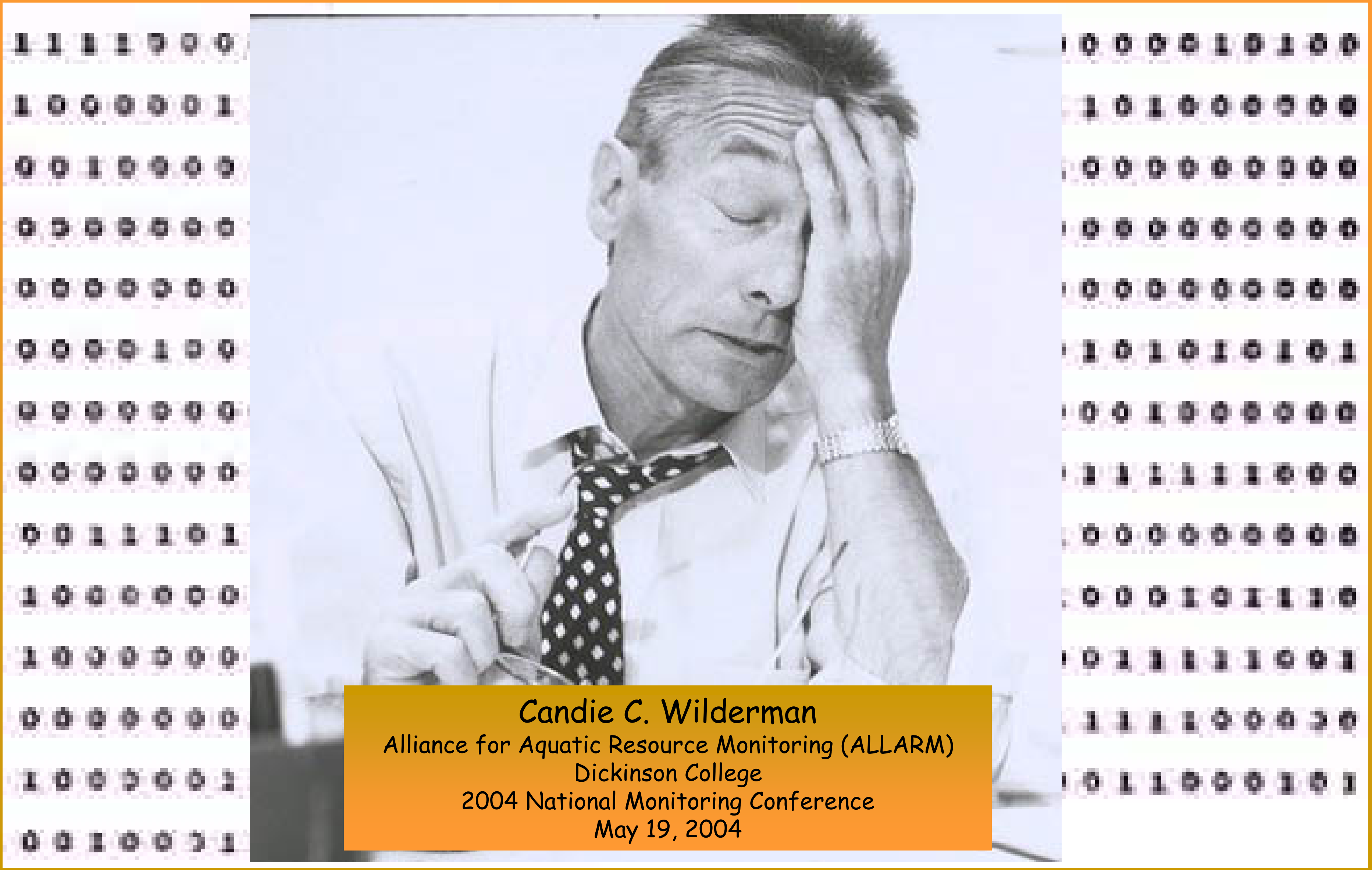
Can Volunteers Climb the Learning Curve to Convert their Data to Information?

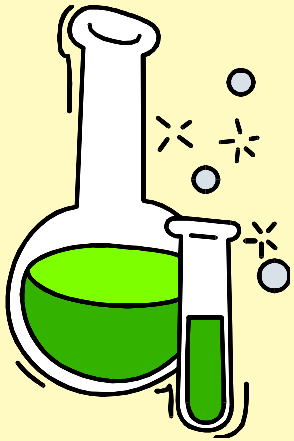


Candie C. Wilderman
Alliance for Aquatic Resource Monitoring (ALLARM)
Dickinson College
2004 National Monitoring Conference
May 19, 2004

Topics to be covered

- Different models for community science
- What is ALLARM
- Challenges and benefits of training volunteers to interpret their own data
- Two-phase model for training volunteers: from data to information

What are some models for citizen science?



- Citizen science involves a research partnership between community people and professional scientists.
- There are a variety of successful operational models for this partnership.
- These models differ in their goals, the nature and scope of the projects, and the extent of community control over the definition and implementation of the project.

Categorizing the various models for community science can be based on answers to five questions:

- Who defines the problem?
- Who designs the study?
- Who collects the samples?
- Who analyzes the samples?
- Who interprets the data?

Community Workers Model #1

Who defines the problem?	Who designs the study?	Who collects the samples?	Who analyzes the samples?	Who interprets the data?
Professional scientists	Professional scientists	Community	Professional scientists	Professional scientists

Examples of Community Workers Model #1

CORNELL LAB of ORNITHOLOGY

Study of the infestation of blue bird nests by Protocalliphora (blowflies)

Rivers and Streams

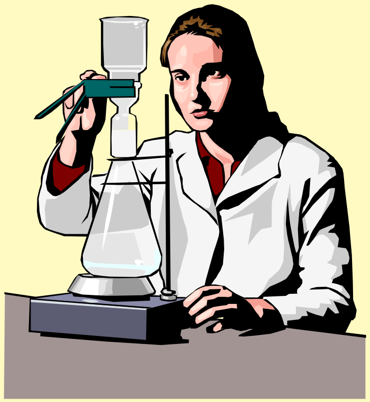
MD DNR Stream Waders Volunteer Monitoring Program (Macroinvertebrate Analysis)

Community Consulting Model (Science for the People)

Who defines the problem?	Who designs the study?	Who collects the samples?	Who analyzes the samples?	Who interprets the data?
Community	Professional scientists	Professional scientists	Professional scientists	Professional scientists

Examples of the consulting model

Some PA Growing Greener Grants support programs using this model



European Science Shops

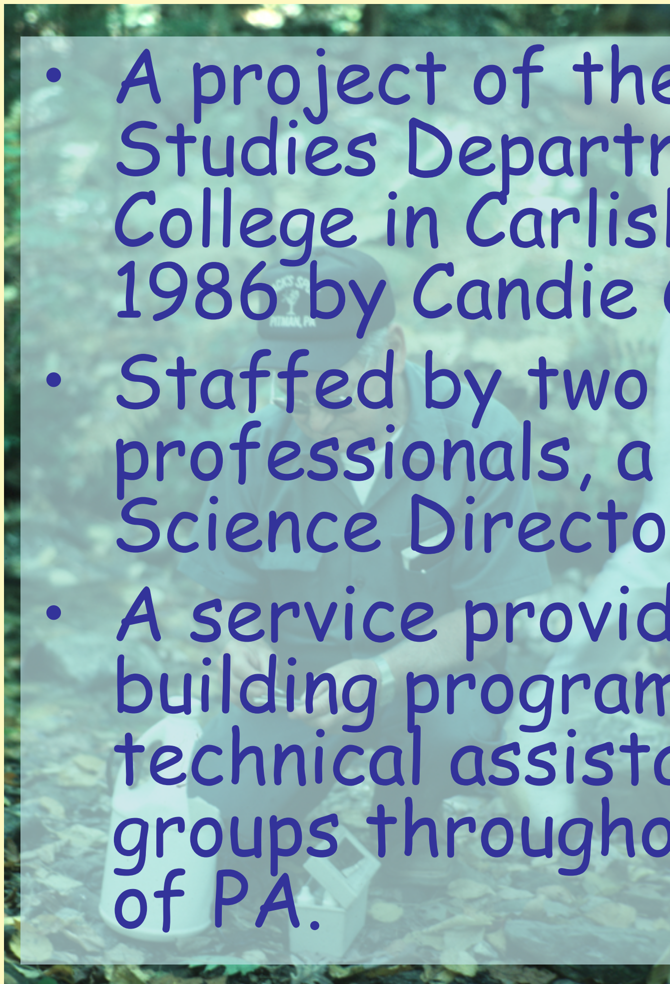
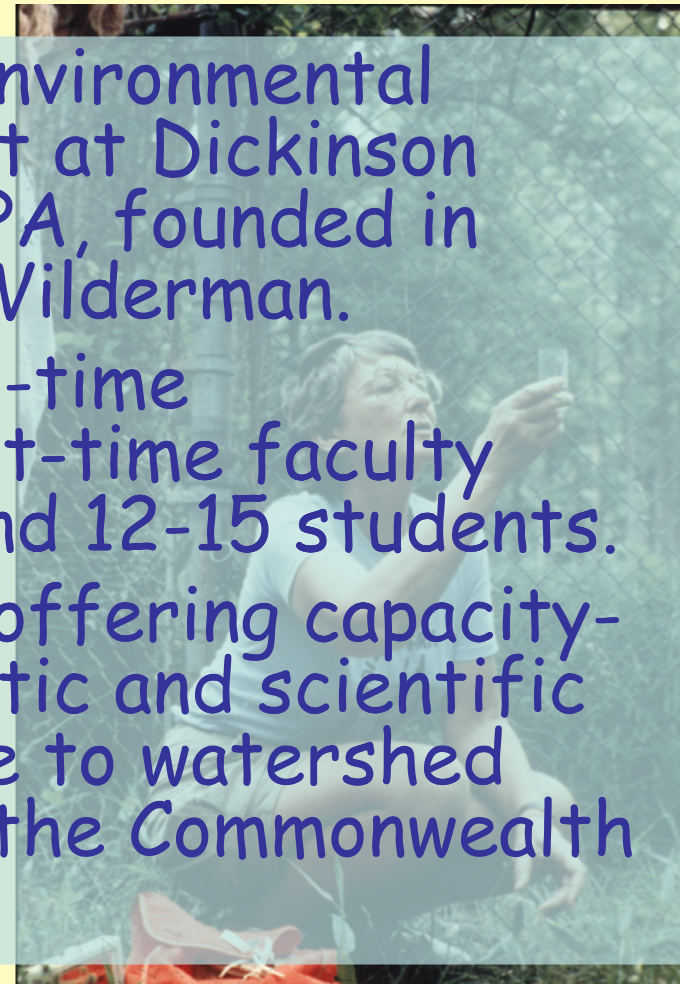
Community-based, Participatory Research Model (Science by the People)

Who defines the problem?	Who designs the study?	Who collects the samples?	Who analyzes the samples?	Who interprets the data?
Community	Community	Community	Community	Community

Examples of Community-based, Participatory Research Model

Watershed-based projects

The Alliance for Aquatic Resource Monitoring (ALLARM) is:

