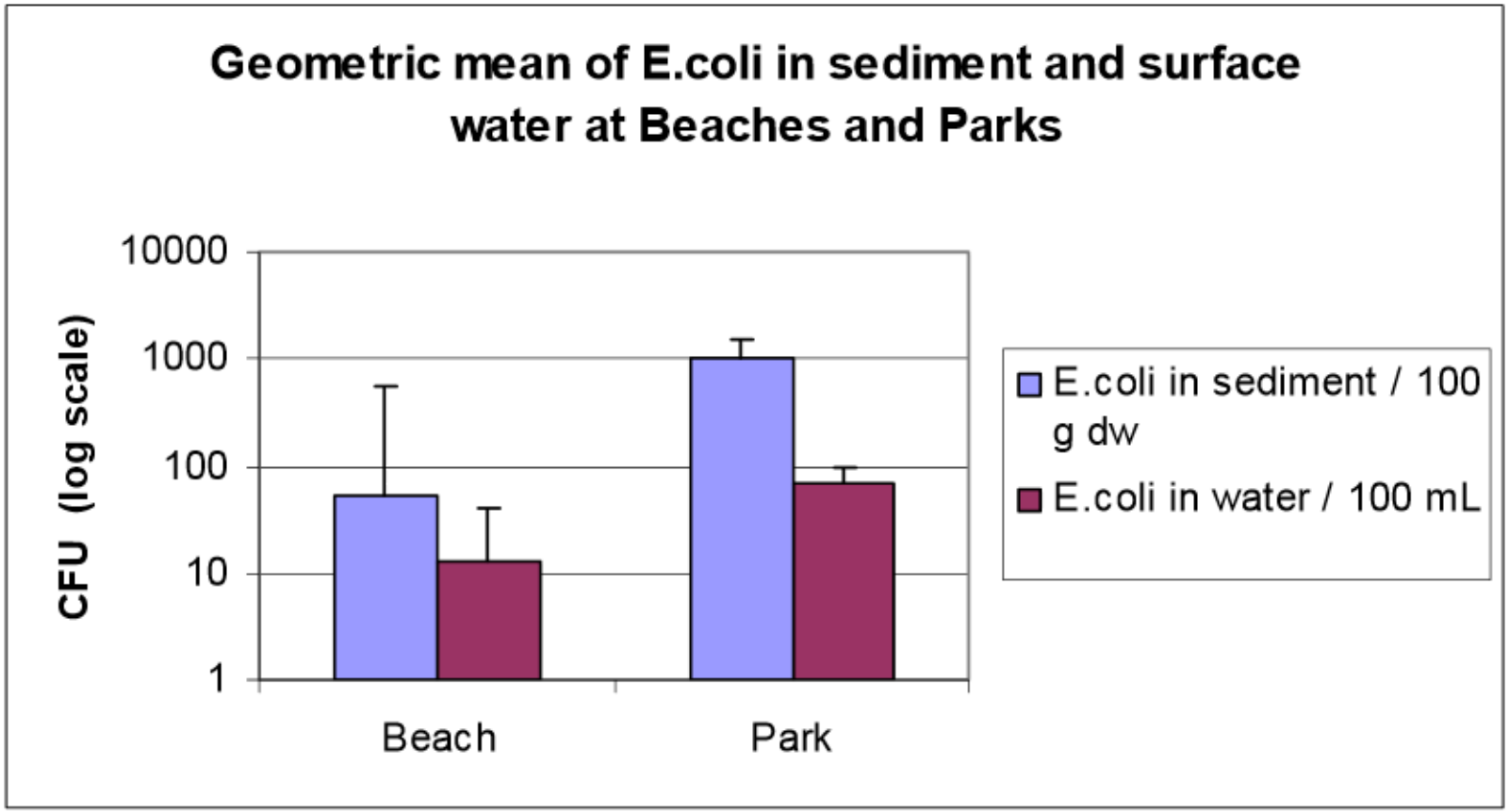
Dr. Joan B. Rose
rosejo@msu.edu
Dr. Phanikumar Mantha
phani@msu.edu
Rebecca Ives, Shikha Singh and Theng Theng Fong and Chao Peng

