Iowa's Water Quality Index: Science to Action

Mary P. Skopec, Ph.D.
Water Quality Monitoring and Assessment
Iowa Department of Natural Resources

What does this mean?

Water Quality Parameter	Units	Number of Samples	Min Value	Percentiles 10th	25th	50th	75th	90th	Max Value
Acetochlor	µg/L	4,113	<0.1	<0.1	<0.1	<0.1	<0.1	0.20	21
Alachlor	µg/L	4,113	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.6
Ammonia (as N)	mg/L	4,214	<0.1	<0.1	<0.1	<0.1	0.06	0.2	5.7
Atrazine	µg/L	4,137	<0.1	<0.1	<0.1	0.1	0.3	1.00	53
Butylate	µg/L	4,047	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Carbonaceous BOD (5 day)	mg/L	3,779	<2	<2	<2	<2	3	6	35
Chloride	mg/L	2,990	2.9	12	16	22	32	44	170
Chlorophyll A	µg/L	3,844	<1	2	5	15	47	130	640
Chlorophyll B	µg/L	3,844	<1	<1	<1	<1	<1	2	70
Chlorophyll C	µg/L	3,844	<1	<1	<1	<1	2	9	66
Corrected Chlorophyll A	µg/L	3,844	<1	<1	3	11	39	114	620
Cyanazine	µg/L	4,047	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.3
Deethylatrazine	µg/L	4,047	<0.1	<0.1	<0.1	0.05	0.12	0.21	2.6
Deisopropylatrazine	µg/L	4,047	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.57
Dimethenamid	µg/L	3,260	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.4
Diss. Orthophosphate (as P)	mg/L	4,119	<0.1	<0.1	<0.1	<0.1	0.17	0.3	8.2
Dissolved Oxygen	mg/L	4,160	0.7	7.7	8.8	10.4	12.8	14.4	20.5
E.coli Bacteria	CFU/100 ml	3,902	<10	<10	18	90	370	2,500	960,000
Enterococci Bacteria	CFU/100 ml	3,899	<10	<10	30	120	390	2,800	390,000
Fecal Coliform Bacteria	CFU/100 ml	4,257	<10	<10	20	130	600	4,100	920,000
Field pH	pH units	3,820	5.0	7.8	8.0	8.2	8.4	8.6	9.6
Field Temperature	Celsius	4,189	0.0	0.2	2.5	13.2	20.8	24.5	34.3
Flow	CFS	3,547	1	11	49	210	890	2,500	39,000
Metolachlor	µg/L	4,113	<0.1	<0.1	<0.1	<0.1	0.12	0.4	36
Metribuzin	µg/L	4,047	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5
Nitrate+Nitrite (as N)	mg/L	4,214	<0.1	0.6	2.3	5	7.9	11.0	28.0
Pheophytin	µg/L	3,844	<1	<1	1	3	10.0	21.0	204.0
Silica	mg/L	3,850	<1	4.1	7.8	12.0	16.0	20.0	120
Simazine	µg/L	3,769	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.56
Specific Conductivity	µmhos/cm	3,943	120	420	510	620	720	840	1,700
Sulfate	mg/L	2,827	6.3	21	27	39	63	100	400
Total Dissolved Solids	mg/L	3,850	95	250	300	360	440	510	1,640
Total Hardness (as CaCO3)	mg/L	3,778	64	190	240	300	350	410	750
Total Kjeldahl Nitrogen	mg/L	3,854	<0.1	0.3	0.5	0.8	1.4	2.2	28
Total Phosphorus	mg/L	4,211	<0.1	<0.1	0.1	0.2	0.4	0.7	26
Total Suspended Solids	mg/L	3,937	<1	3	8	29	79	200	17,000
Trifluralin	µg/L	4,047	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.35
Turbidity	NTU	4,203	<1	2.6	5.3	17.0	44.0	120.0	8,500

µg/L – micrograms per liter (parts per billion)
mg/L – milligrams per liter (parts per million)
CFU/100 ml – Colony Forming Units per 100 milliliters of water

CFS – Cubic Feet per Second (ft^3/sec)
µmhos/cm – micromhos per centimeter
NTU – Nephelometric Turbidity Units
< – less than detection limit shown

*Includes monthly and event samples for all stream sites.

(Iowa Geological Survey 2004,1)