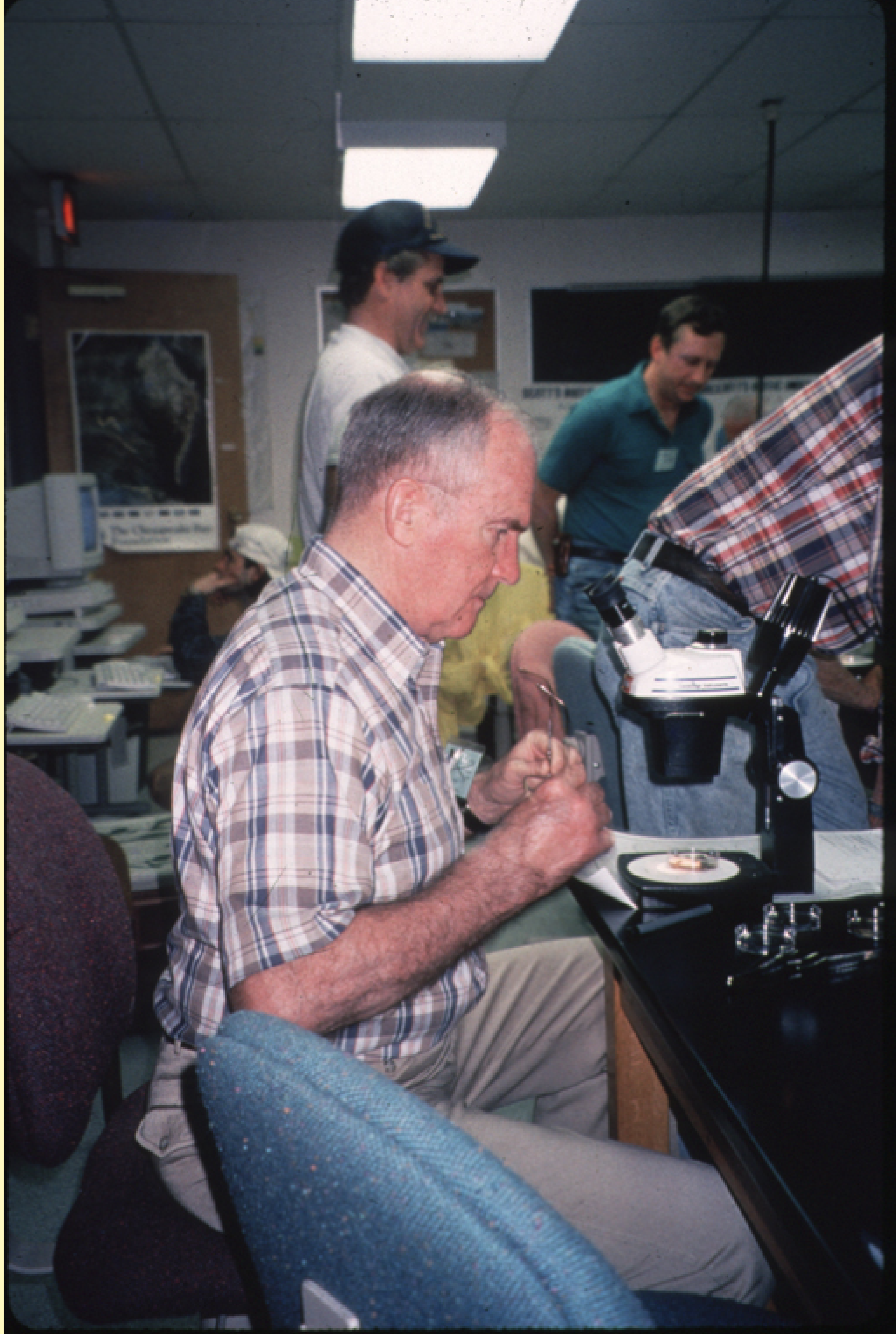
- A project of the Environmental Studies Department at Dickinson College in Carlisle, PA, founded in 1986 by Candie C. Wilderman.
- Staffed by two full-time professionals, a part-time faculty Science Director and 12-15 students.
- A service provider offering capacity-building programmatic and scientific technical assistance to watershed groups throughout the Commonwealth of PA.

ALLARM'S goals are:

1. To empower communities with scientific knowledge, and

2. To enhance the quality of undergraduate education at Dickinson College.

The roles in which ALLARM engages citizen-scientists have varied over the past 18 years, but recently we have focused on the community-based participatory research model.



We have found the greatest challenge in this model is having volunteers "find the story" in their data.

Who defines the problem?	Who designs the study?	Who collects the samples?	Who analyzes the samples?	Who interprets the data?
Community	Community	Community	Community	Community

This process involves intensive training by the professional partner (service provider) and a high level of commitment by the volunteers.

Presenting the story to the group

Training the volunteers to find the story in the da selves

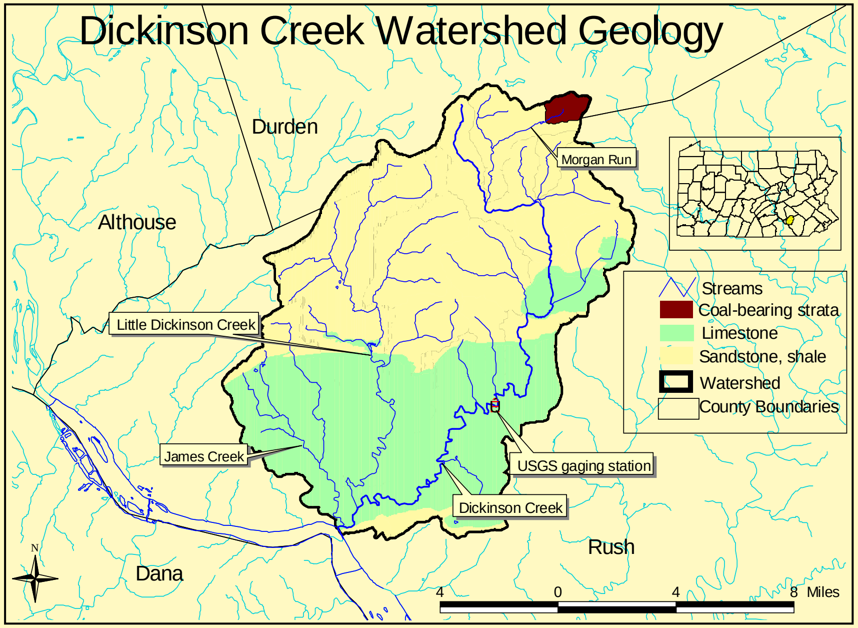
Steps in the Data to Information Training Process

Workshop #1: Learn the basics using a virtual watershed (Dickinson Creek)

Workshop #2: Apply these skills to the real watershed data collected by volunteers; provide insights for action

Workshop #1. Learning the basics: the virtual watershed

- Why a virtual watershed?
- Materials
- Agenda and process
- What we learn

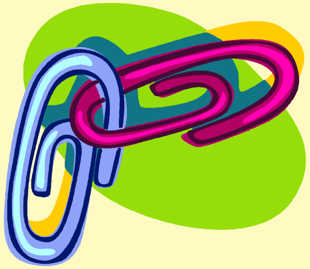


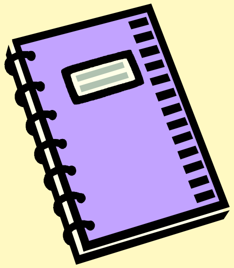
Why a virtual watershed?

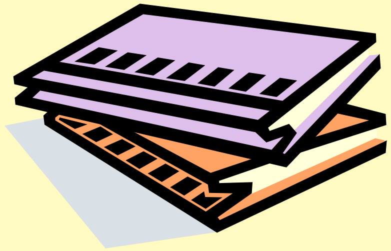
- Allows us to keep the data simple, the sites limited to a few, and the patterns clear.
- Allows us to use just those indicators with which the group is familiar.
- Allows us to demonstrate expected relationships between indicators, land use, geology, and seasons.
- Allows us to add outliers and impossible values for volunteers to discover, discuss, and figure out how to handle.

Summary of materials needed

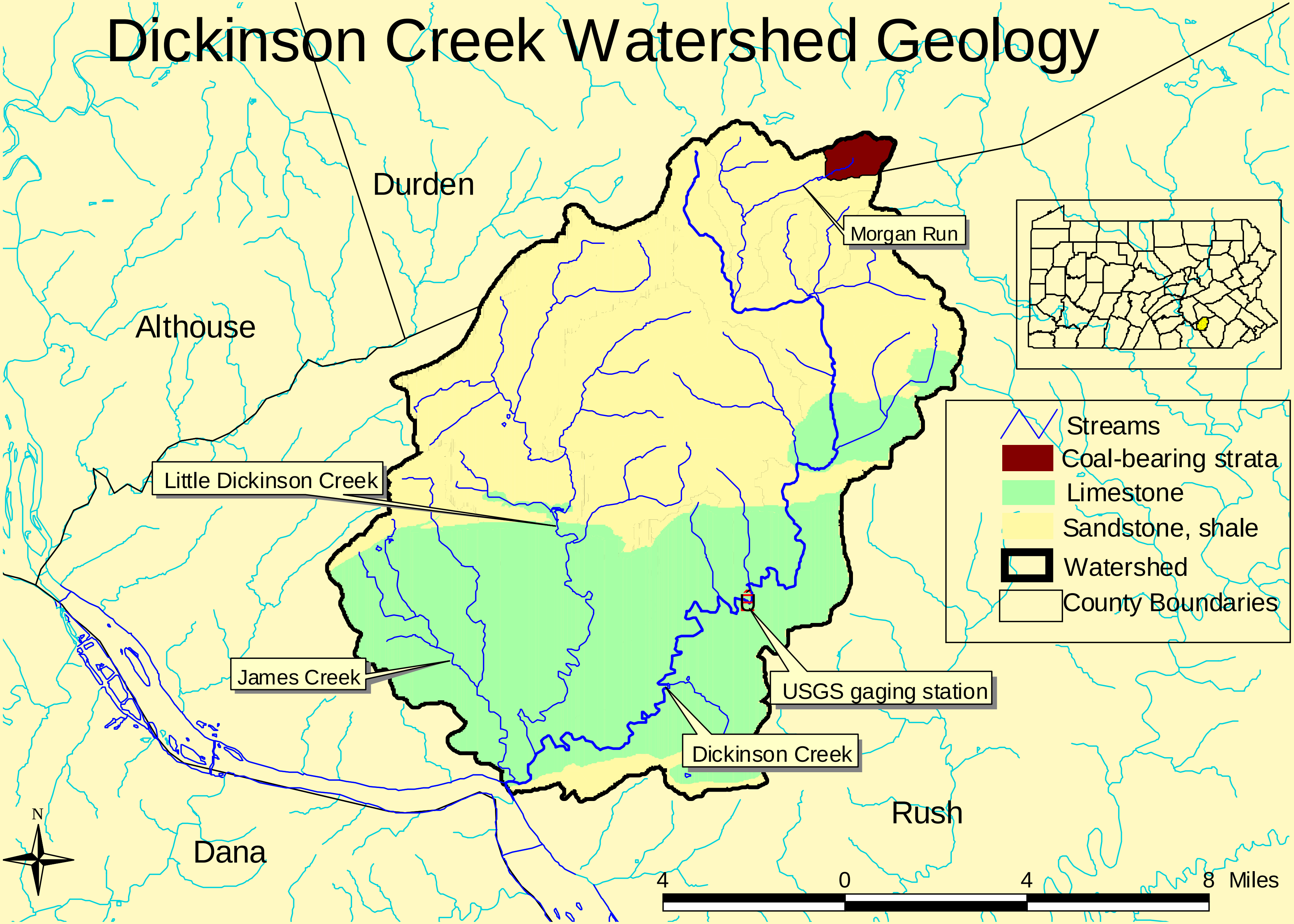
- GIS maps
- Data tables on indicators, along with graphs showing annual summaries for each site, and monthly summaries for all sites
- Questions to help them work through the data
- Resource materials for their use