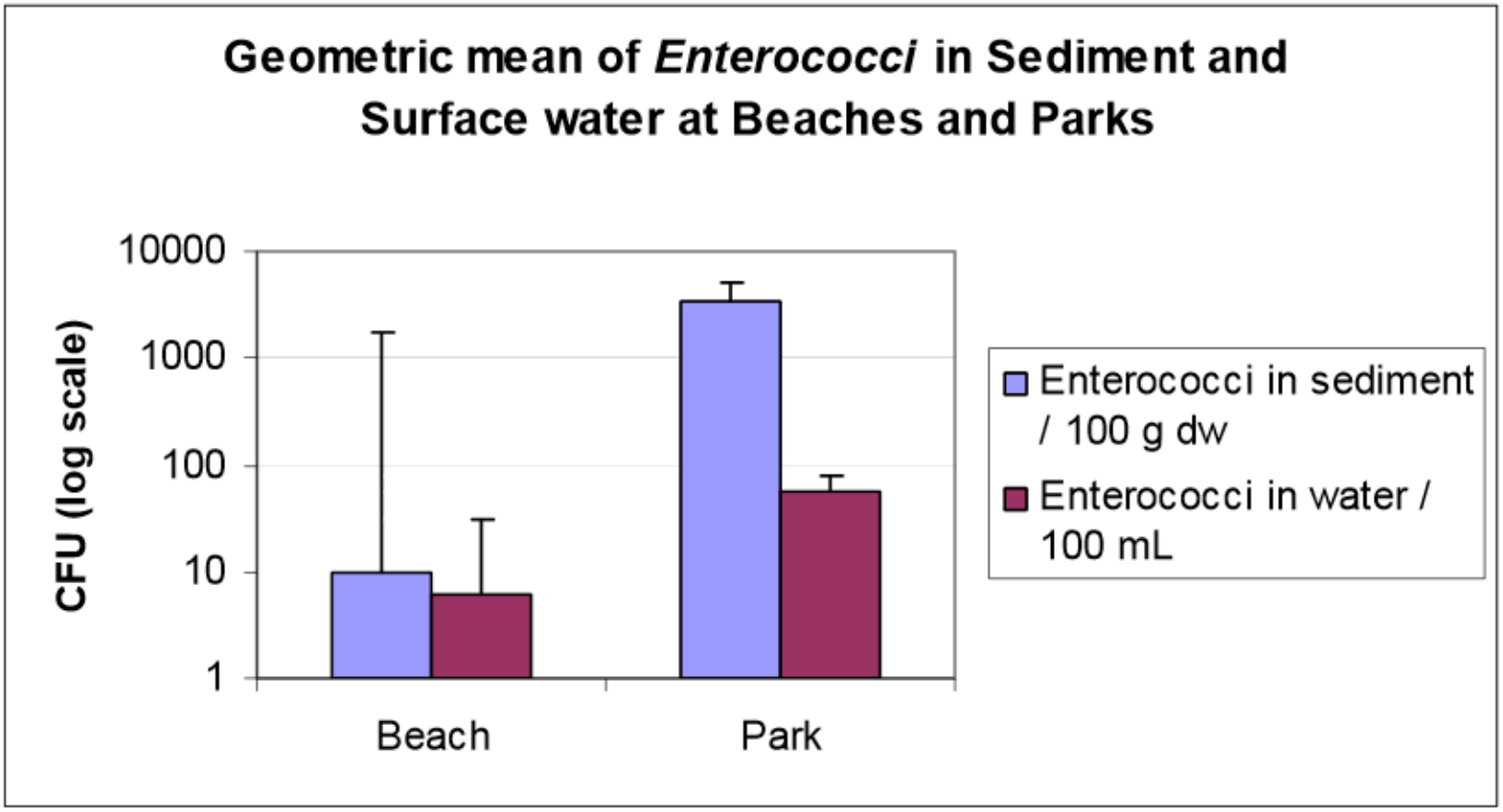
MICHIGAN STATE UNIVERSITY

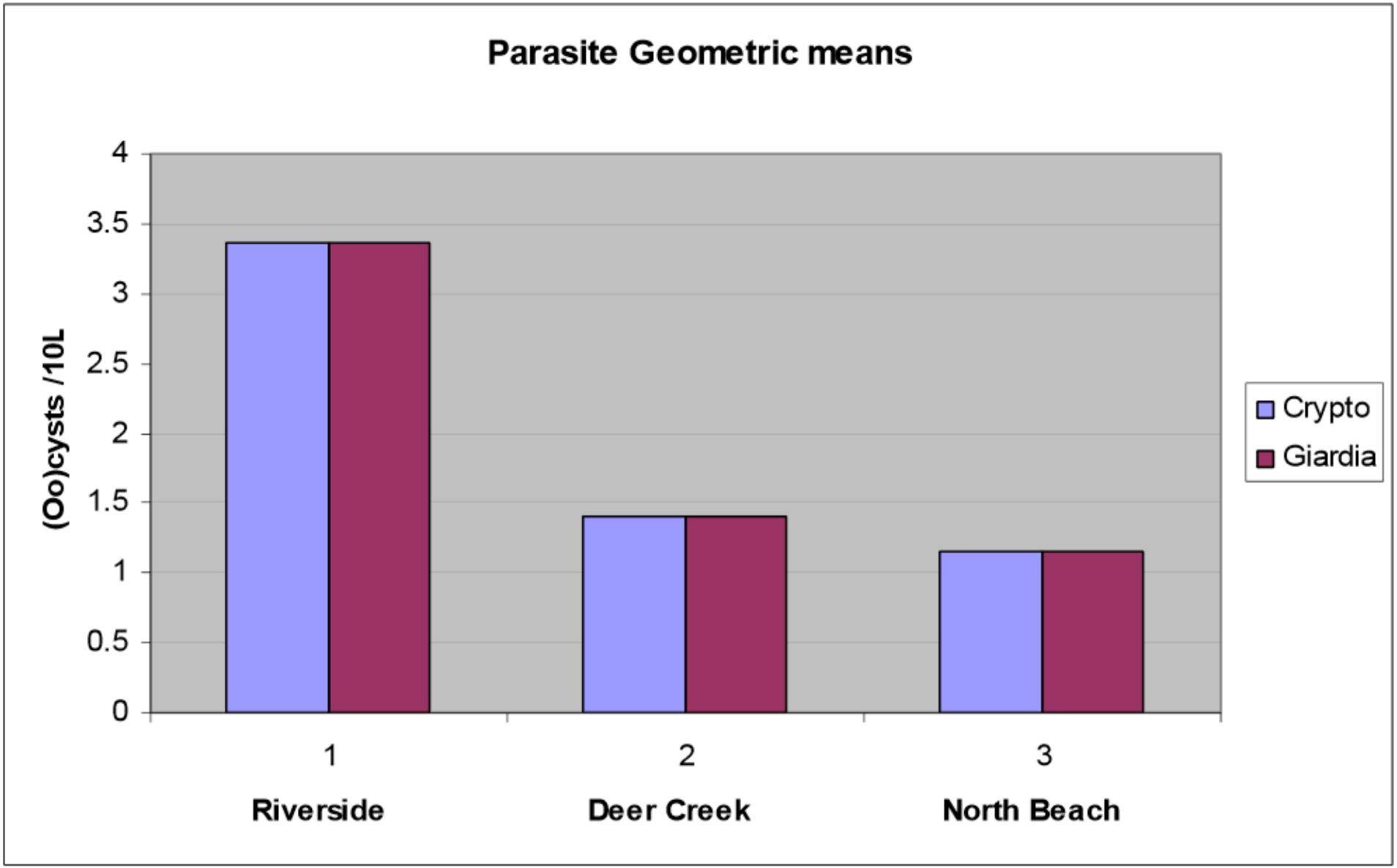
Presented at 1st Annual Ottawa County WQF



Sites sampled 1/week June to Sept and 1/month from Oct. to Dec.


Geometric mean of E.coli in sediment and surface water at Beaches and Parks
CFU (log scale)
10000
1000
100
10
1
Beach
Park
E.coli in sediment / 100 g dw
E.coli in water / 100 mL


Geometric mean of *Enterococci* in Sediment and Surface water at Beaches and Parks
CFU (log scale)
10000
1000
100
10
1
Beach
Park
Enterococci in sediment / 100 g dw
Enterococci in water / 100 mL


Parasite Geometric means
(Oo)cysts /10L
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
Riverside
Deer Creek
North Beach
Crypto
Giardia

Indicator Violations in the River for full body contact

- 26.6 % samples exceeded the US EPA *Enterococci* criterion
- 9.4 % samples exceeded US EPA criterion for *E.coli*
- 5.5 % samples exceeded Michigan standard for *E.coli*
- 10.2% samples exceeded the Hawaii fresh water criteria for *C. perfringens*

Microbial Source Tracking Study in The Grand River

Presented at 7th Annual Ottawa County WQF

Vijay Kannappan
Sr. Environmental Health Specialist

Michigan Beach Water Quality Standards

- Single sample standard : 300 CFU/100ml of *E. coli*
  (daily geometric mean of at least three samples).

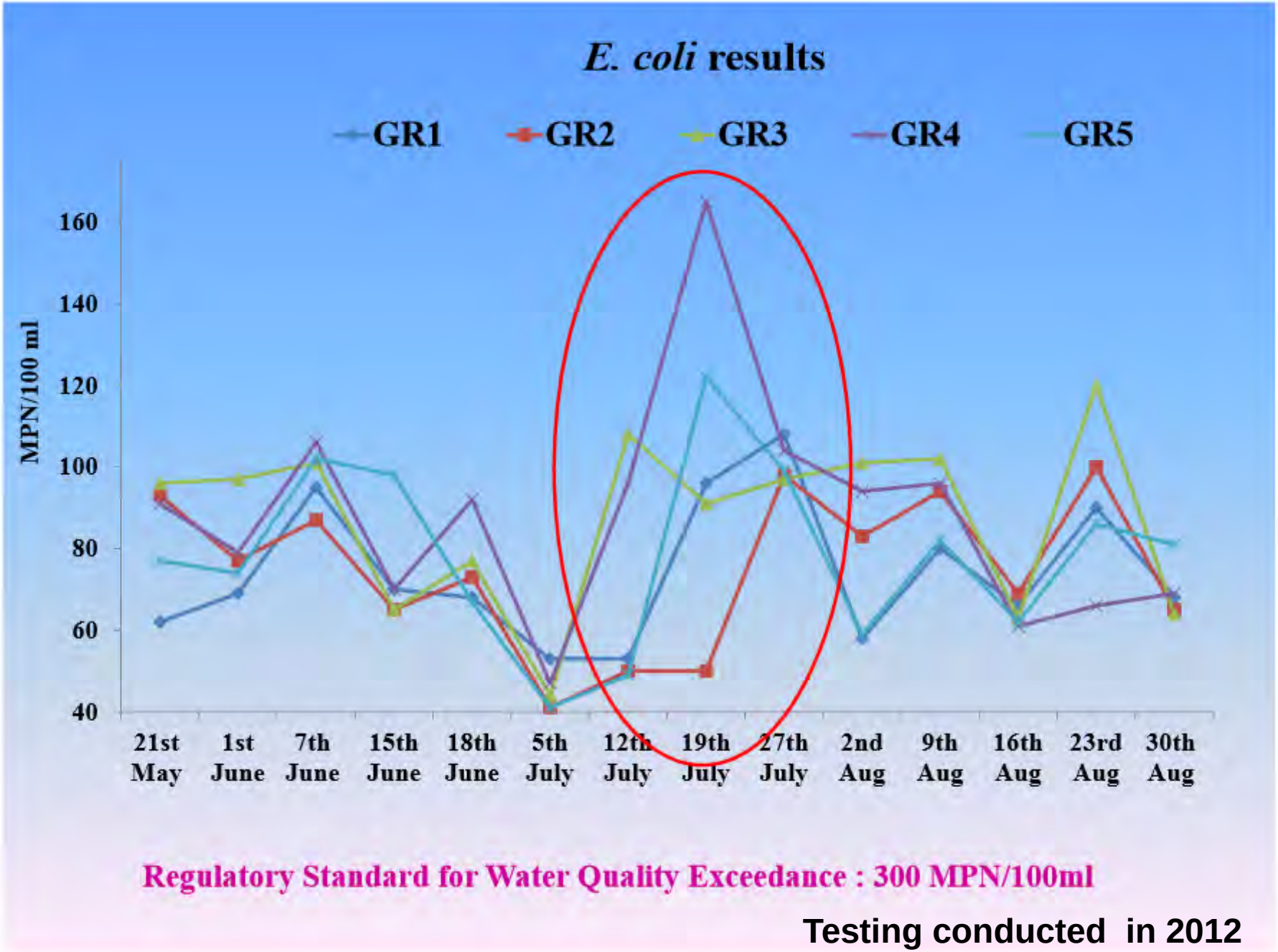
- 130 CFU *E.coli*/ 100 mL
  (monthly geometric mean of at least 5 sampling events)

- Michigan Water Quality Standards for recreational beaches are slightly different from the EPA's criteria.