What is Needed: A Yardstick for Measuring Water Quality

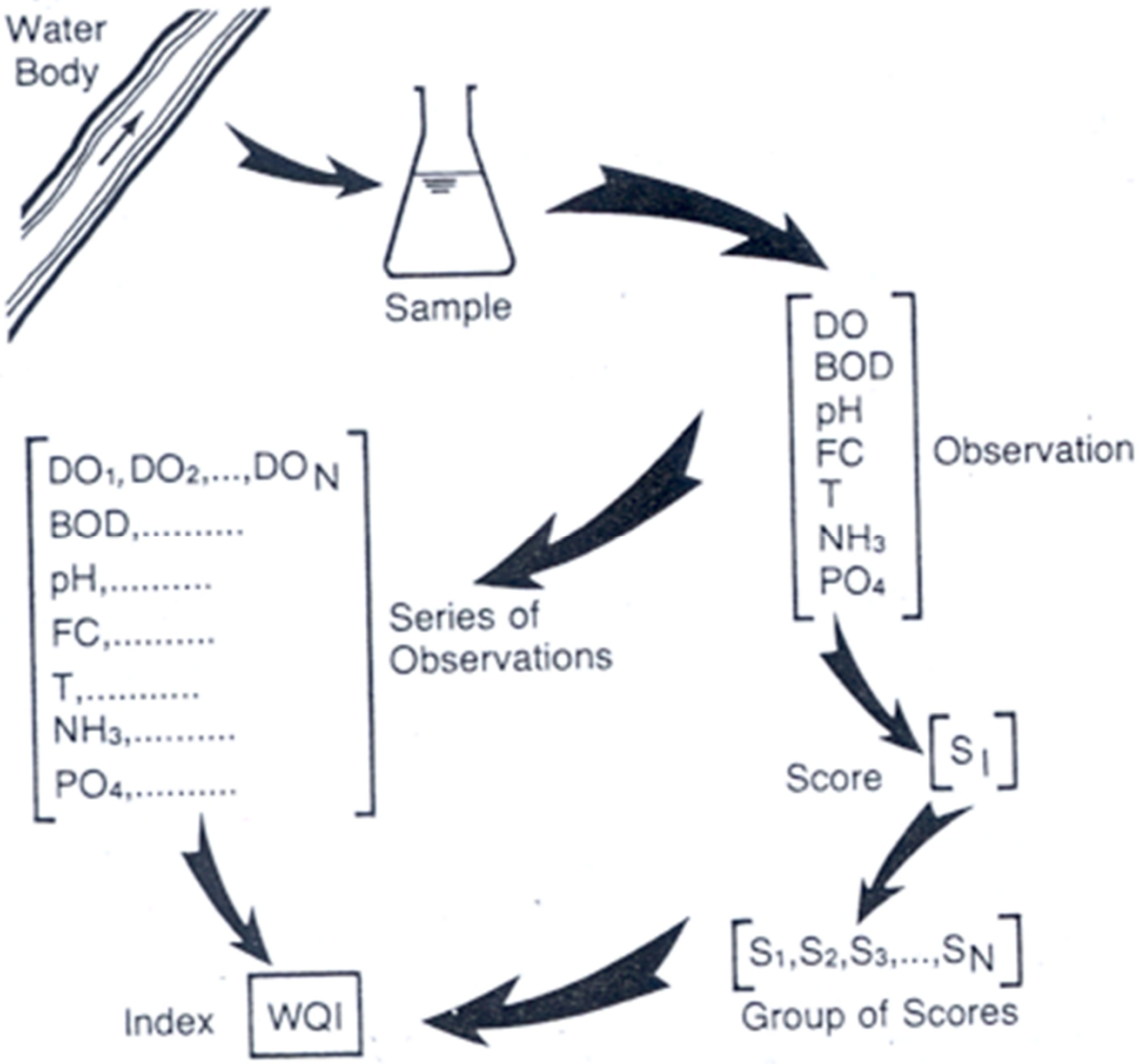
- Large quantities of water quality data on their own do not inform water resources decision making
- A quick way to draw meaning from data is needed

"What is clearly needed is a yardstick of water quality." (Brown et al. 1970, 339)