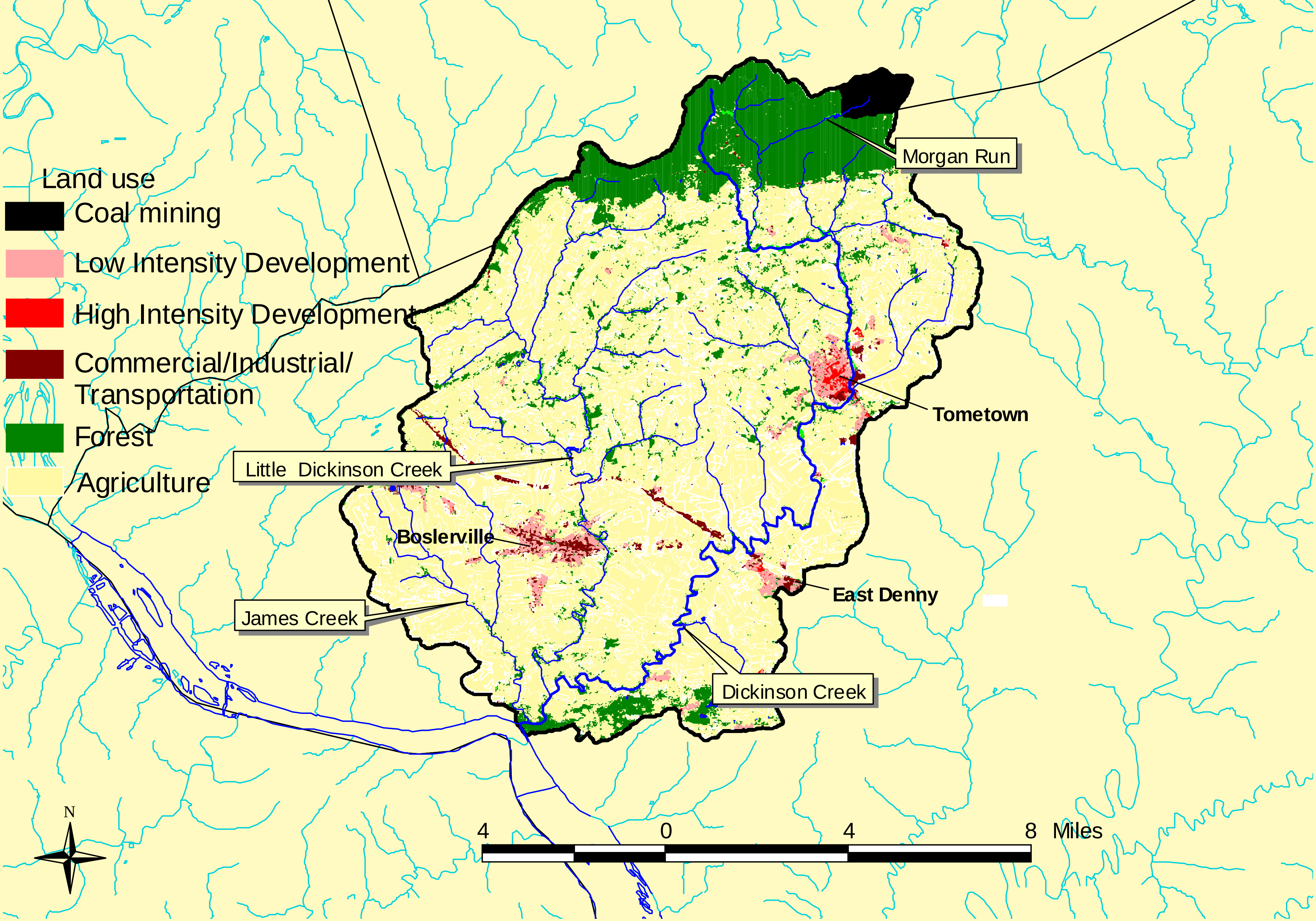




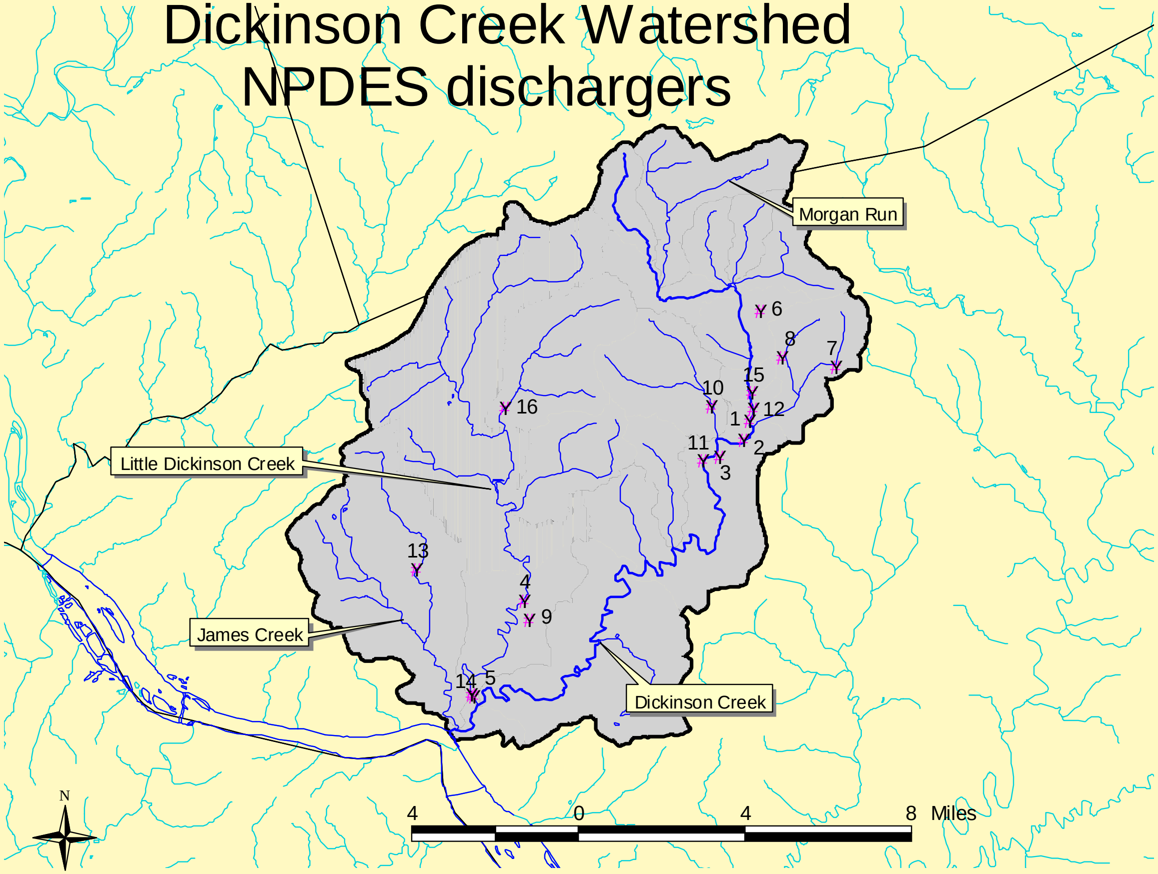
Dickinson Creek Watershed Geology



Land Use in the Dickinson Creek Watershed



Dickinson Creek Watershed NPDES dischargers



Facility Name	Number on map
Raymark Inc.	1
Fuller Co. -- Tometown Plant	2
Tometown STP	3
Boslerville Borough Authority	4
Marietta-Donegal Jnt Sew Auth	5
Pine View Acres MHP	6
Chadaga, PCS. MD.	7
Pleasant View Retirement Comm	8
Boslerville Wire Corporation	9
Tometown Borough	10
Hilltop Acres MHP	11
Northwestern Rush County	12
Imgrund, Lauren	13
Boslerville Borough Authority	14
Worley & Obetz, Inc.	15

Site locations on Dickinson Creek

DC 27.4: Dickinson Creek. Near the source. Forested.

JC 5.2: James Creek, agriculture, limestone. Determined to be meeting designated uses by DEP in 2002.

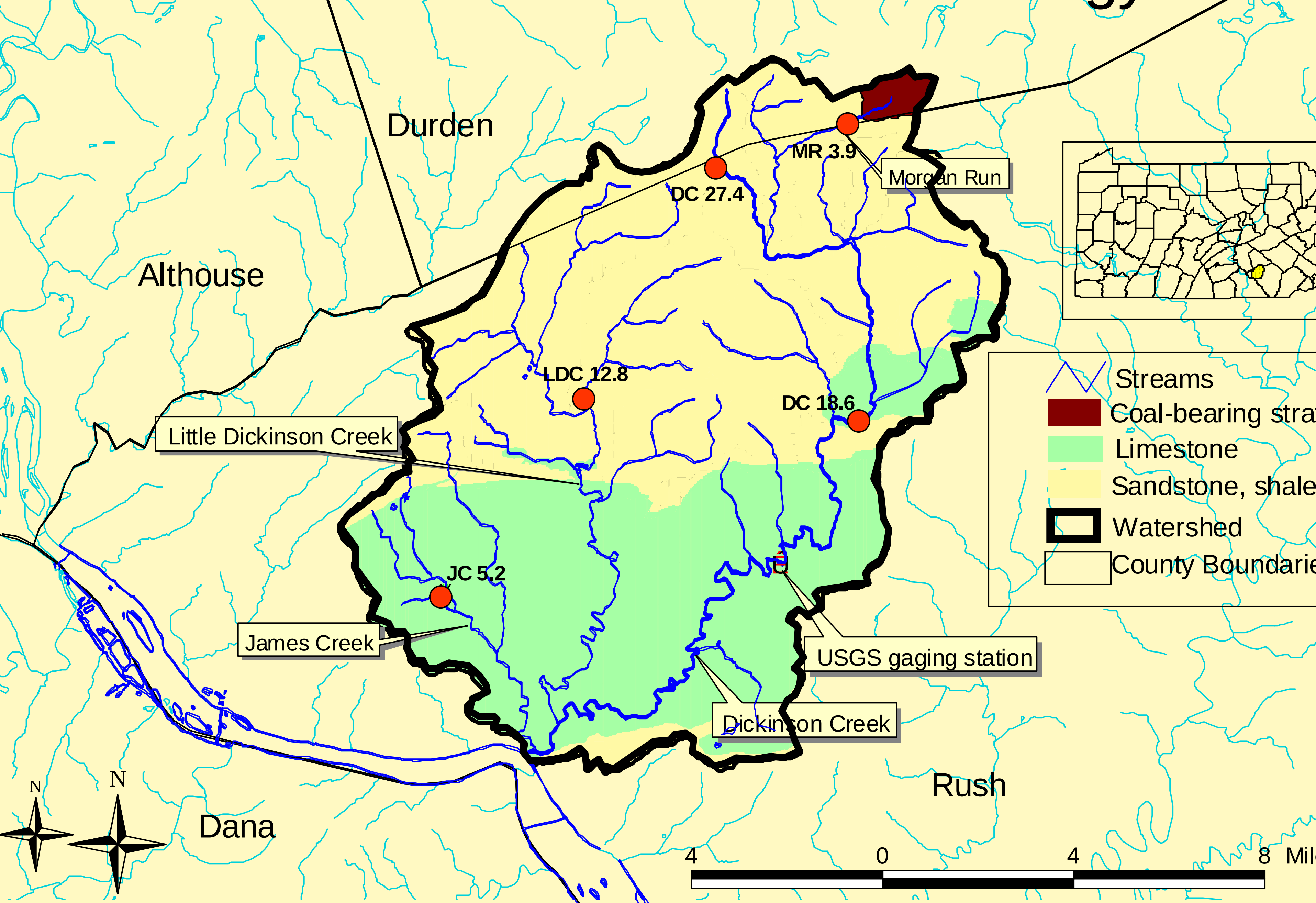
LDC 12.8: Little Dickinson Creek, agriculture, no limestone. Determined to be impaired by DEP in 2002.

MR 3.9: Morgan Run, forested, abandoned mine drainage. Determined to be impaired by DEP.

DC 18.6: Dickinson Creek, near town of Tometown; receives urban runoff from Tometown.

Site locations on Dickinson Creek

Dickinson Creek Watershed Geology



Resource materials

- A chart on chemical pollutants associated with land use
- A fact sheet on water quality indicators, including typical concentrations

AN AGENDA

6:00-7:00 PM Statistics 101: Introduction to data analysis

7:00-8:00 PM **The pieces:** Finding the story of Dickinson Creek, one indicator at a time (small group activity)

Small group presentations

8:00-9:00 PM **The big picture:** large group compilation and discussion

Statistics 101 (mini-version)

- Define and discuss statistical summary terms.
- Show how box and whisker plots are constructed and used.
- Examine the data structure.
- Examine box and whisker plots for our virtual data.