- Below the EPA's acceptable risk level of 1%
  (10 people per 1000 getting sick).

Problem

"FIB such as *E. coli* is not human specific."



Testing conducted in 2012

Alternate FIB : Bacteroides species

- *Bacteroides* is a genus of Gram-negative, rod-shaped, non- endospore forming anaerobes.
- Normal commensals in mammalian gastro intestinal tract and feces.
- Make up a significant portion of the fecal bacterial population.
- Present in intestine and feces at thousand times greater than *E. coli.*
- Unlike *E. coli*, Bacteroides spp. do not proliferate in the environment
- Bacteroides hosts (human, cow, swine) are well established for environmental application.
- Examples of Bacteroides species :
  B. fragilis, B. thetaiotaomicron, B. uniformis, B. ovatus, B. vulgatus, B. caccae, B. eggerthii.

Study Findings : General Bacteroides

- Were present in all the tested samples
- Comparable to 10^{-3} concentration of sewage.
- Water quality rating : No conclusion can be drawn

Study Findings : Human specific Bacteroides

- Scarcely present.
- Very Low concentrations.
- Comparable to 10^{-6} concentration of sewage.

(GR1 site; August sample comparable to 10^{-3} sewage concentration)

- Water quality rating : Good

Study Findings : Cow specific Bacteroides

- Scarcely present.
- Low concentrations
- Comparable to 10^{-5} concentration of cow feces.
- Water quality rating : Good

Study Findings : Swine specific Bacteroides

- Moderately present.
- Low concentrations
- Comparable to 10^{-4} concentration of swine feces.
- Water quality rating : Moderate to low risk

USGS
science for a changing world

Selected pesticide and trace organics monitoring studies, statewide context for observations from the Grand River

Joe Duris
Water Quality Specialist
USGS Michigan Water Science Center
In Cooperation with Michigan Department of Environmental Quality and Great Lakes Restoration Initiative

U.S. Department of the Interior
U.S. Geological Survey

Presented at 9th Annual Ottawa County WQF

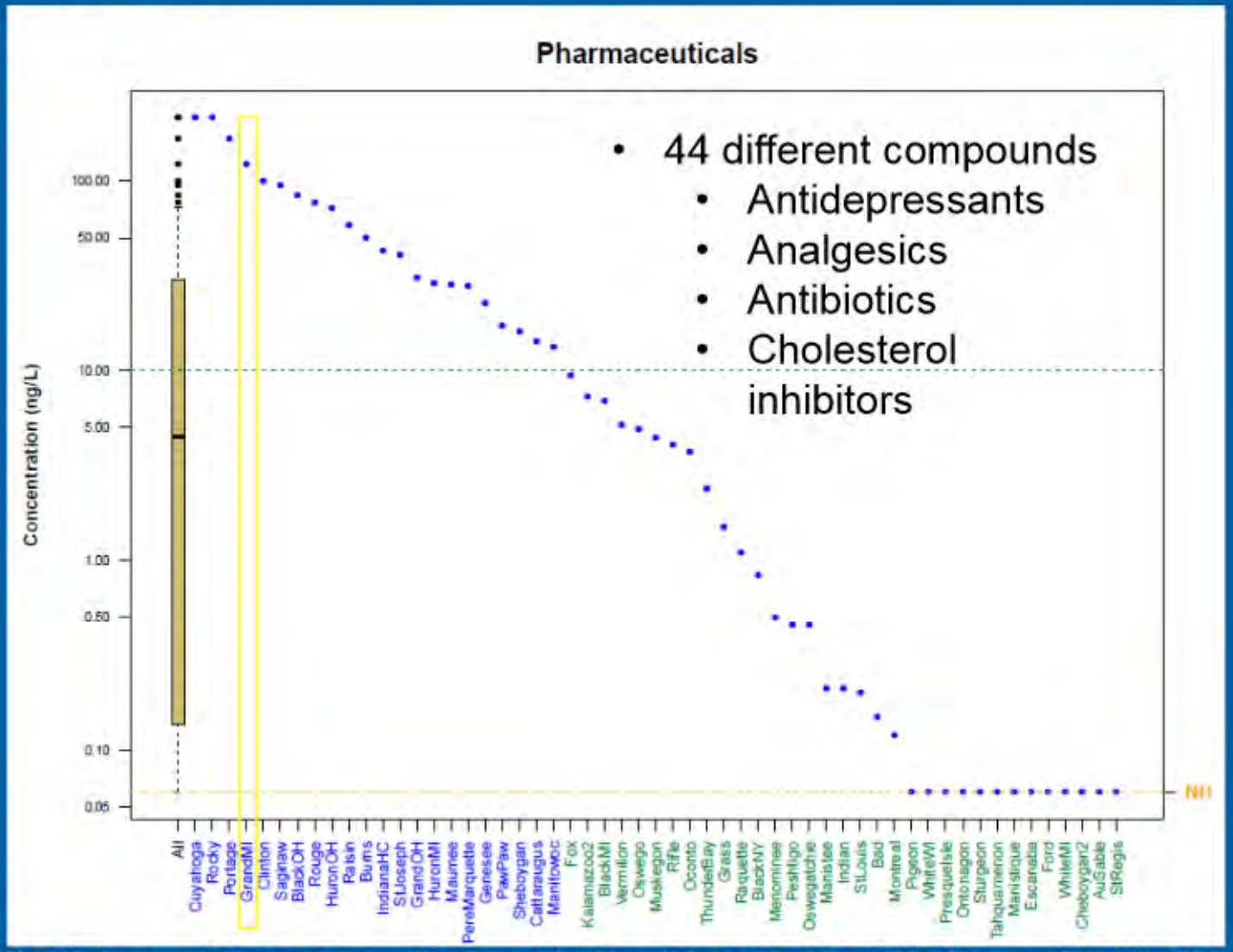
USGS
science for a changing world

GLRI Tributary Monitoring

- **Nutrients**, sediment, major ions, and continuous water quality
  - Temp, pH, Specific Conductance, DO, Turbidity
- Isco auto-sampler, automated virus sampler, flow integrated samples, & passive sampler
- Pathogens, fDOM, **emerging chemicals**
  - Goal: Develop relations with co-occurring contaminants and surrogates
  - Ongoing since 2010
  - Currently developing surrogate relations