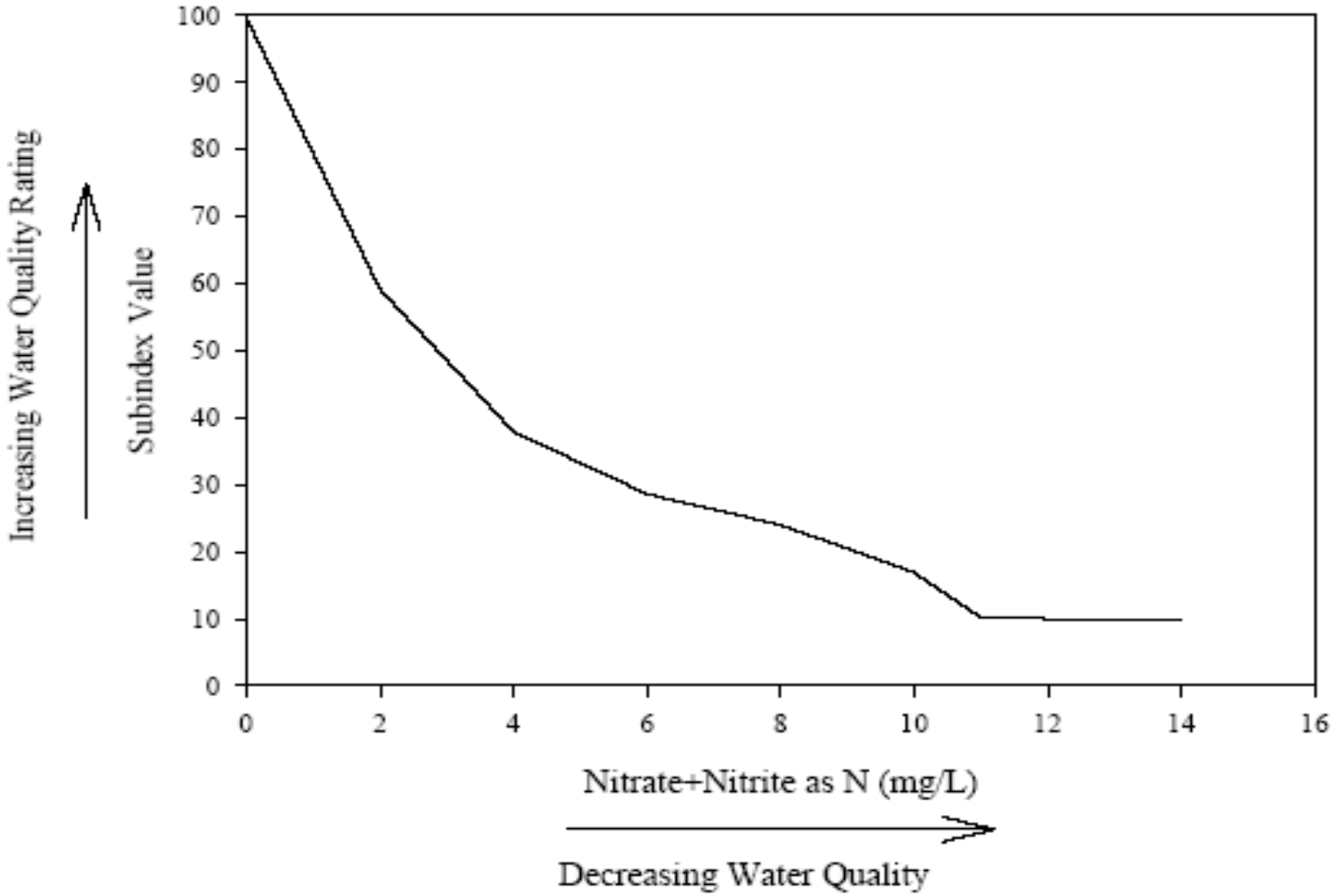
Value of WQIs

- In 1972, the Council on Environmental Quality stated that accurate and timely information on the state of the environment was essential to forming policy
  - Indices are one of the most effective tools to compare and evaluate environmental conditions
    - **Examples include**: Water Quality Index, Air Quality Index, Index of Biotic Integrity, Trophic State Index, and Species Diversity Index

Process of WQI Calculation



Example of a Subindex Rating Curve



Qualitative Rating

Rating	*Index Value*
Very Poor	**10-25**
Poor	**25.01-50**
Fair	**50.01-70**
Good	**70.01-90**
Excellent	**90.0-100**

Motivation

- National Sanitation Foundation Water Quality Index (**NSFWQI**)
  - Most respected and utilized WQI in U.S.
  - "One size fits all" structure criticized for overlooking regional water quality concerns

When applied to 3 years of Iowa data:

- Rated streams/rivers: **79% medium and 21% good**
- How to ground-truth these results…

Index Development

- IWQI developed in 2005 by **custom-fitting the NSFWQI to Iowa.**
  - Geographically specific water quality index to represent a full range of water quality conditions in Iowa.
  - Index was validated with data of known water quality
  - Statistics used to answer the question: is the IWQI better than the NSFWQI at characterizing Iowa's water quality?

Attributes of NSFWQI & IWQI

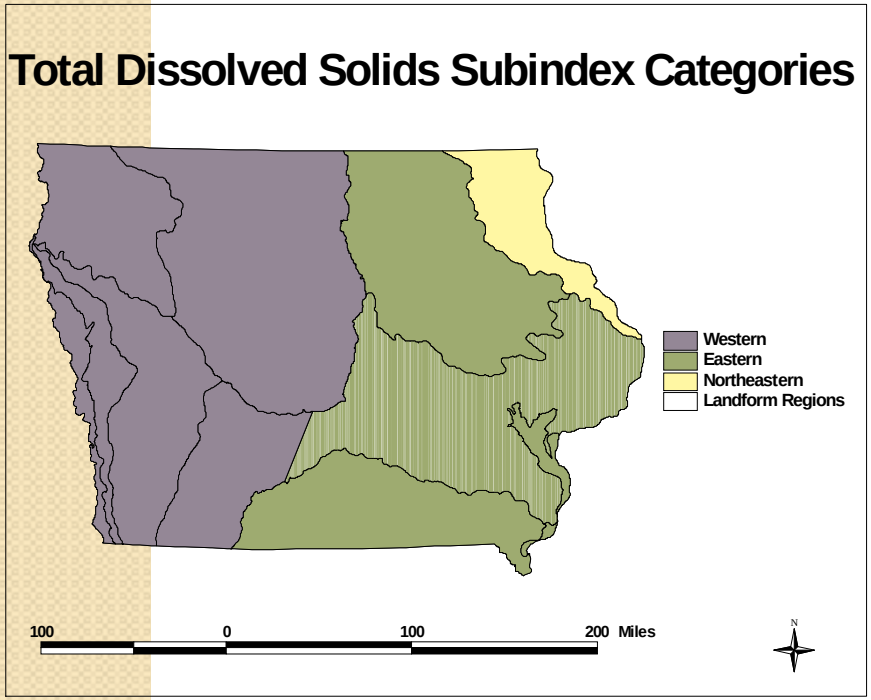
Parameters Included	NSFWQI	IWQI
Biological Oxygen Demand	X	X
Dissolved Oxygen	X	X
E.coli		X
Fecal coliforms	X	
Nitrate - N	X	
Nitrate+Nitrite - N		X
Pesticides		X
pH	X	X
Water Temperature	X	
Total Dissolved Solids	X	X
Phosphorus	X	X
Total Suspended Solids		X
Turbidity	X	
Averaging Function	*Weighted linear sum	**Unweighted harmonic square mean