THE DATA STRUCTURE OF THE DICKINSON CREEK VIRTUAL WATERSHED

Sample Raw Data for Statistics

Total Suspended Solids (TSS) (ppm)													
LAND USE	**SITE**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
Forest	DC 27.4	9.3	9.9	10.4	10.0	13.3	7.8	0.0	0.0	0.0	0.0	6.7	9.6
Ag	JC 5.2	35.4	45.3	52.2	48.5	136.7	26.5	15.3	151.6	13.1	13.6	25.1	32.6
Ag; Pt. Dis.	LDC 12.8	52.2	152.3	189.3	175.2	456.3	125.6	100.3	50.2	56.3	62.3	103.2	135.2
Forest; AMD	MR 3.9	4.8	5.9	6.9	6.3	12.0	4.6	0.0	0.0	0.0	0.1	5.6	5.9
Urban	DC 18.6	133.8	158.2	185.6	178.3	365.2	85.6	25.6	20.8	19.8	25.4	75.8	125.6

Sample Data Summary Tables for Box and Whisker Plot

Total Suspended Solids (TSS) (ppm) - Annual Summary for Each Site

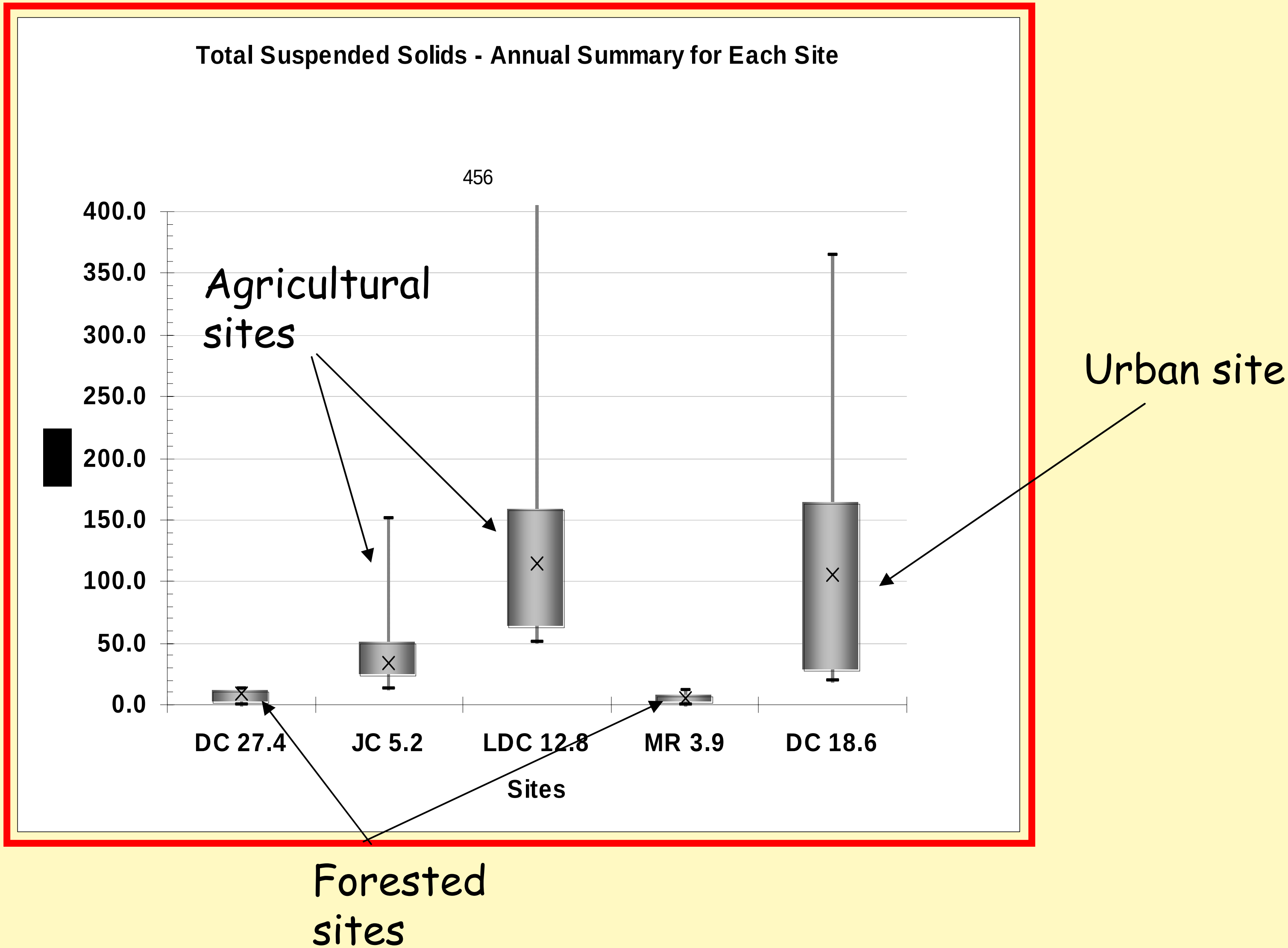
LAND USE	SITE	Average	Min	25th	Median	75th	Max	Range	IQ Range
Forest	DC 27.4	6.4	0.0	0.0	8.6	9.9	13.3	13.3	9.9
Ag	JC 5.2	49.7	13.1	22.7	34.0	49.4	151.6	138.5	26.8
Ag; Pt. Dis.	LDC 12.8	138.2	50.2	60.8	114.4	158.0	456.3	406.1	97.2
Forest; AMD	MR 3.9	4.3	0.0	0.1	5.2	6.0	12.0	12.0	5.9
Urban	DC 18.6	116.6	19.8	25.6	105.6	163.2	365.2	345.4	137.7

Total Suspended Solids (TSS) (ppm) - Monthly Summary for *All Sites*

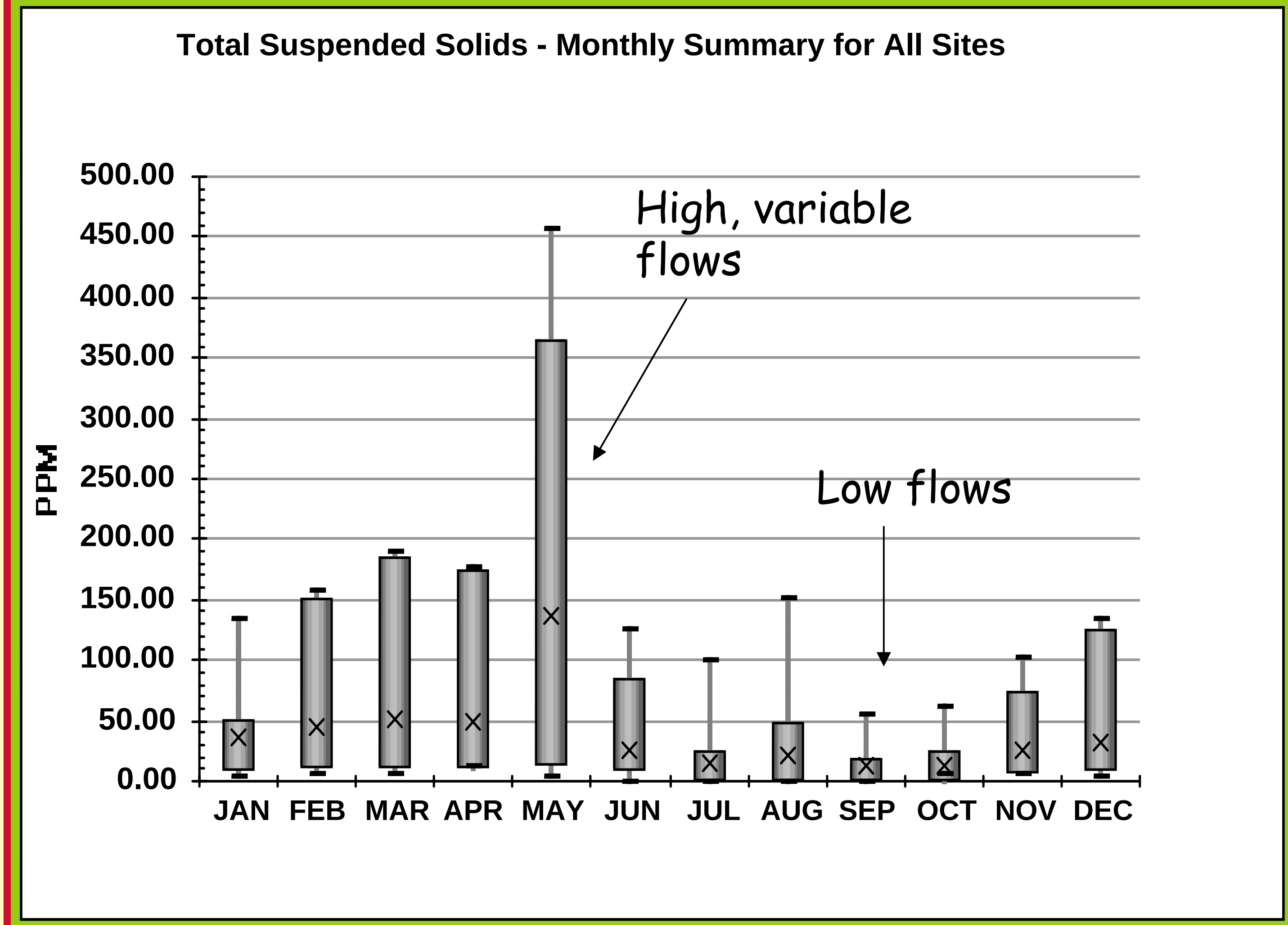
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Average	47.10	74.32	88.88	83.66	196.70	50.02	28.24	44.52	17.84	20.28	43.28	61.78
Min	4.80	6.90	6.30	12.00	4.60	0.00	0.00	0.00	0.00	5.60	5.90	4.34
25th	9.30	9.90	10.40	10.00	13.30	7.80	0.00	0.00	0.00	0.10	6.70	9.60
Median	35.40	45.30	52.20	48.50	136.70	26.50	15.30	20.80	13.10	13.60	25.10	32.60
75th	52.20	152.30	185.60	175.20	365.20	85.60	25.60	50.20	19.80	25.40	75.80	125.60
Max	133.80	158.20	189.30	178.30	456.30	125.60	100.30	151.60	56.30	62.30	103.20	135.20

THE BOX AND WHISKER PLOTS OF THE DICKINSON CREEK VIRTUAL WATERSHED

Sample Box and Whisker Plot for Sites



Sample Box and Whisker Plot for Months



The pieces: finding the story of Dickinson Creek

IA. Using Raw Data and Maps

1. e.g. What is the highest nitrate concentration recorded at any site?

- Group is divided into small groups; each small group has **1-2 chemical indicators** to study