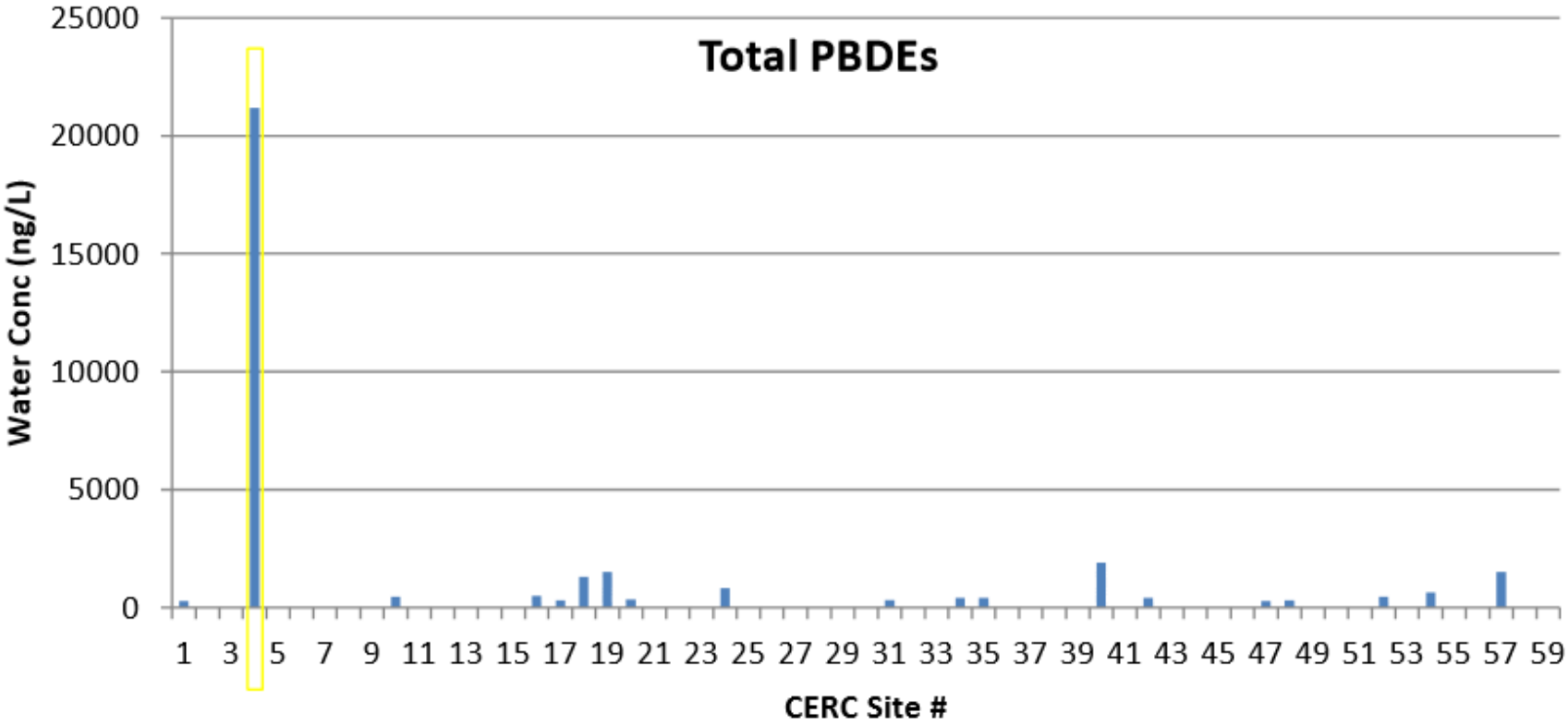
USGS

How does the Grand compare to other sites?



USGS

Elevated Total PBDEs (flame retardants)



USGS

Other Components of Ecological Health

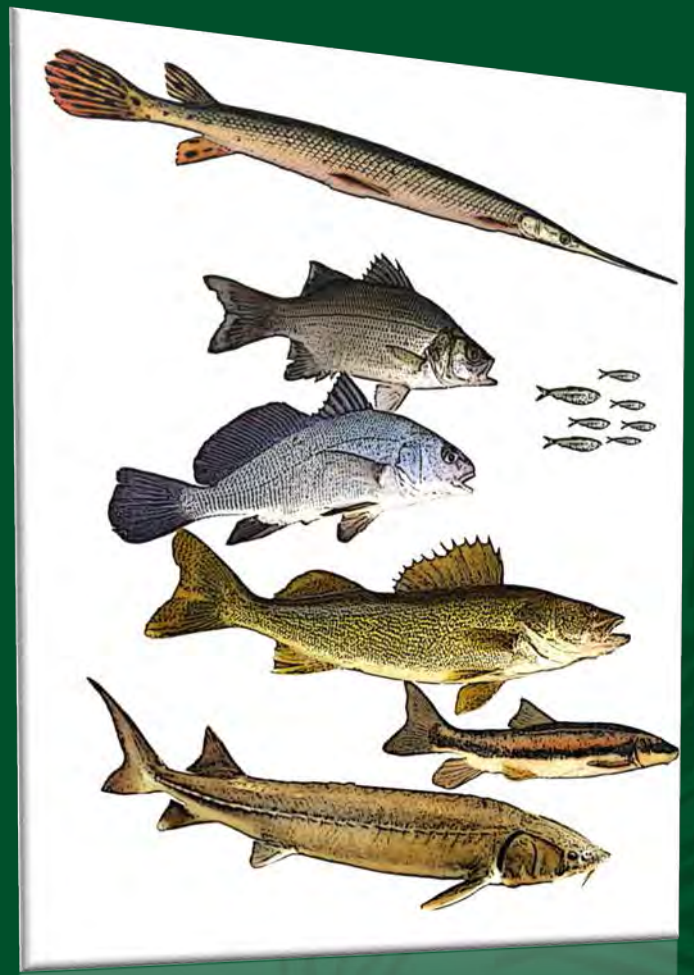
- Biological Communities – fish, invertebrates
- Contaminants in Fish – PCBs, mercury
- Stream Hydrology – patterns of stream flow over time
- Watershed – soils, land use, BMPs, nutrient sources
- Habitat – riparian vegetation, substrate, sinuosity

Macroinvertebrates

"Bloodworms" are a larval chironomids that tolerate low O_2.

Many caddisfly species do not tolerate poor water quality.

- Diverse dragonflies and damselflies in lower Grand
- 2009 DEQ survey found "poor" macroinvertebrates at all three Ottawa Co. Grand River sites
- Mostly chironomids and very few sensitive species



Fish Diversity

- 108 fish spp. in Grand River watershed
- ~100 in Ottawa County
- Two state threatened species in Ottawa Co.
- Diverse habitats and connectivity are critical

Journal of Great Lakes Research 36 (2010) 505–519

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

An ecological assessment of Great Lakes tributaries in the Michigan Peninsulas

Catherine M. Riseng [a,*], Michael J. Wiley [a,1], Paul W. Seelbach [b,2], R. Jan Stevenson [c,3]

[a] School of Natural Resources and Environment, University of Michigan, Ann Arbor, Michigan 48109, USA
[b] Great Lakes Science Center, U.S. Geological Services, Ann Arbor, Michigan 48105, USA
[c] Department of Zoology, Michigan State University, East Lansing, MI 48824, USA

- 31 watersheds in Michigan assessed
- Impairment ranged from 1.7% to 90.1%
- 38.6% of rkm in Grand watershed impaired
- Grand ranked 9 of 31 most impaired

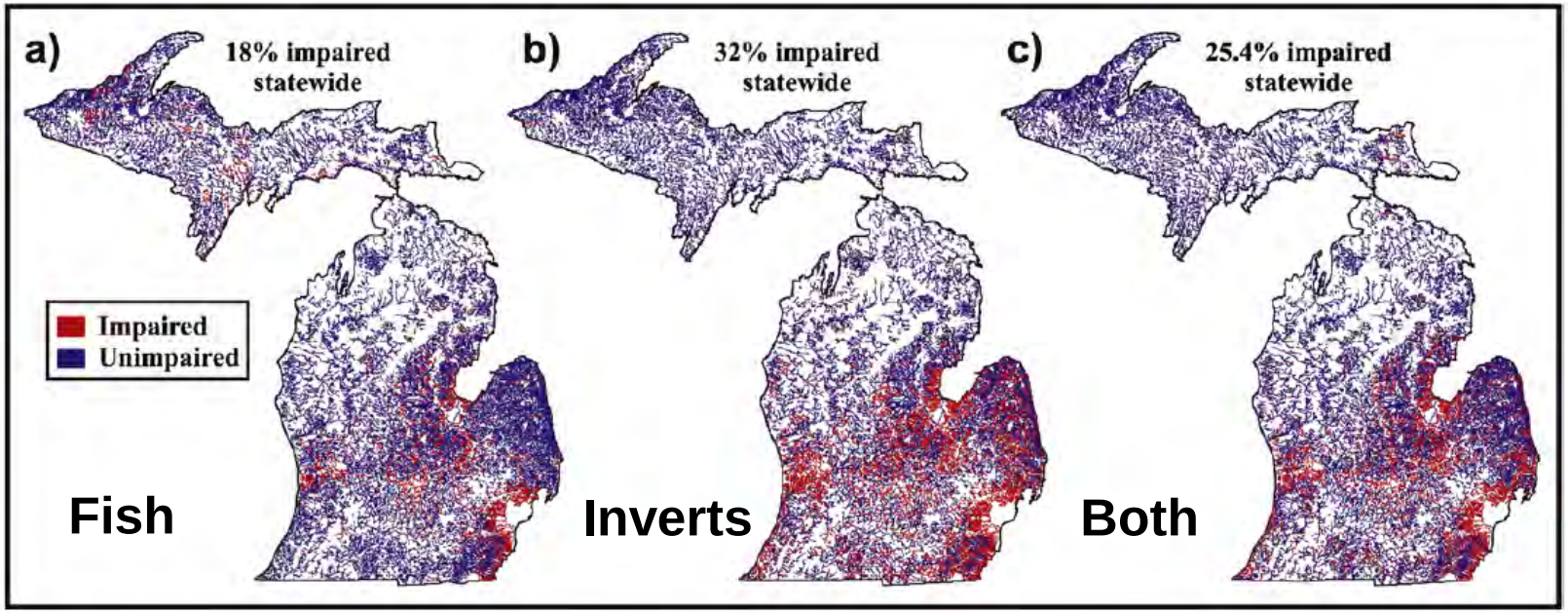


Fig. 5. Mapped current assessment status of the streams and rivers of the state of Michigan based on regionally normalized scores for a) fish, b) invertebrate, and c) fish and invertebrate multimetric (average of overall fish and invertebrates scores). Assessment is based on impaired vs. unimpaired status as defined in Table 5 for sampled and unsampled (CART modeled) reaches.