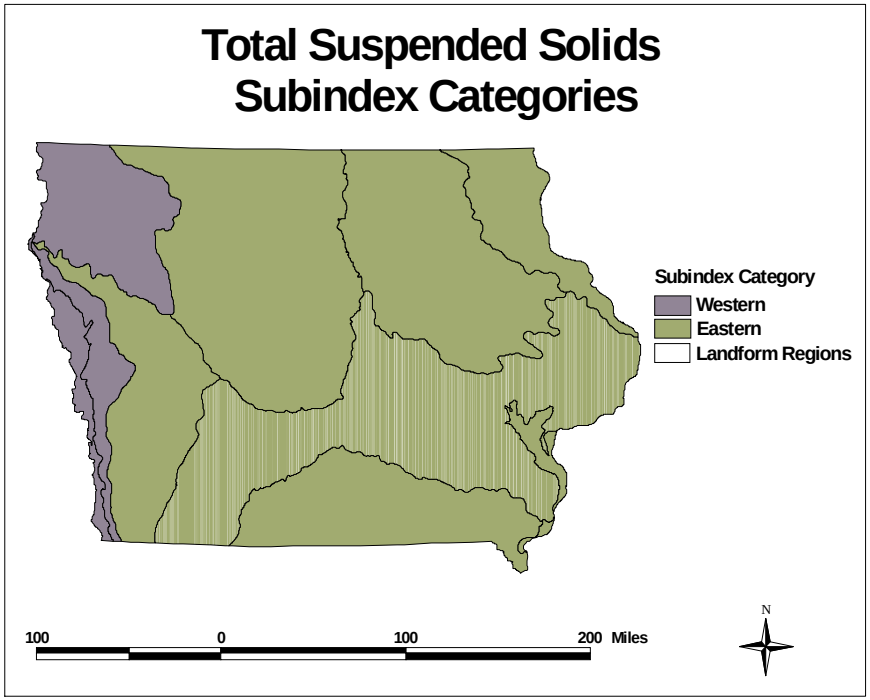
X = parameter used in index calculation

*Weights are associated with each parameter. The overall index is calculated by the sum of the all of the products of the parameter weights' and subindex values.

**No weights associated with each parameter. The overall index score is calculated by the square root of the number of subindices divided by the sum of the reciprocal of the squares of the subindex values.

Geographically-Specific Subindex Rating Curves: TDS and TSS





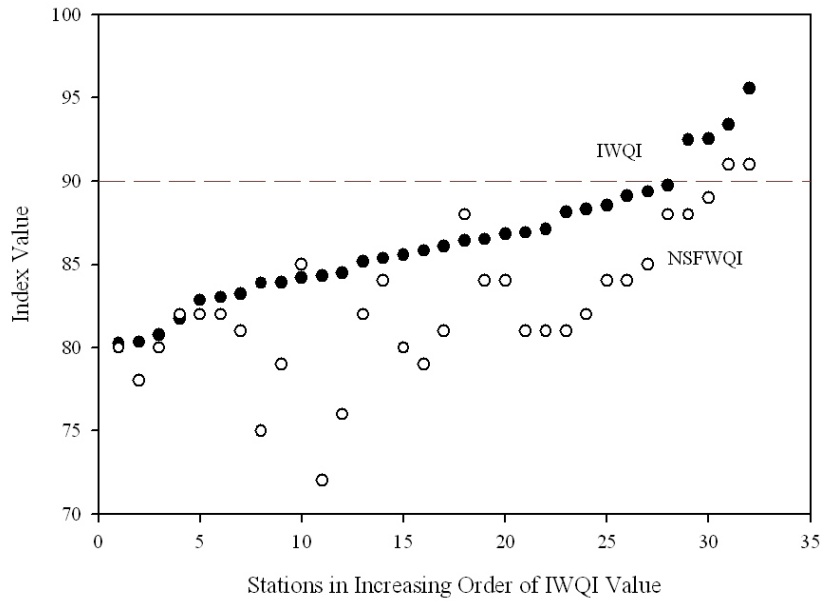
Index Performance

Is the IWQI better than the NSFWQI at rating Iowa's water quality?