Ib: Using Summary Data

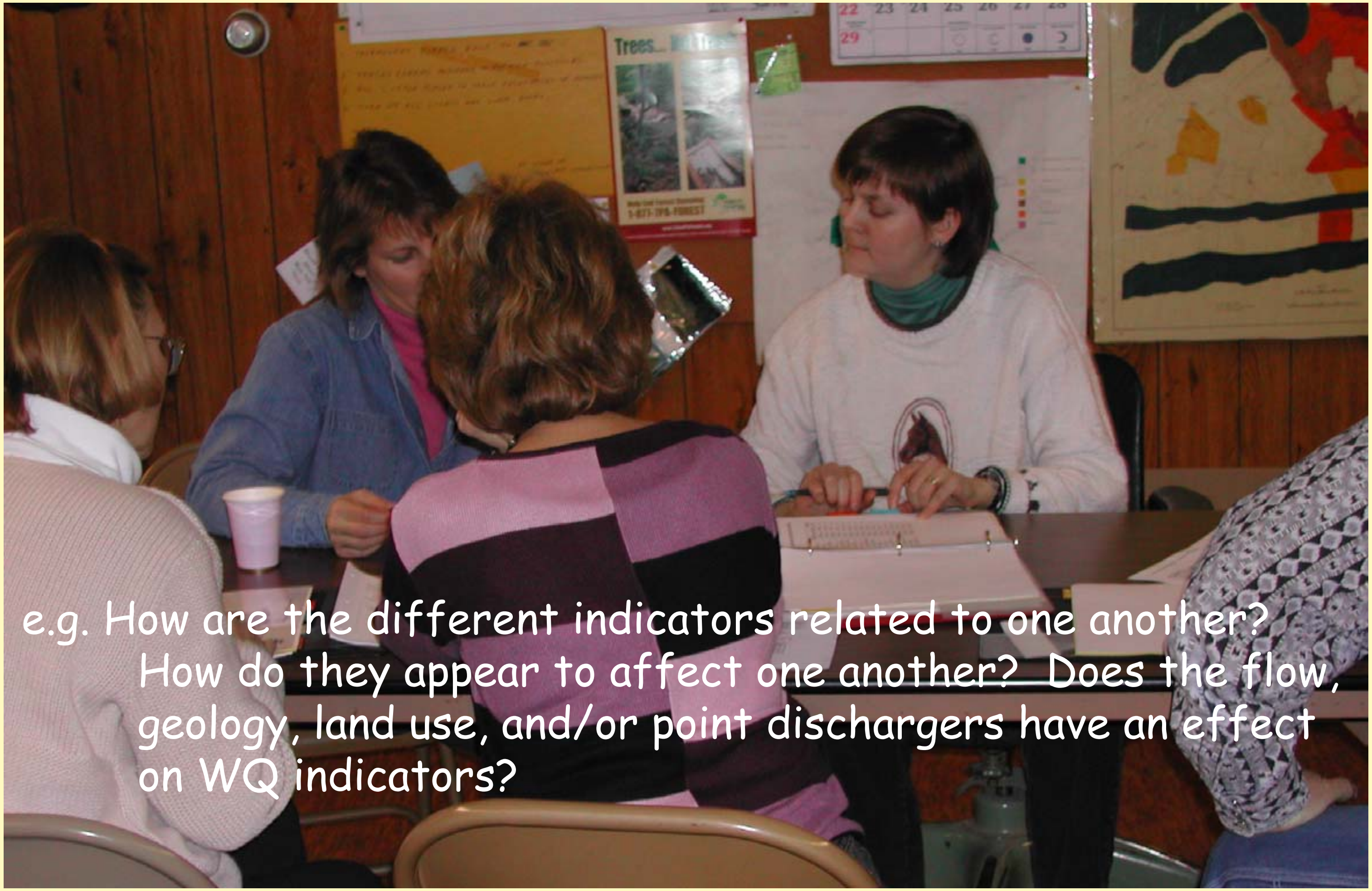
1. e.g. Based on the Box-and-Whisker graphs for your indicator, which sites are most different from each other?

II: Interpretation

1. e.g. If levels of your indicator are different between sites, what might explain this?

The big picture: large group compilation and discussion

Section III: Looking At All the Data Together



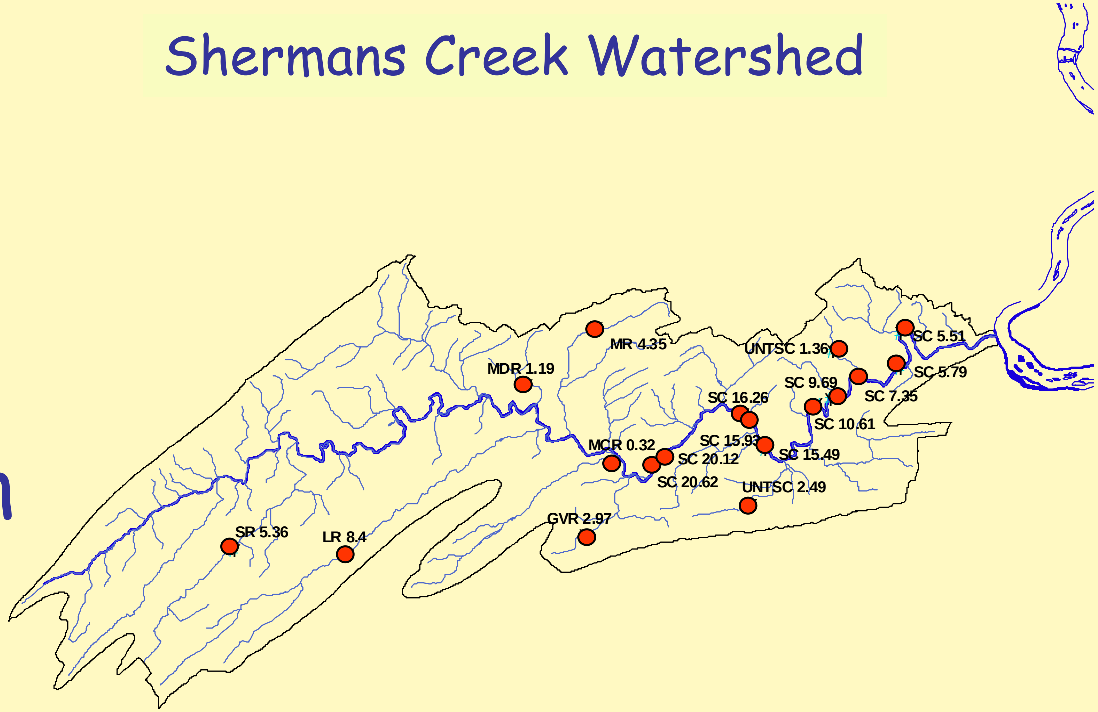
e.g. How are the different indicators related to one another? How do they appear to affect one another? Does the flow, geology, land use, and/or point dischargers have an effect on WQ indicators?

What they learn beyond basic statistical and graphical concepts

- A feel for typical concentrations of indicators; what is the central tendency, how much variation there is, what is an outlier.
- Indicators vary seasonally (patterns and causes).
- Indicators vary with land use and geology (patterns and causes).
- Some indicators are more useful than others in determining stream health.
- There is a need to have reference conditions with which to compare our data.
- We can do this; let's get on with the real data!

Workshop #2. Applying new skills to find the story in the real watershed data

Shermans Creek Watershed

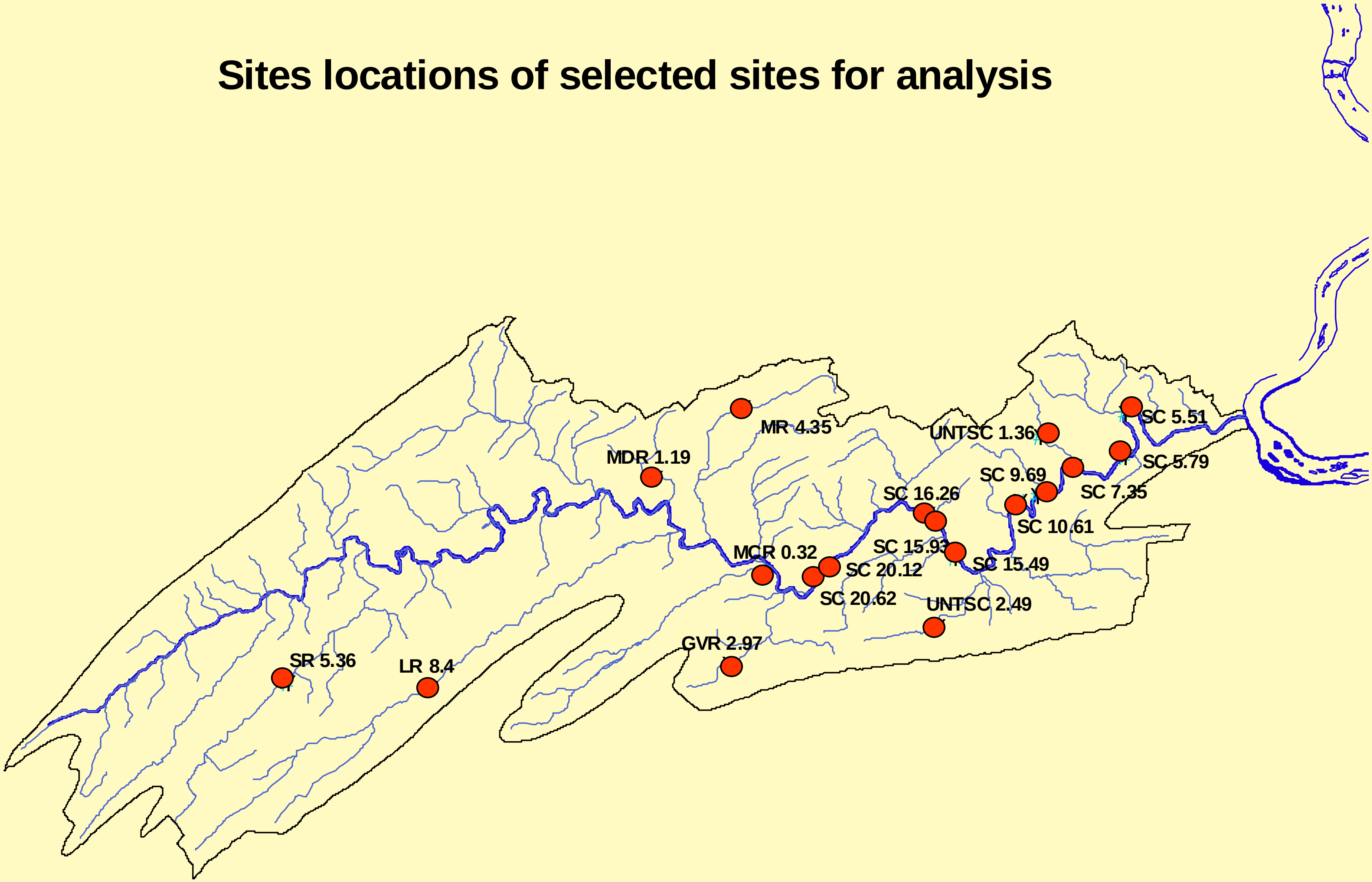


- Materials
- What we learn

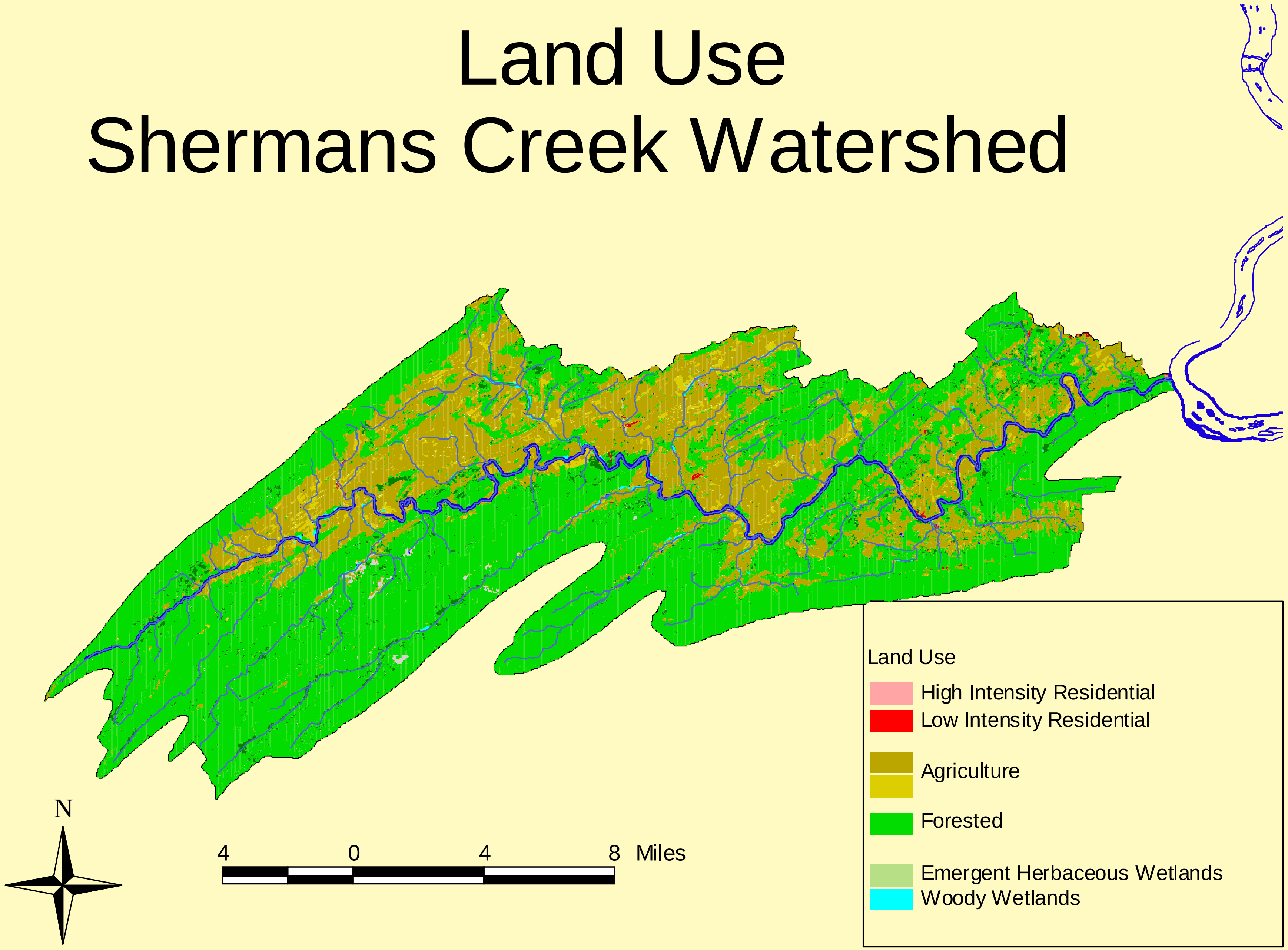
Indicators for which data have been collected by SCCA