Riseng et al. 2010

Other Components of Ecological Health

- Biological Communities – fish, invertebrates
- Contaminants in Fish – PCBs, mercury
- Stream Hydrology – patterns of stream flow over time
- Watershed – soils, land use, BMPs, nutrient sources
- Habitat – riparian vegetation, substrate, sinuosity

Grand River (Ottawa County)

Type of Fish	Chemicals of Concern	Size of Fish (length in inches)	MI Servings per Month*
Carp	PCBs	Any	Limited▲
Catfish	PCBs	Any	2[2x]
Suckers	PCBs	Any	1[2x]
Walleye	PCBs	Any	Limited▲

Lake Michigan

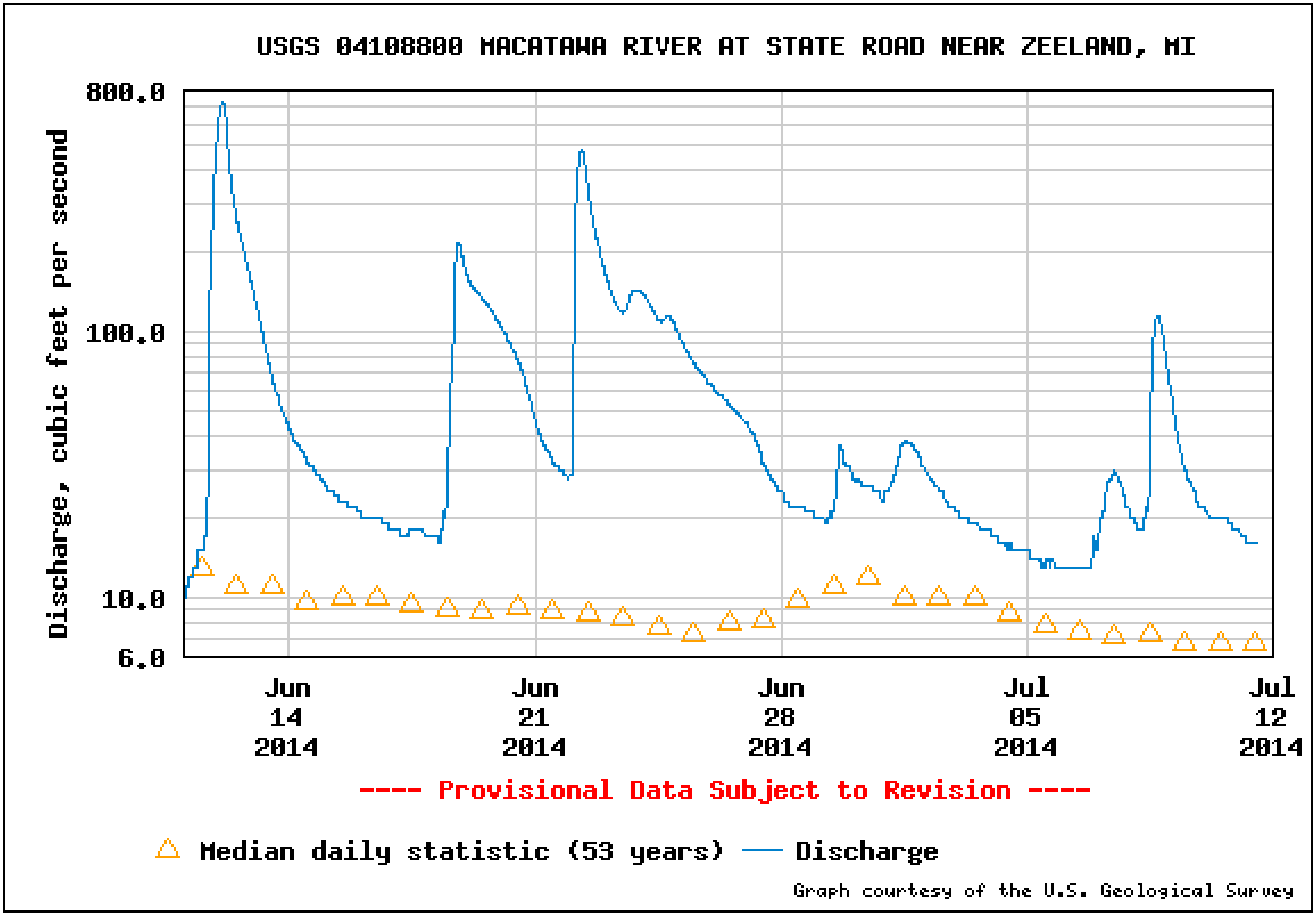
Type of Fish	Chemicals of Concern	Size of Fish (length in inches)	MI Servings per Month*
Brown Trout	PCBs	Any	Limited▲
Burbot	PCBs	Any	1[2x]
Carp	PCBs	Any	Do Not Eat▲
Suckers	PCBs	Any	6 Per Year[2x]
Walleye	PCBs & Mercury	Under 18"	2
	PCBs	18" to 22"	6 Per Year[2x]
	PCBs	Over 22"	Limited▲
Yellow Perch	PCBs	Under 10"	4[2x]
	PCBs & Mercury	Over 10"	4