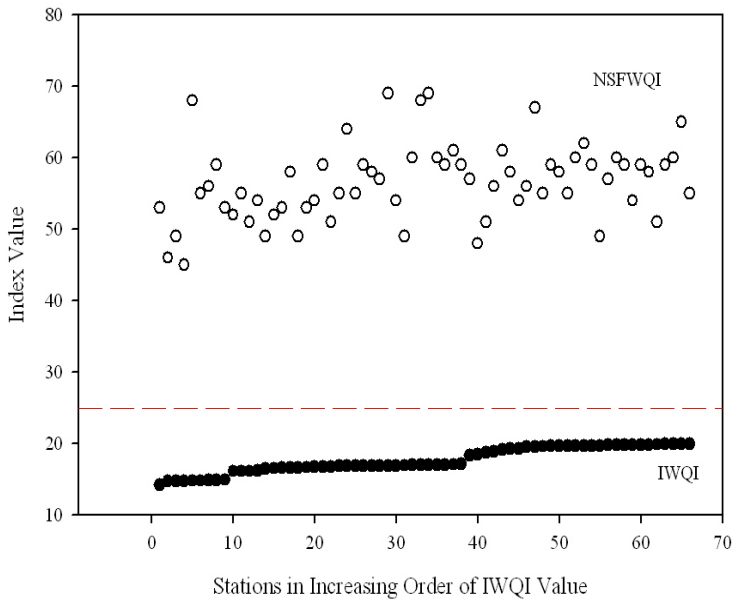
- Subset of the validation datasets chosen
  - Reference and impaired waters data records
- Determine relative performance of the two indices

Comparative Analysis

Most Pristine Water Quality as Rated by the IWQI and the NSFWQI



Most Impaired Water Quality as Rated by the IWQI and the NSFWQI



Is the IWQI better than the NSFWQI at rating Iowa's water quality?

- **YES!**
  - Analysis suggests that IWQI rates the most impaired water quality worse and the most pristine water quality better than does the NSFWQI
- **Why?**
  - Index Design: Parameters, Subindex Rating Curves and Aggregation Function

Reason 1: Parameters Included

Non point source pollution is the #1 water quality challenge in Iowa

- IWQI includes two more nonpoint source pollutants in the index compared to NSFWQI
  - 84% of Iowa's stream miles have major sediment impacts (TSS)
  - 81% of Iowa's surface water samples have detectable levels of pesticides (total pesticides)
- Temperature change excluded

Reason 2: Subindex Rating Curves

- IWQI has geographically specific subindex rating curves
  - Distinguishes background from impaired conditions
- IWQI has consistent maximum (100) and minimum (10) values
  - No artificial over or under-estimation of water quality conditions
- Subindex curves appropriate for Iowa's waters
  - Phosphorus, DO, and BOD rated more stringently (accounts for eutrophication risk)
  - TDS is not rated as stringently (climate and geologic variability)

Uses for the IWQI

1. Evaluating changes in water quality over time
   - Quantify the effectiveness of water quality regulations and protection programs
     - BMPs

2. Comparing water quality conditions in different locations → resource prioritization

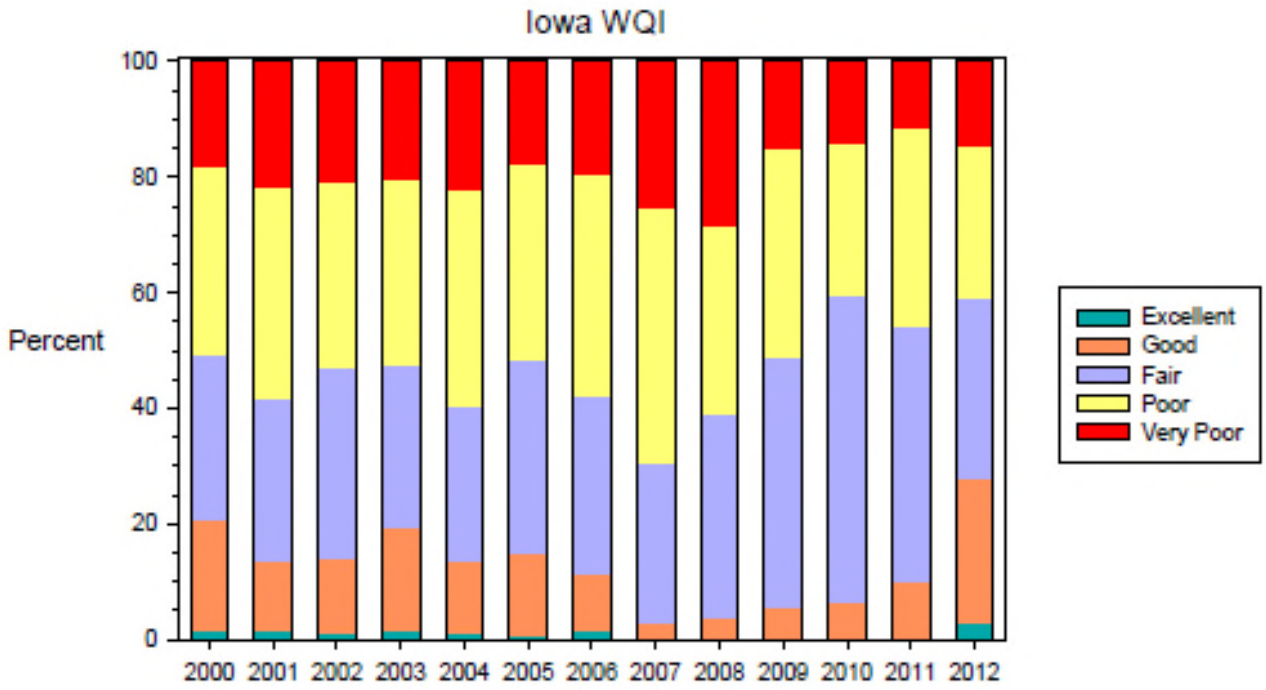
3. Determining the extent to which existing water quality standards are met → informing policy