- DO (dissolved oxygen)
- Temperature
- Using DO and Temperature, we can calculate Percent Saturation of DO
- Nitrate
- Alkalinity
- pH
- Macroinvertebrates (7 sites)
- Bacteria (4 sites)
- Visual Assessments

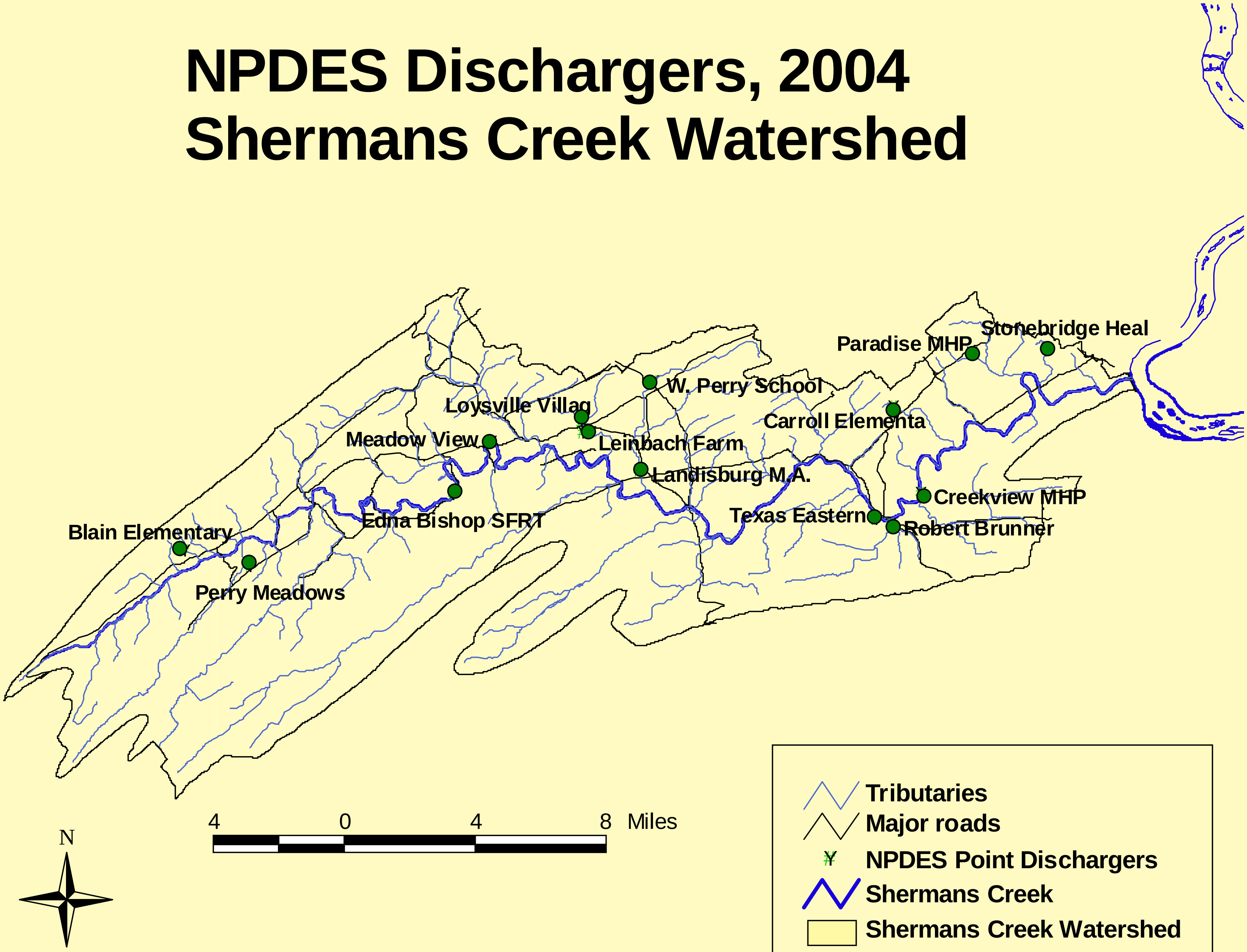
Sites locations of selected sites for analysis



Land Use
Shermans Creek Watershed



NPDES Dischargers, 2004
Shermans Creek Watershed



NITRATE CONCENTRATION DATA TABLES

NITRATES (mg/L)

SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SC 10.61		1.00	0.70	0.70	0.50	0.70	0.62	0.52			0.20	
SC 15.93	0.7	1	1.00	0.90	0.96	0.58		0.42	0.39	0.40	0.27	0.46
SC 16.26	0.64	0.89	0.91	0.88	0.86	0.80	0.76	0.68	0.38		0.36	0.37
SC 20.62		0.9	0.93	0.88	0.94		0.86	0.57	0.43			0.36
SC 5.51							0.63	0.37	0.08	0.10	0.00	0.31
SC 9.69					0.58		0.64	0.36	0.12	0.00	0.03	0.06
SR 5.36					0.17	0.20	0.22	0.14	0.18	0.18	0.07	0.12

Raw Data, 2001

NITRATES (mg/L) - Annual Summary For Each Site

SITE	Average	Min	25th	Median	75th	Max	Range	IQ Range
SC 10.61	0.62	0.20	0.52	0.66	0.70	1.00	0.80	0.19
SC 15.93	0.64	0.27	0.41	0.58	0.93	1.00	0.73	0.52
SC 16.26	0.68	0.36	0.51	0.76	0.87	0.91	0.55	0.36
SC 20.62	0.73	0.36	0.54	0.87	0.91	0.94	0.58	0.37
SC 5.51	0.25	0.00	0.09	0.21	0.36	0.63	0.63	0.27
SC 9.69	0.26	0.00	0.05	0.12	0.47	0.64	0.64	0.43
SR 5.36	0.16	0.07	0.14	0.18	0.19	0.22	0.15	0.05

Statistical summaries, 2001

NITRATES (mg/L) - Monthly Summary for All Sites

MONTH	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Average	0.67	0.95	0.89	0.84	0.67	0.57	0.62	0.44	0.26	0.17	0.16	0.28
Min	0.64	0.89	0.70	0.70	0.17	0.20	0.22	0.14	0.08	0.00	0.00	0.06
25th	0.66	0.90	0.86	0.84	0.52	0.49	0.62	0.37	0.14	0.08	0.04	0.17
Median	0.67	0.95	0.92	0.88	0.72	0.64	0.64	0.42	0.28	0.14	0.14	0.34
75th	0.69	1.00	0.95	0.89	0.92	0.73	0.73	0.55	0.39	0.24	0.25	0.37
Max	0.70	1.00	1.00	0.90	0.96	0.80	0.86	0.68	0.43	0.40	0.36	0.46

NITRATE CONCENTRATION DATA TABLES

NITRATES (mg/L)

SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
GVR 2.97	0.13	0.15	0.12	0.17	0.15	0.13	0.07				0.35	0.04
MCR 0.32				0.36	0.49	0.31	0.18	0.08	0.08	0.48	0.22	0.02
MR 4.35	3.40	4.00	7.80		7.50			5.55		2.58	9.10	
SC 15.93	0.67	7.00	0.84	0.52	0.69	0.65	0.48	0.00	0.05	0.97		
SC 16.26	0.66	0.52		0.30			0.32	0.18				
SC 20.12			0.12	0.54		0.08		0.20	0.10	1.00	0.96	0.99
SC 20.62	0.61		0.67	0.39			0.45			0.20	0.50	
SC 5.51	0.90	0.87	0.91		0.63	0.83	0.10	0.00	0.00	1.00	1.00	1.00
SC 7.35	0.92	0.96	0.85		0.84		0.16					
SC 9.69	0.50		0.99	0.38	7.13	0.59	0.17		0.20	1.00	0.82	
SR 5.36	0.24	0.23	2.40	0.24	0.24	0.12	0.17	0.24	0.20	0.09	0.12	

NITRATES (mg/L) - Annual Summary For Each Site

SITE	Average	Min	25th	Median	75th	Max	Range	IQ Range
GVR 2.97	0.15	0.04	0.12	0.13	0.15	0.35	0.31	0.03
MCR 0.32	0.25	0.02	0.08	0.22	0.36	0.49	0.47	0.28
MR 4.35	5.70	2.58	3.70	5.55	7.65	9.10	6.52	3.95
SC 15.93	1.19	0.00	0.49	0.66	0.80	7.00	7.00	0.31
SC 16.26	0.40	0.18	0.30	0.32	0.52	0.66	0.48	0.22
SC 20.12	0.50	0.08	0.12	0.37	0.97	1.00	0.92	0.85
SC 20.62	0.47	0.20	0.41	0.48	0.58	0.67	0.47	0.18
SC 5.51	0.66	0.00	0.37	0.87	0.96	1.00	1.00	0.59
SC 7.35	0.75	0.16	0.84	0.85	0.92	0.96	0.80	0.08
SC 9.69	1.31	0.17	0.38	0.59	0.99	7.13	6.96	0.61
SR 5.36	0.39	0.09	0.15	0.23	0.24	2.40	2.31	0.10

Raw Data, 2002

Statistical summaries, 2002

NITRATES (mg/L) - Monthly Summary for All Sites

MONTH	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Average	0.89	1.96	1.63	0.36	2.21	0.39	0.23	0.89	0.11	0.92	1.63	0.51
Min	0.13	0.15	0.12	0.17	0.15	0.08	0.07	0.00	0.00	0.09	0.12	0.02
25th	0.50	0.38	0.67	0.29	0.43	0.13	0.16	0.04	0.06	0.41	0.32	0.04
Median	0.66	0.87	0.85	0.37	0.66	0.31	0.17	0.18	0.09	0.99	0.66	0.52
75th	0.90	2.48	0.99	0.42	2.41	0.62	0.32	0.22	0.18	1.00	0.97	0.99
Max	3.40	7.00	7.80	0.54	7.50	0.83	0.48	5.55	0.20	2.58	9.10	1.00

NITRATE CONCENTRATION DATA TABLES

NITRATES (mg/L)

SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
GVR 2.97	0.35	0.27	0.37	0.30	0.32	0.13	0.12					
LR 8.4	0.29			0.19	0.15	0.10	0.06	0.16				
MCR 0.32		0.40	0.31			0.32	0.12					
MR 1.19	6.1	7.5	3.75	4.40	4.10		6.95					
SC 15.49	3.10	2.70	2.30	1.23	1.10	1.90	1.20	1.00				
SC 5.51	1.00	1.00		0.40	0.62		0.91	0.45				
SC 5.79	2.03	1.85				0.20						
SC 9.69	0.90	10.00	0.98		0.42	0.76	0.95	0.58				
UNTSC 2.49	0.22	0.23		0.26	0.10	0.06	0.16	0.14				
SR 5.36	0.30	0.21	0.38		0.20	0.32	0.14	0.14				
UNTSC 1.36				0.80	0.33	0.53	0.00					