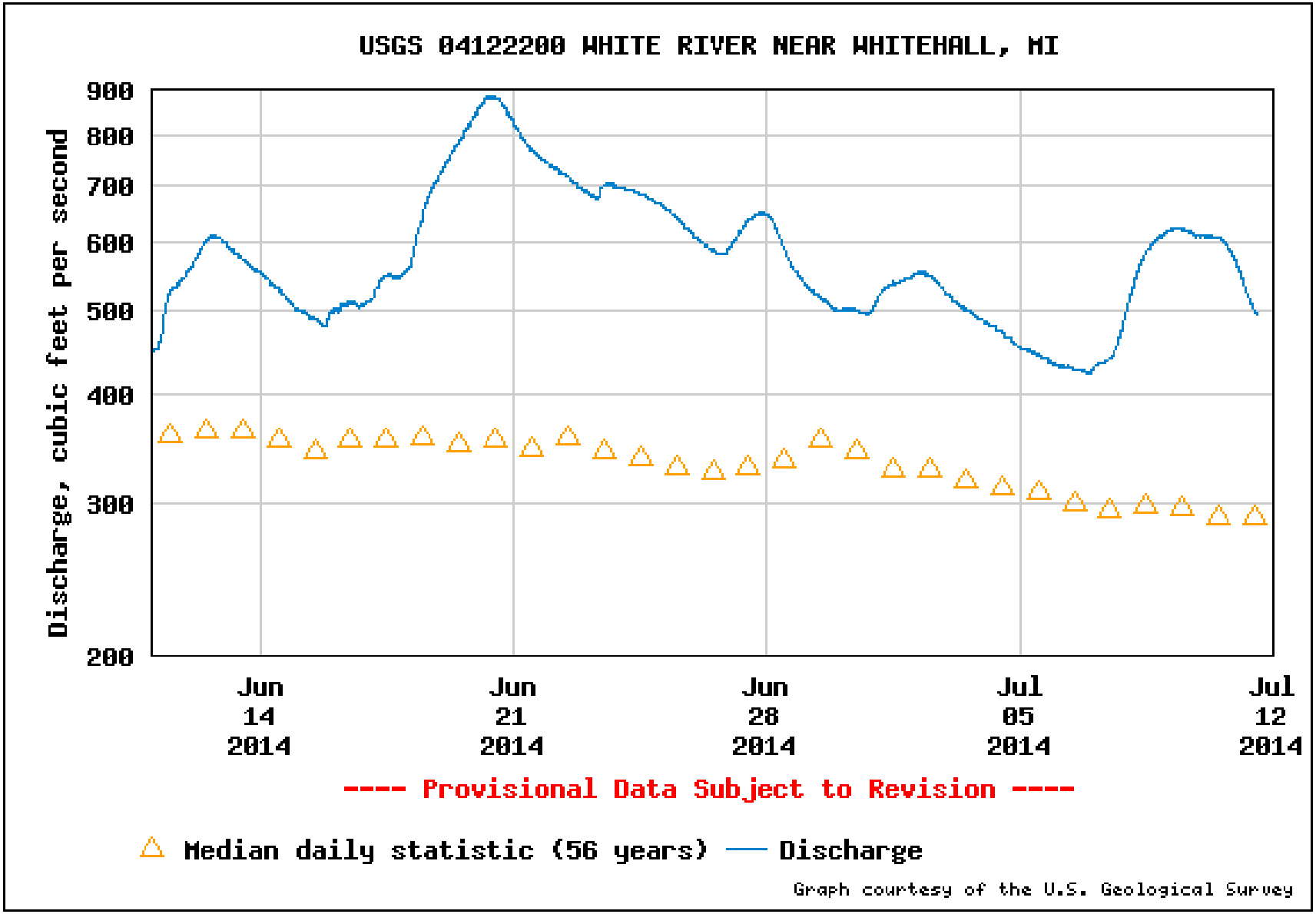
From MCDH *Eat Safe Fish Gide*

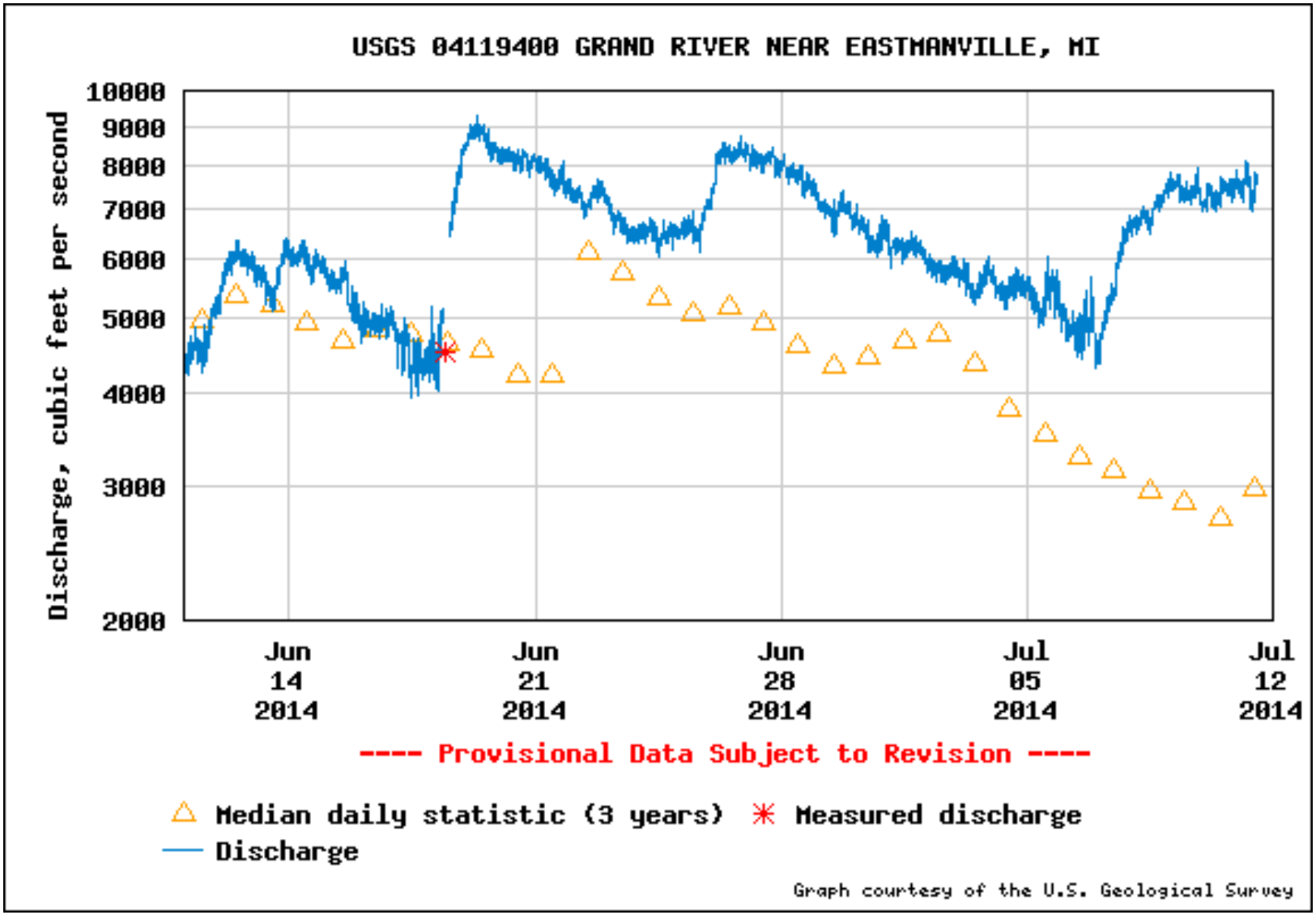
Other Components of Ecological Health

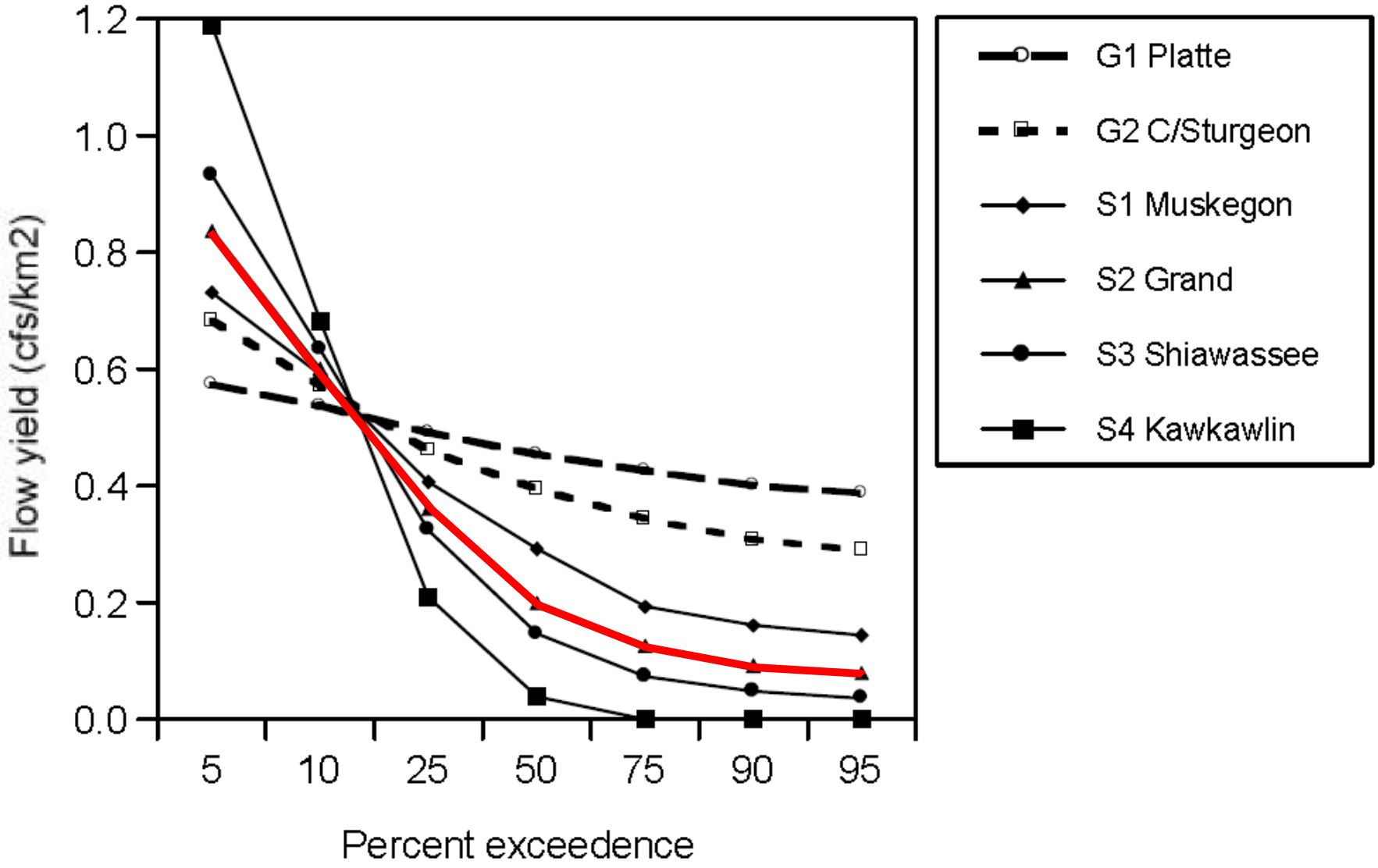
- Biological Communities – fish, invertebrates
- Contaminants in Fish – PCBs, mercury
- Stream Hydrology – patterns of stream flow over time
- Watershed – soils, land use, BMPs, nutrient sources
- Habitat – riparian vegetation, substrate, sinuosity