4. Developing reports required by the Clean Water Act (305(b) and 303 (d) list)

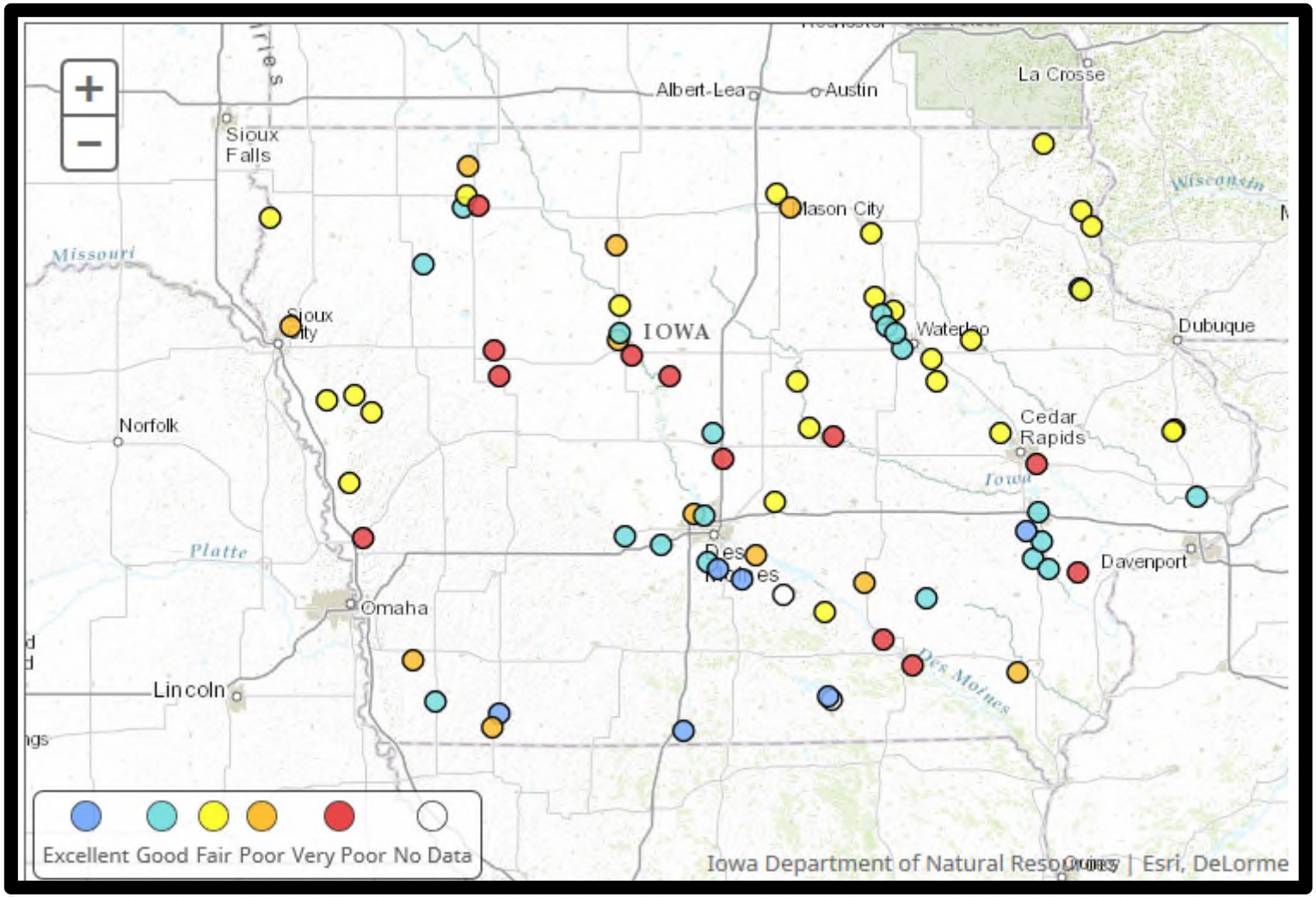
Science to Action

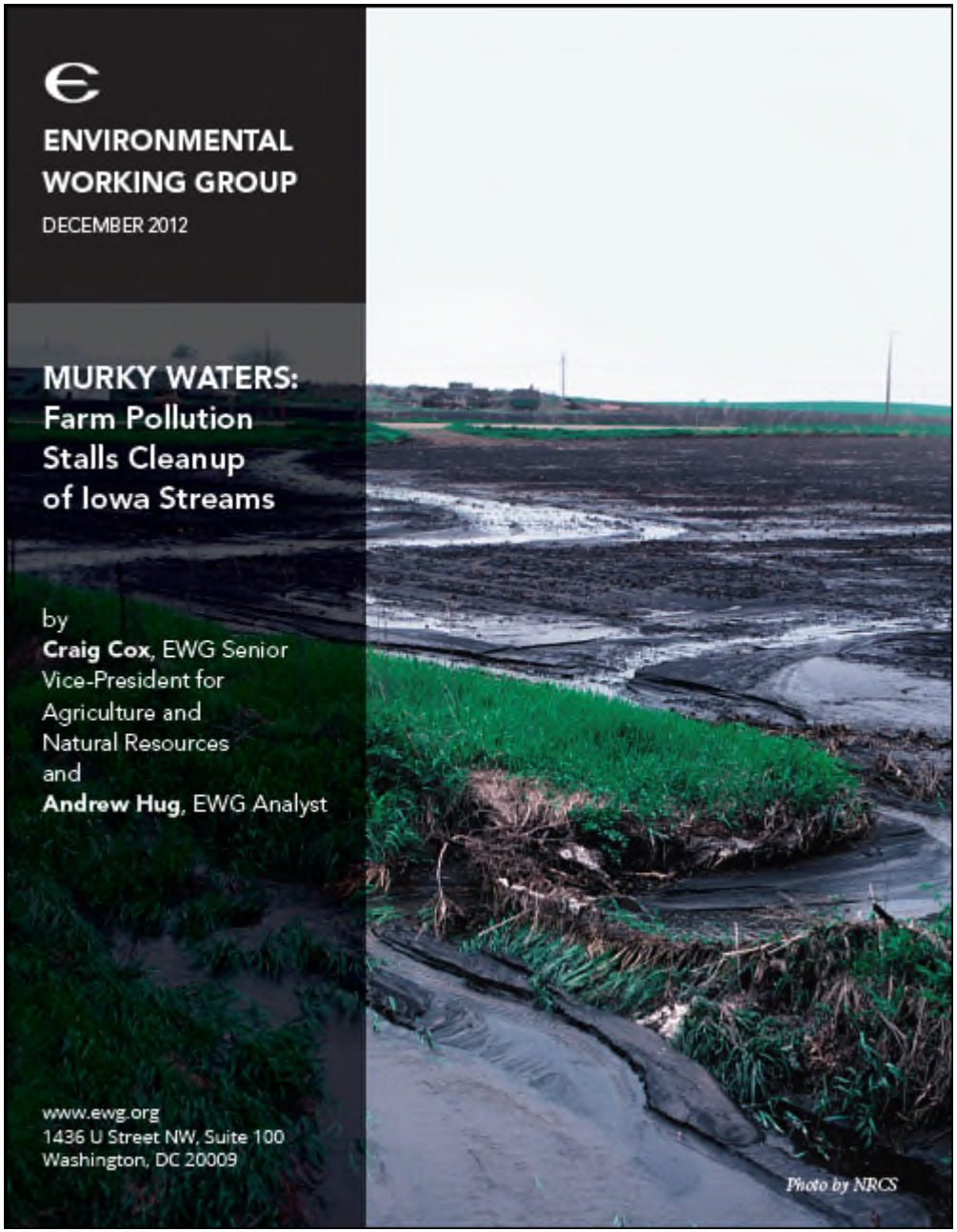
- IWQI reported to Iowa's Governor on a quarterly basis
- Accessible to citizens at all levels of scientific knowledge
- Facilitating Discussion on Iowa's Water Quality:
  - Drought Example
  - EWG Example

Iowa's Water Quality Index: All Years Average


Iowa WQI
Percent
100
80
60
40
20
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Excellent
Good
Fair
Poor
Very Poor