Raw Data, 2003

NITRATES (mg/L) - Annual Summary For Each Site

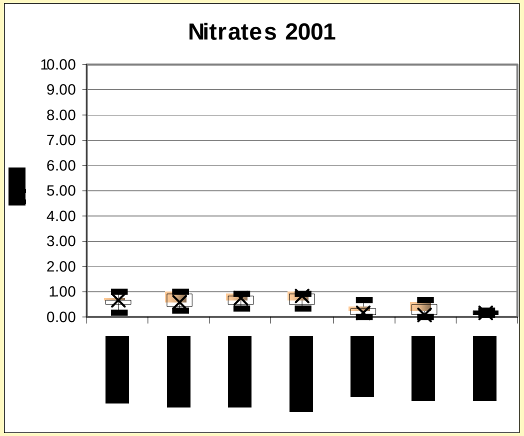
SITE	Average	Min	25th	Median	75th	Max	Range	IQ Range
GVR 2.97	0.27	0.12	0.20	0.30	0.34	0.37	0.25	0.14
LR 8.4	0.16	0.06	0.11	0.16	0.18	0.29	0.23	0.07
MCR 0.32	0.29	0.12	0.26	0.32	0.34	0.40	0.28	0.08
MR 1.19	5.47	3.75	4.18	5.25	6.74	7.50	3.75	2.56
SC 15.49	1.82	1.00	1.18	1.57	2.40	3.10	2.10	1.23
SC 5.51	0.73	0.40	0.49	0.77	0.98	1.00	0.60	0.49
SC 5.79	1.36	0.20	1.03	1.85	1.94	2.03	1.83	0.92
SC 9.69	2.08	0.42	0.67	0.90	0.97	10.00	9.58	0.30
UNTSC 2.49	0.17	0.06	0.12	0.16	0.23	0.26	0.20	0.11
SR 5.36	0.24	0.14	0.17	0.21	0.31	0.38	0.24	0.14
UNTSC 1.36	0.42	0.00	0.25	0.43	0.60	0.80	0.80	0.35

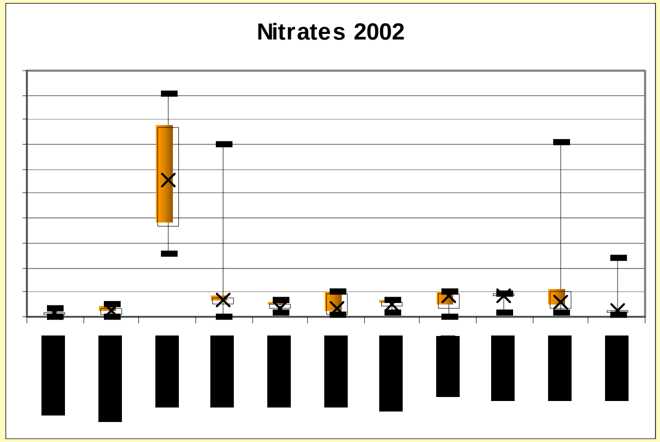
Statistical summaries, 2003

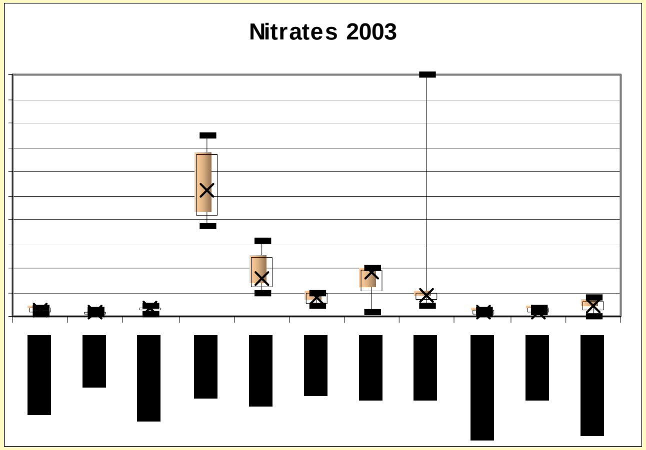
NITRATES (mg/L) - Monthly Summary for All Sites

MONTH	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Average	1.59	2.68	1.35	1.08	0.82	0.48	1.06	0.41				
Min	0.22	0.21	0.31	0.19	0.10	0.06	0.00	0.14				
25th	0.30	0.27	0.37	0.28	0.20	0.13	0.12	0.15				
Median	0.90	1.00	0.68	0.40	0.33	0.32	0.15	0.31				
75th	2.03	2.70	1.97	1.02	0.62	0.53	0.94	0.55				
Max	6.10	10.00	3.75	4.40	4.10	1.90	6.95	1.00				