Hydrograph of a “Flashy” Stream




USGS 04122200 WHITE RIVER NEAR WHITEHALL, MI
Discharge, cubic feet per second
900
800
700
600
500
400
300
200
Jun 14 2014
Jun 21 2014
Jun 28 2014
Jul 05 2014
Jul 12 2014
---- Provisional Data Subject to Revision ----
Median daily statistic (56 years)
Discharge
Graph courtesy of the U.S. Geological Survey


USGS 04119400 GRAND RIVER NEAR EASTMANVILLE, MI
Discharge, cubic feet per second
10000
9000
8000
7000
6000
5000
4000
3000
2000
Jun 14 2014
Jun 21 2014
Jun 28 2014
Jul 05 2014
Jul 12 2014
---- Provisional Data Subject to Revision ----
Median daily statistic (3 years)
Measured discharge
Discharge
Graph courtesy of the U.S. Geological Survey


1.2
1.0
0.8
0.6
0.4
0.2
0.0
Flow yield (cfs/km2)
5
10
25
50
75
90
95
Percent exceedence
G1 Platte
G2 C/Sturgeon
S1 Muskegon
S2 Grand
S3 Shiawassee
S4 Kawkawlin

MDNR Figure

Factors Leading to Flashy Hydrology

- Channelization and snag removal

  Certain tributaries extensively channelized

- Draining of wetlands and levee building

  Half of historic wetlands have been filled

- Soil type and impervious surfaces

  Diverse soil types; 9% urban land use

- Frequency, timing, and magnitude of precipitation events and climate change

Other Components of Ecological Health

- Biological Communities – fish, invertebrates
- Contaminants in Fish – PCBs, mercury
- Stream Hydrology – patterns of stream flow over time
- Watershed – soils, land use, BMPs, nutrient sources
- Habitat – riparian vegetation, substrate, sinuosity

Journal of Great Lakes Research 41 (2015) 618–629

Contents lists available at ScienceDirect

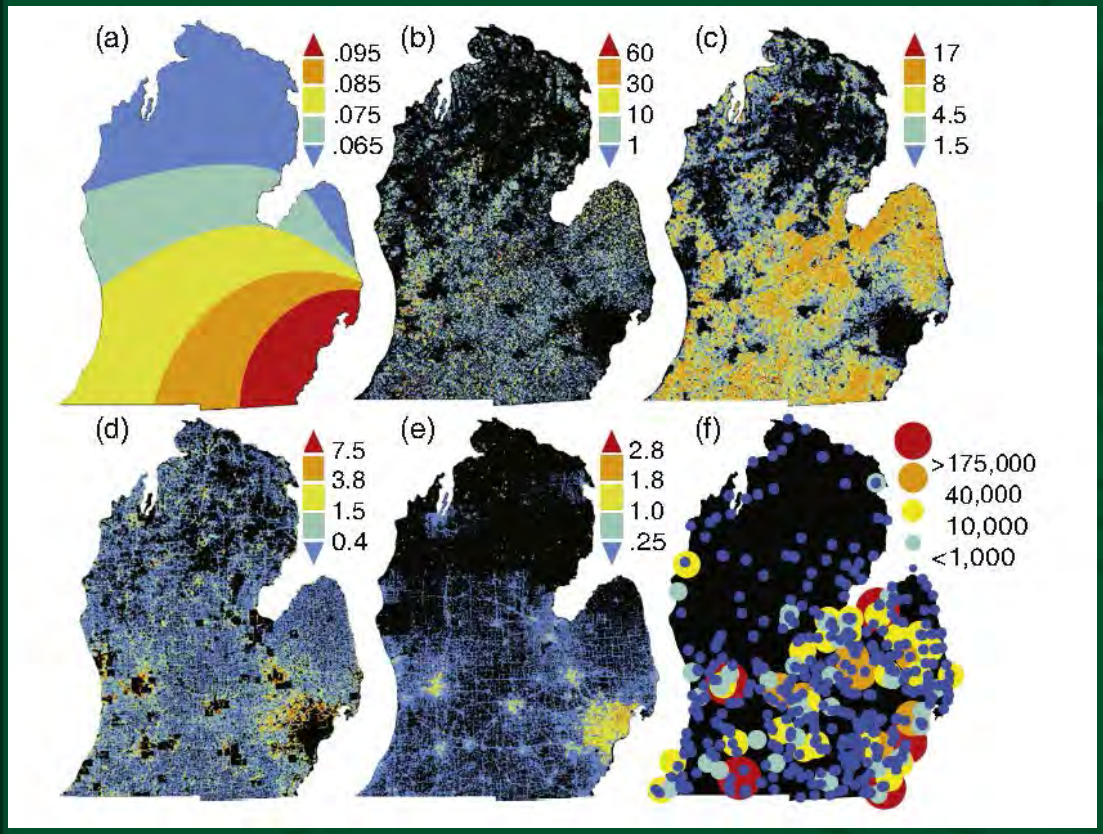
Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

High resolution spatially explicit nutrient source models for the Lower Peninsula of Michigan

Emily C. Luscz *, Anthony D. Kendall [1], David W. Hyndman [2]

Department of Geological Sciences, Michigan State University, East Lansing, MI, USA



Phosphorus Sources

a) Atmospheric deposition

b) Manure application

c) Agricultural chemical fertilizer

d) Septic tanks

e) Non-agricultural fertilizer

f) Point sources

From Luscz et al. 2015

Watershed Sources of Gross Total Phosphorus

These values are kg/ha/yr applied to land in each watershed.

		Agricultural Chemical Fertilizer
1	Au Sable	0.20
2	Black	0.37
3	Lone Lake - Ocqueoc	0.45
4	Thunder Bay	0.61
5	Cheboygan	0.84
6	Au Gres - Rifle	0.86
7	Betsie - Platte	0.87
8	Manistee	0.91
9	PM- White	1.04
10	Boardman - Chlx	1.46
11	Muskegon	1.51
12	Clinton	1.52
13	Huron	1.67
14	Tittabawassee	1.88
15	Flint	3.62
16	Lower Grand	3.77
17	Macatawa	3.84
18	Kalamazoo	4.06
19	Upper Grand	4.13
20	Pine	4.13
21	Thornapple	4.98
22	Cass	5.10
23	Kawkalin - Pine	5.36
24	Shiawassee	5.98
25	Maple	6.60
26	Saginaw	6.70
27	Pigeon - Wiscoggin	7.09
28	Birch - Willow	8.39