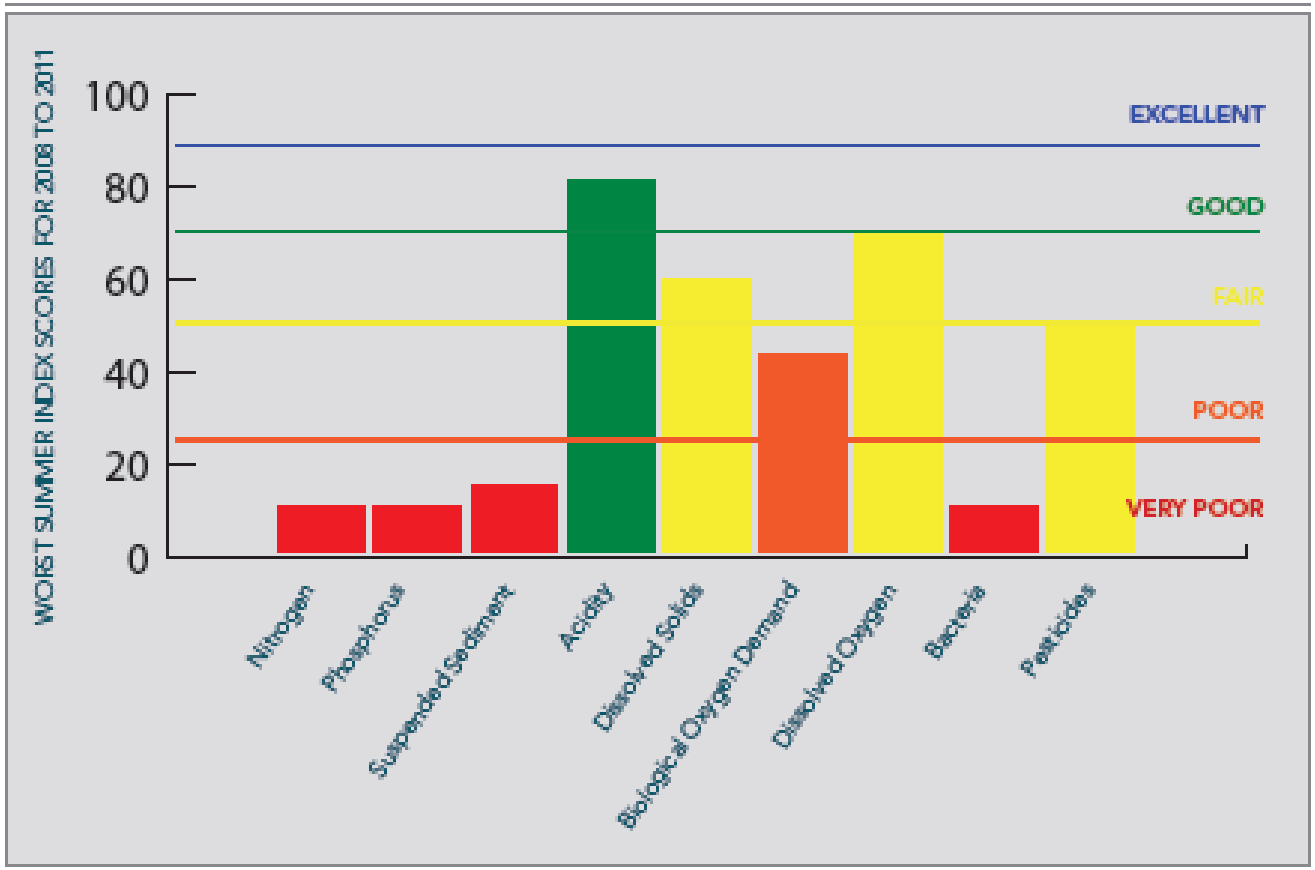
Impact of Drought on Iowa's Water Quality
Water Quality Index February 2014





Use of IWQI to Report On State Progress Toward Water Quality Improvements

Summer Subindex Scores 2008 - 2011



Source: EWG, 2012

Sites with Consistently "Poor" or "Very Poor" Water Quality Index Scores

Year-Round Condition									
Index Ranking	Nitrogen	Phosphorus	Suspended Sediment	Acidity	Dissolved Solids	Biological Oxygen Demand	Dissolved Oxygen	Bacteria	Pesticides
Average	Poor	Poor	Fair	Good	Good	Good	Excellent	Good	Fair
Worst	Very Poor	Very Poor	Poor	Good	Poor	Fair	Good	Fair	Fair
Best	Poor	Fair	Excellent	Excellent	Excellent	Good	Excellent	Good	Fair

Summer Months									
Index Ranking	Nitrogen	Phosphorus	Suspended Sediment	Acidity	Dissolved Solids	Biological Oxygen Demand	Dissolved Oxygen	Bacteria	Pesticides
Average	Poor	Poor	Fair	Good	Excellent	Fair	Good	Fair	Fair
Worst	Very Poor	Very Poor	Very Poor	Good	Fair	Poor	Fair	Very Poor	Fair
Best	Fair	Fair	Good	Excellent	Excellent	Good	Excellent	Excellent	Fair

Source: EWG, 2012

Estimated Water Quality Index Scores Theil-Sen Test

	2011		2021	
	Number	%	Number	%
Very Poor	6	8	5	7
Poor	31	43	31	43
Fair	33	46	34	47
Good	2	3	2	3
Excellent	0	0	0	0
Total	72	100	72	100

Source: EWG, 2012

Questions?

Mary.Skopec@dnr.iowa.gov

515-725-3434