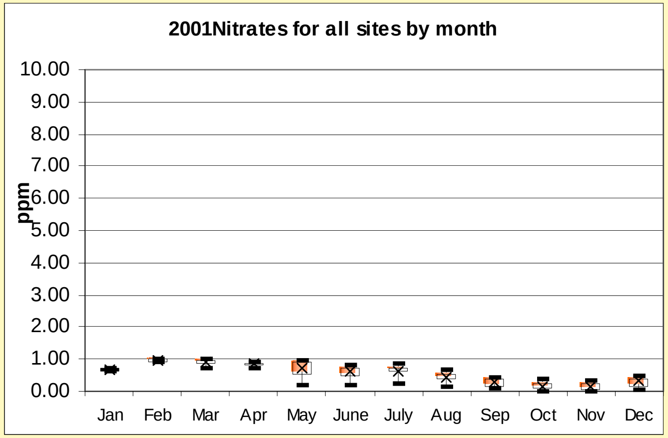
ANNUAL SUMMARY OF EACH SITE

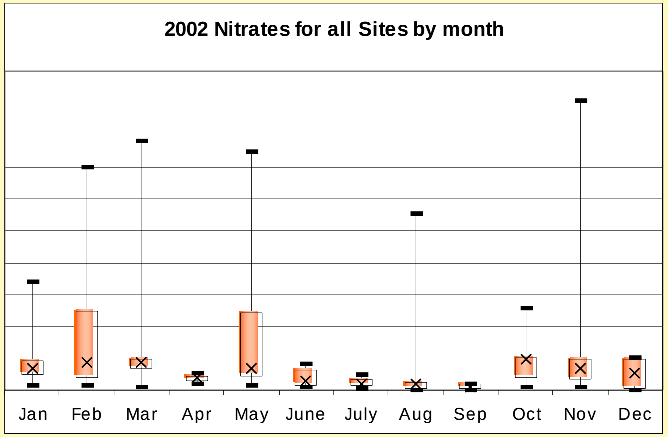


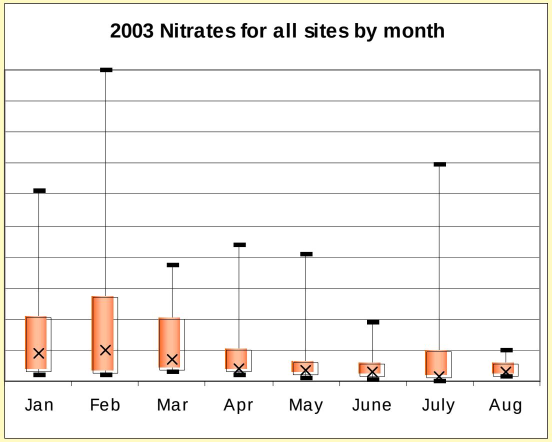




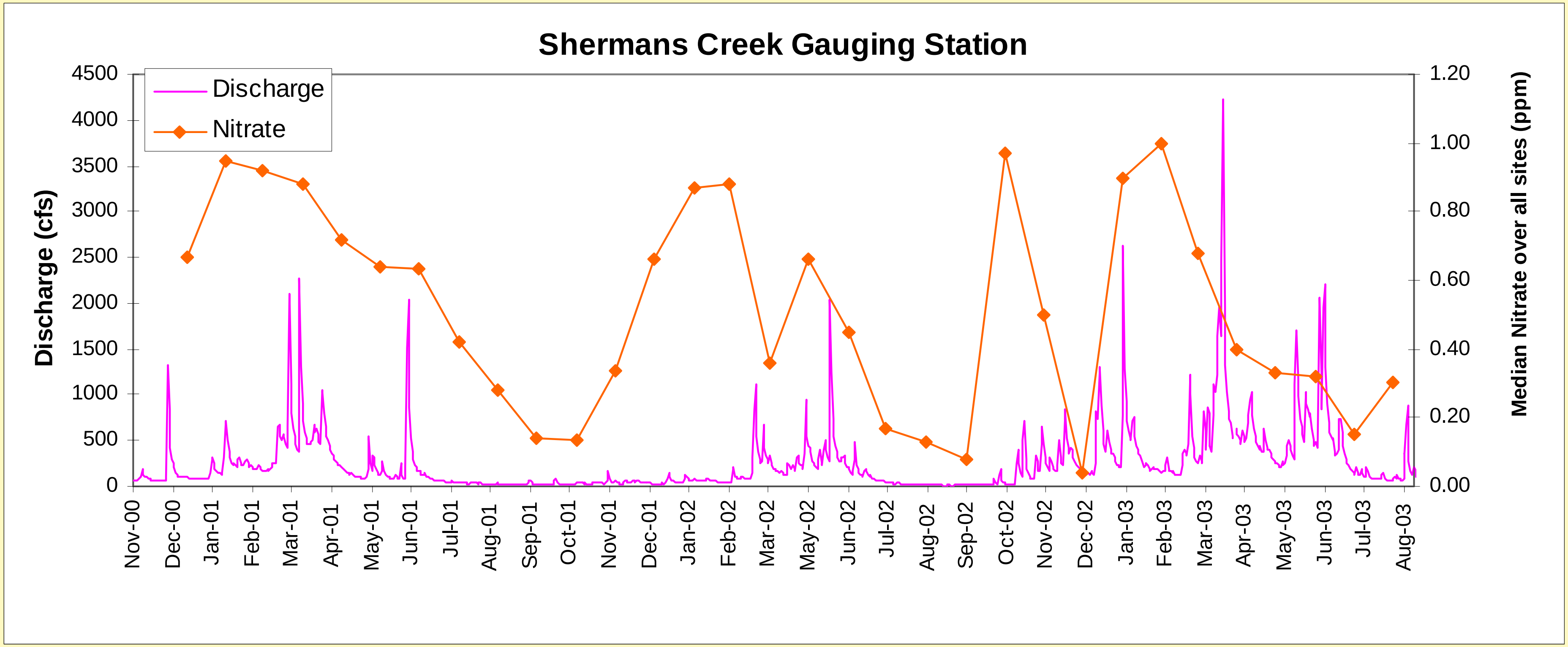
MONTHLY SUMMARIES OF ALL SITES



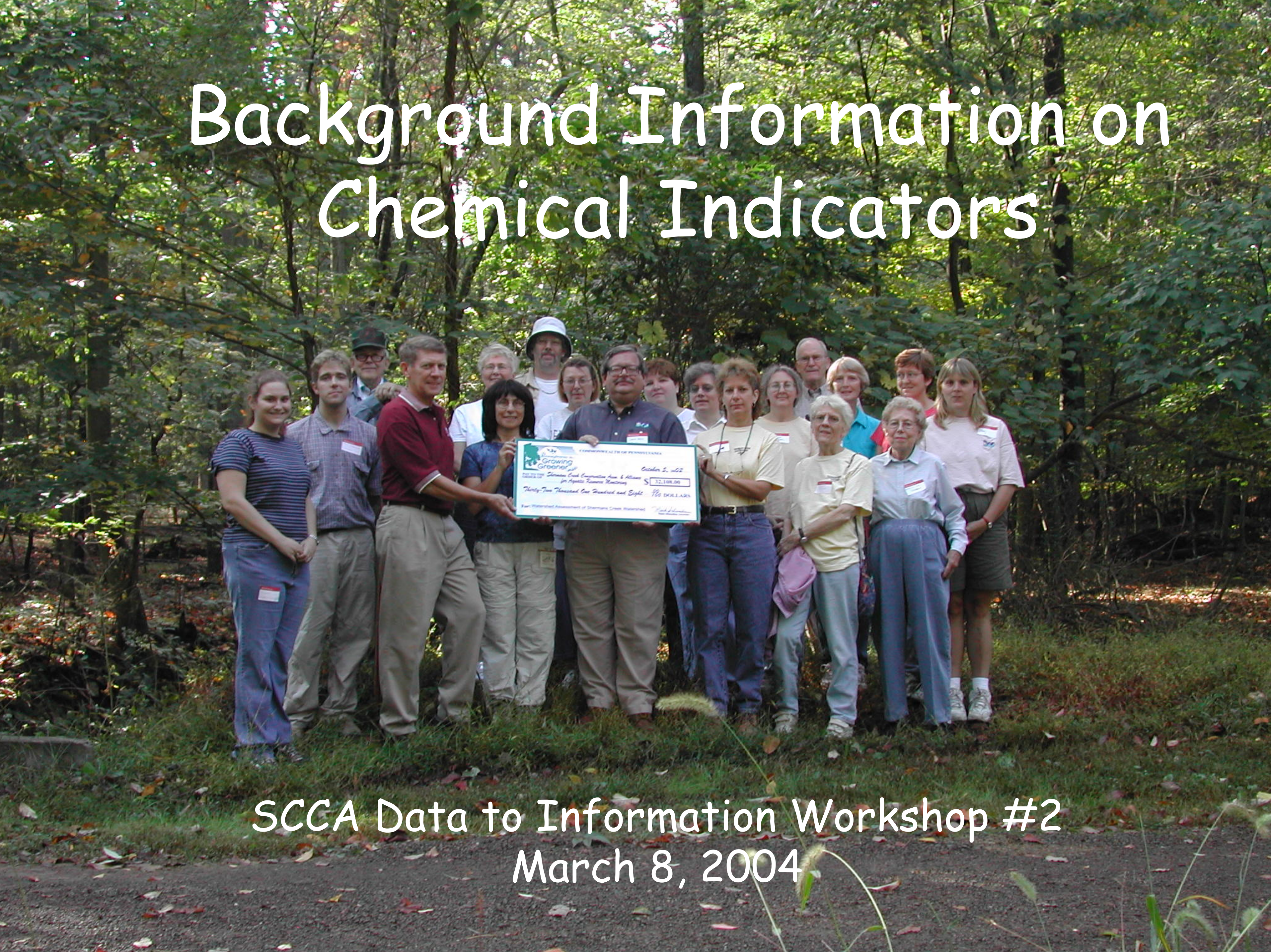




Relationship between flow and median monthly nitrate concentrations

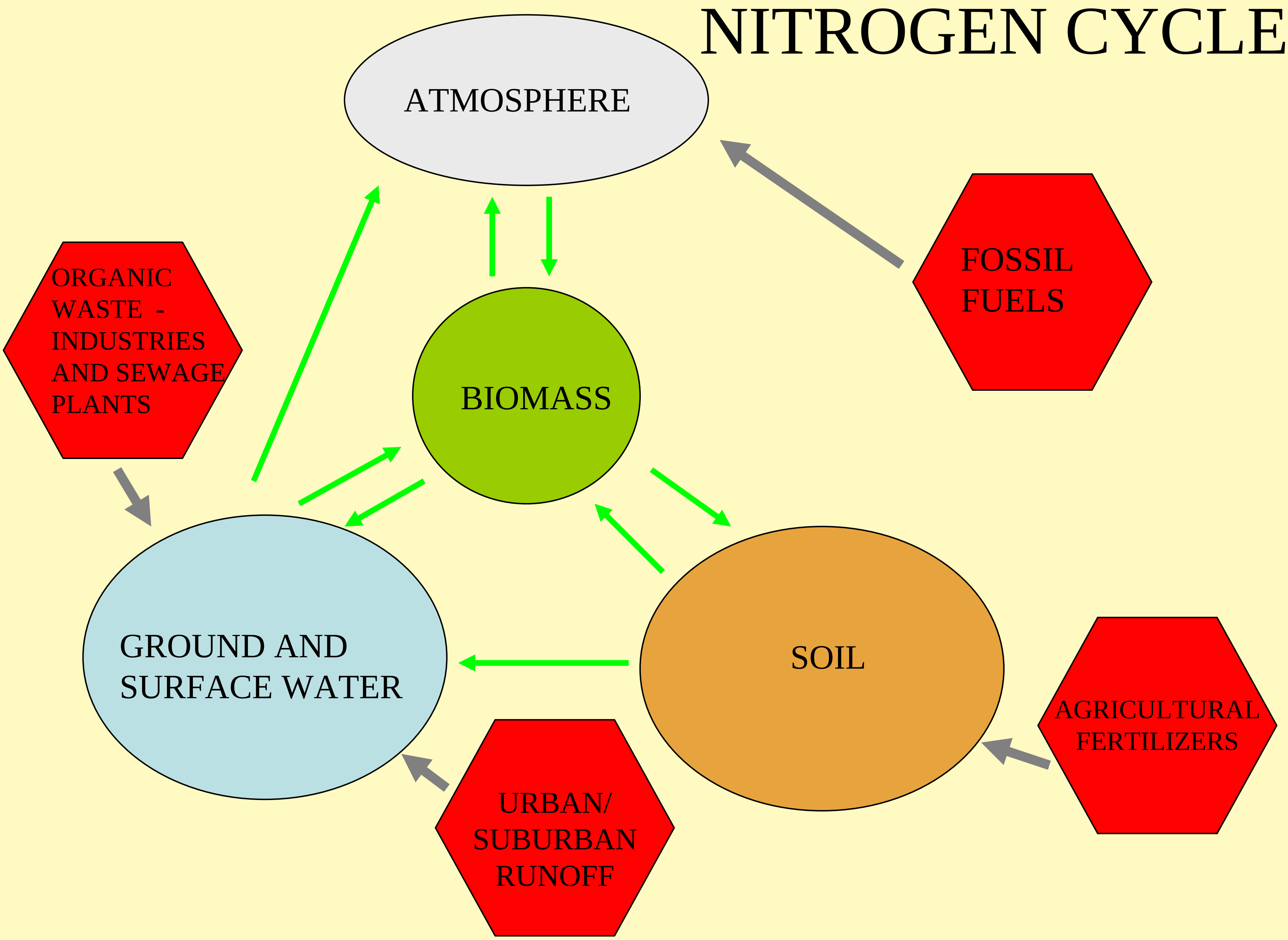


Background Information on Chemical Indicators



SCCA Data to Information Workshop #2

March 8, 2004


NITROGEN CYCLE
ATMOSPHERE
FOSSIL FUELS
ORGANIC WASTE - INDUSTRIES AND SEWAGE PLANTS
BIOMASS
GROUND AND SURFACE WATER
SOIL
AGRICULTURAL FERTILIZERS
URBAN/ SUBURBAN RUNOFF

Specific Water Quality Criteria (all waters should meet these criteria)

Parameter	Criteria
Alkalinity	Minimum of 20 mg/l as $CaCO_3$, except where natural conditions are less. Where discharges are to waters with 20 mg/l or less alkalinity, the discharge should not further reduce the alkalinity of the receiving waters.
pH	From 6.0 to 9.0 inclusive
Aluminum	Maximum of 0.1 of the 96-hour LC_{50} for representative important species as determined through substantial literature data or bioassay tests tailored to the ambient quality of the receiving waters.
Total Suspended Solids	No state specific criteria
Nitrate	Maximum 10 mg/L as nitrogen
Flow	No state specific criteria
Total Phosphorus	No state specific criteria
Dissolved Oxygen (Warm Water Fishery)	Min. Daily average 5.0 mg/l; min. 4.0 mg/l
Dissolved Oxygen (Cold Water Fishery)	Min. Daily Average 6.0 mg/l, minimum 5.0 mg/l

Note these criteria are based on the critical use of the watershed in our case study and your watershed may have different criteria. Refer to Title 25, Chapter 93 of the Pennsylvania Code for specific criteria for your watershed.

Excerpt from chart showing typical values of chemical parameters found in healthy streams

Percent saturation oxygen	Values of percent saturation of oxygen in healthy streams generally fall between 80% and 120%. Anything above or below that range is cause for concern.
pH	Although some streams are naturally acidic, anything below 6.0 (or above 8.5) is not considered typical.
Alkalinity	Low alkalinity values are of concern. Any stream with less than 20 mg/L (ppm) of alkalinity has little buffering capacity and is at risk for impact from acidic deposition.
Nitrates	Typical values in non-impacted streams are below 1 mg/L.

ETC.

The pieces: finding the story of OUR watershed

I. Groups use skills learned in first workshop to find patterns in their parameter and to identify problem sites.

- Group is divided into small groups; each small group has **1-2 chemical indicators** to study

II. Group presentations

III. Together, we compile and record the big picture on a large summary table.

INDIVIDUAL GROUP WORKSHEET TO RECORD OBSERVATIONS ON SINGLE INDICATORS IN SMALL GROUPS

Parameter = ___________

Year	Relation to Flow?		Seasonal Pattern?	Relation to Land use?	Relation to Geology?	Problem sites	In what way are they problems?' (violation of criteria, atypical, etc.)
2001						1. ______ 2. ______ 3. ______ 4.	______ ______ ______
2002						1. ______ 2. ______ 3. ______ 4.	______ ______ ______
2003						1. ______ 2. ______ 3. ______ 4.	______ ______ ______

MASTER WORKSHEET TO COMPILE ALL INFORMATION GATHERED FROM ALL GROUPS (ALL INDICATORS)

PROBLEM SITES	YEAR OF PROBLEM	INDICATOR(S) OF PROBLEM	POSSIBLE CAUSE(S) OF PROBLEM
1.			
2.			
3.			
4.			
5.			

Examples of findings

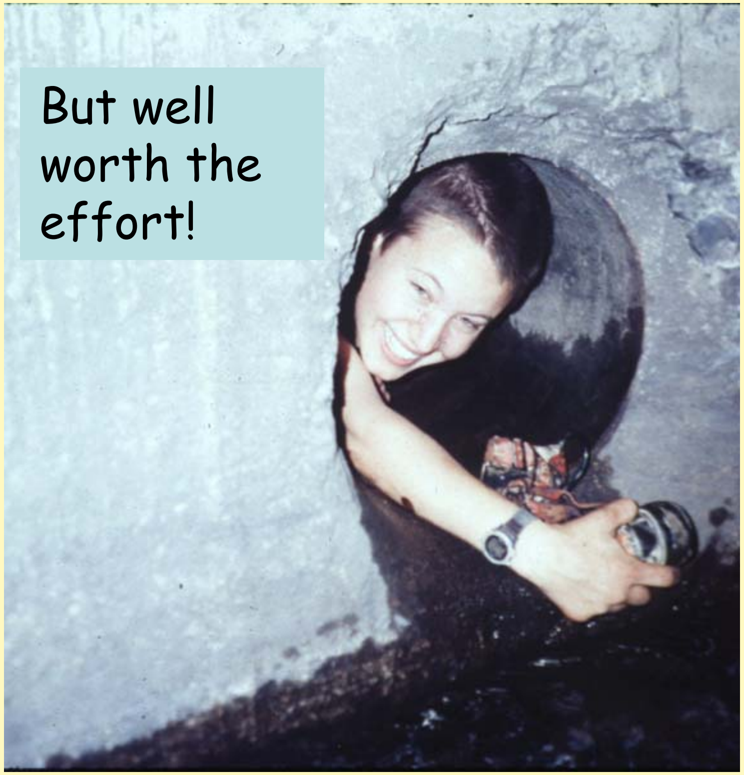
- Certain stream segments are impacted from acid deposition.
- Certain stream segments are impacted from agricultural activities.
- Overall, the watershed demonstrates high water quality, and there are critical areas which should be protected and upgraded.
- Nitrates are significantly higher during high flow years.
- There are numerous bacterial violations.
- Macroinvertebrate communities corroborate evidence from chemical indicators.

What we have learned about the outcomes of this process:

In the gathering of scientific knowledge, there is a trade-off between efficiency on the one hand and democracy/ sustainability on the other hand.

Model	Efficiency	Democracy "knowledge is power"	Sustainability
Consulting or Community Workers	Immediate, measurable scientific results	Only experts can use the data	Money runs out, consultants leave, activities end
Community-based Participatory Research	Requires more time and patience	Volunteers can use the data; levels the playing field in decision-making	Builds community capacity to continue even after experts and monies are gone


Training volunteers to
convert their data to
information is challenging,


But well
worth the
effort!