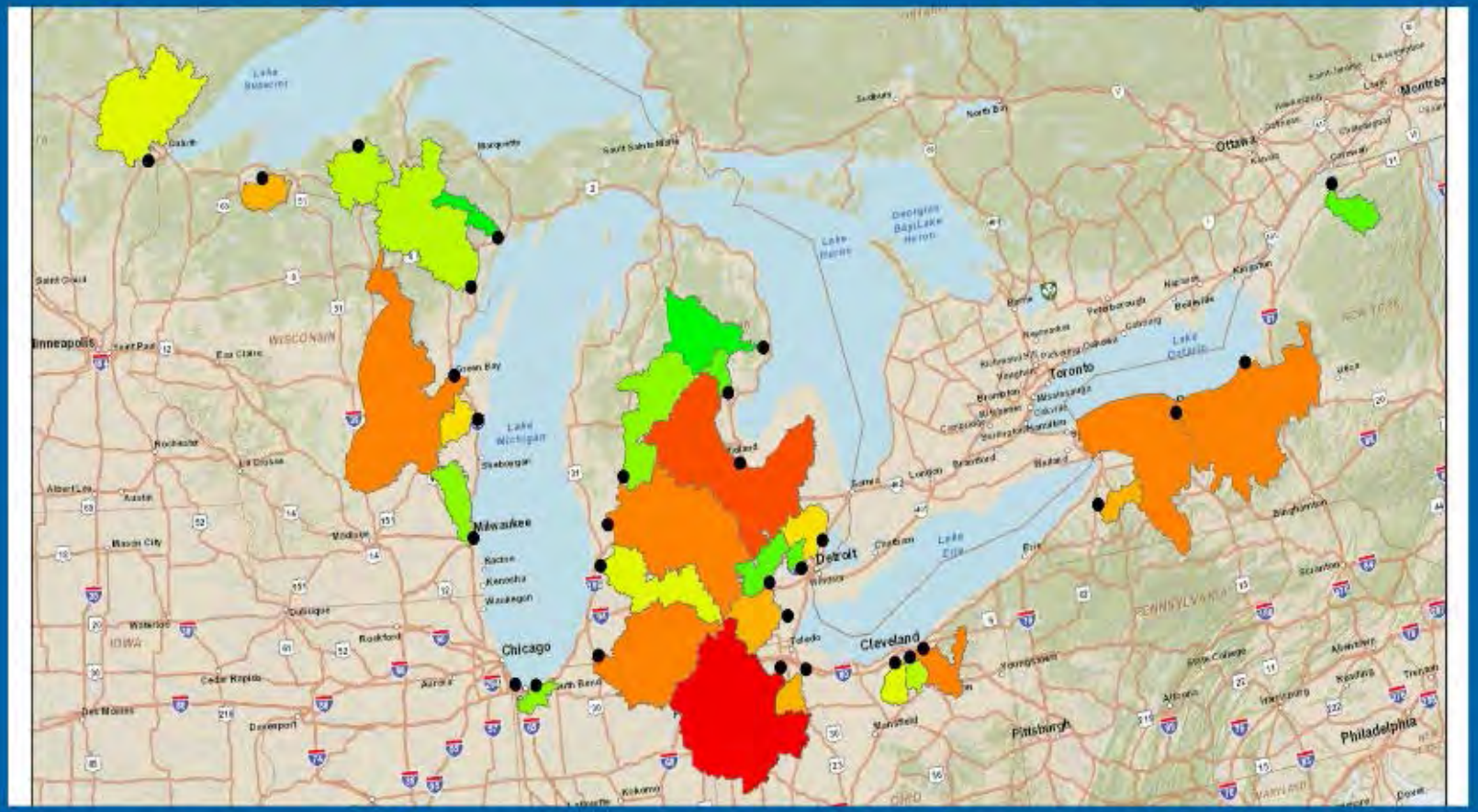
		Manure
1	Betsie - Platte	0.21
2	Black	0.22
3	Au Sable	0.24
4	Lone Lake - Ocqueoc	0.27
5	Manistee	0.34
6	Cheboygan	0.35
7	Clinton	0.37
8	Boardman - Chx	0.42
9	Huron	0.71
10	Thunder Bay	0.72
11	PM - White	0.74
12	Kawkalin - Pine	0.81
13	Saginaw	0.93
14	Au Gres - Rifle	1.01
15	Flint	1.07
16	Tittabawassee	1.10
17	Shiawassee	1.47
18	Muskegon	1.57
19	Cass	1.73
20	Upper Grand	1.79
21	Pine	1.91
22	Thornapple	2.36
23	Pigeon - Wiscoggin	2.99
24	Maple	3.08
25	Lower Grand	3.24
26	Kalamazoo	3.50
27	Birch – Willow	3.53
28	Macatawa	4.99

		Non-Agricultural Chemical Fertilizer
1	Au Sable	0.01
2	Black	0.01
3	Lone Lake - Ocqueoc	0.01
4	Thunder Bay	0.01
5	Au Gres - Rifle	0.01
6	Manistee	0.01
7	Pere Marquette - White	0.02
8	Maple	0.02
9	Pigeon - Wiscoggin	0.02
10	Birch - Willow	0.02
11	Betsie - Platte	0.03
12	Cass	0.03
13	Muskegon	0.04
14	Pine	0.04
15	Tittabawassee	0.05
16	Cheboygan	0.06
17	Kawkalin - Pine	0.06
18	Boardman - Charlevoix	0.07
19	Thornapple	0.07
20	Shiawassee	0.10
21	Macatawa	0.11
22	Kalamazoo	0.12
23	Clinton	0.14
24	Upper Grand	0.18
25	Lower Grand	0.24
26	Flint	0.25
27	Saginaw	0.28
28	Huron	0.48

Values from Luscz et al. 2015

Slide Credit: Joe Duris, USGS, 9th Annual Ottawa Co. WQF

Relative Load of Orthophosphate



USGS

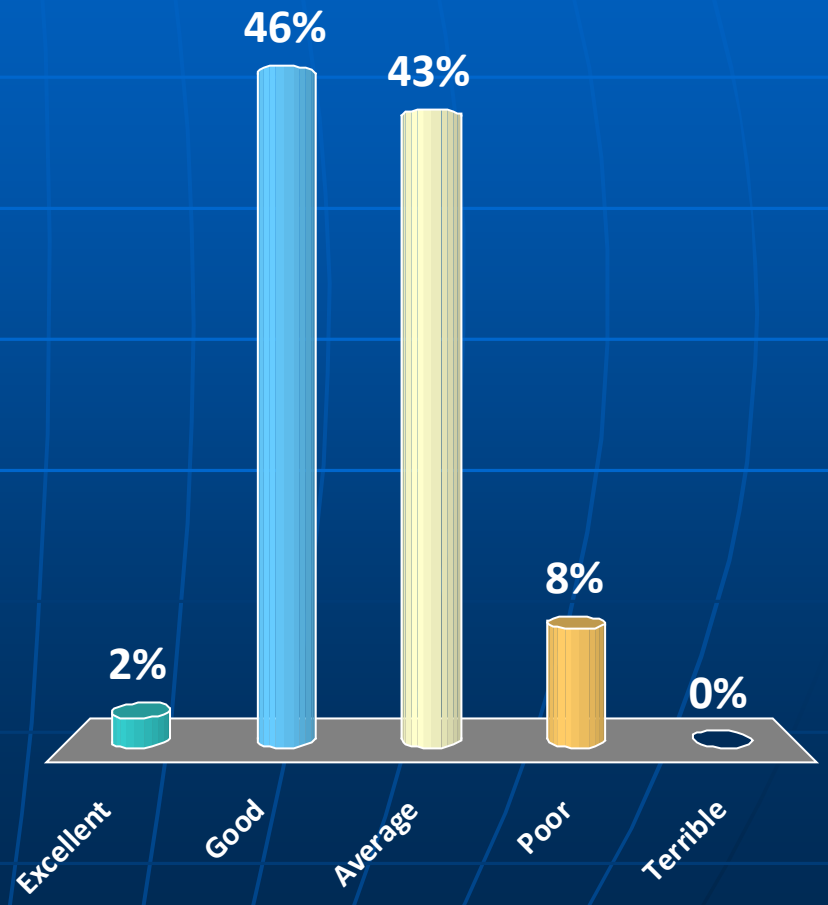
"Preliminary Information—Subject to Revision. Not for Citation or Distribution"

Acknowledgements

- Mike Lunn and Eric Delong, City of Grand Rapids
- Dr. Joan Rose and Dr. Phanikumar Manta, MSU
- Dr. Vijay Kannappan, Michigan DEQ
- Sam Noffke, Michigan DEQ
- Joe Duris, U.S. Geological Survey
- Dr. Catherine Riseng, U of M & Michigan Sea Grant
- Scott Hanshue, Michigan DNR
- Dr. Don Jackson, Mississippi State University

How would you rate surface water quality in the Grand River in relation to other areas of the state?

1. Excellent
2. Good
3. Average
4. Poor
5. Terrible




QUESTIONS?

Other Components of Ecological Health

- Biological Communities – fish, invertebrates
- Contaminants in Fish – PCBs, mercury
- Stream Hydrology – patterns of stream flow over time
- Watershed – soils, land use, BMPs, nutrient sources
- Habitat – riparian vegetation, substrate, sinuosity

Legacy of Dredging

- 1881 River and Harbor Act authorized dredging to Grand Rapids
- 1886 completion of 60’ wide 4 ½’ deep channel
- 1887 report concluded in-channel deep water connection from Grand Rapids to Lk. MI
- 1930 River and Harbor Act abandoned Grand River above Bass River
- Adjacent canal using river water proposed but never attempted…