Session 9: Analyze Water Quality Data to Characterize the Watershed and Pollutant Sources

In This Training Session

- Introduction
- Do you have the data you need to answer important questions about the impairment?
- Goals of water quality data analysis
- The importance of data management
- Common principles of data analysis
- Reducing uncertainty when analyzing data
- Commonly used analytical tools
- TMDL analytical tools vary in their complexity
- Commonly used analytical tools – in more detail
    - Summary statistics
    - Duration curves
    - Comparative analysis
    - Pollutant load analysis
    - Temporal
    - Spatial analysis
    - Visual verification and discovery
- Getting started with your analysis
- Describing relationships between pollutants
- Summarize, document and communicate your findings
- Tips for communicating your findings
- Summary
- Contacts
- References

Acronyms

BMP – Best Management Practices
CREP – Conservation Reserve Enhancement Program
EDA – Environmental Data Access
EPA – Environmental Protection Agency
GIS – Geographical Information Systems
MCES – Metropolitan Council Environmental Services
NPS – Nonpoint Source
NWIS – National Water Information System
MOS – Margin of Safety
MPCA – Minnesota Pollution Control Agency
QA/QC – Quality Assurance/Quality Control
TMDL – Total Maximum Daily Load
TSS – Total Suspended Solids
USGS – United States Geological Survey

Introduction

By this point in time, you and your colleagues will have invested a good deal of time and effort collecting and organizing existing data and filling data gaps with new data from the field. The goal of all data collection is to turn data into information.

Data analysis requires a good deal of experience, observation, intuition, and an ability to see the big picture. Thoughtful analysis of water quality data requires the analyst to think like a doctor or crime scene investigator.

Doctors need to integrate multiple laboratory tests, a physical examination, patient history, etc. before making a diagnosis. A crime scene investigator must piece together many minor pieces of evidence to determine who committed a crime. Similarly, you will use multiple analytical tools to analyze your data, often beginning with the simplest and graduating to the more complex tools where needed. By inter-relating the results with other observations, a reasonably accurate picture of what is happening in the watershed should emerge.

This chapter describes different ways of applying analytical tools to water quality data to get needed information about the causes and sources of an impairment. This chapter may also be useful when developing a monitoring plan (Chapter 7) to help in identifying potential analytical tools and data needs.

Note that this chapter focuses solely on the analysis of water chemistry and flow data. One could rightly argue that other types of data, such as land use and biological data are inextricably linked with water quality data and should be analyzed as a whole. However, an artificial line will be drawn in this chapter to make the material more manageable and understandable. Later chapters will describe how other data sets can be gathered and analyzed to answer critical questions.

This chapter provides a general overview of the kinds of analytical tools used to characterize water quality. In addition, this chapter presents several important things to consider as you prepare to analyze your water quality data.

Do You Have the Data You Need to Answer Important Questions About the Impairment?

When conducting an initial analysis of the data you have (existing and new), you may have noticed that certain data gaps still exist. This may lead you to wrestle with the difficult decision of whether to conduct additional water quality monitoring activities or to simply proceed with what you have. Ask yourself, “What is an acceptable level of error for this project? What are the risks of being wrong?”

Financial and time constraints impact many TMDL projects. It is important to carefully consider whether the imperfections in your data are significant enough to warrant spending additional money and staff time to correct.

If high scientific rigor is an important goal in your TMDL study, you may be justified in collecting additional data. In other cases, weaknesses in data may be addressed by increasing the Margin of Safety (MOS) when developing a TMDL allocation formula. Decisions about additional data gathering will need to be made on a case-by-case basis. Discuss these issues with your technical team before you proceed with any additional data gathering activities.

Keep in mind that in the final analysis, the TMDL must be of sufficient scientific rigor such that it meets the review criteria established by the MPCA and U.S. Environmental Protection Agency (EPA).

Goals of Water Quality Data Analysis

When initiating your TMDL project, data collection goals were developed. Refer to chapter 7 and its worksheets for more information. With existing and new data now in hand, you may be able to accomplish these goals:

- Develop an understanding of current water quality conditions
- Track water quality trends over time
- Understand spatial, temporal differences in water quality
- Understand pollutant delivery dynamics
- Identify pollutant sources
- Identify data gaps

Some or all of these goals may apply to your project. Ask yourself, “What questions are essential to answer? And what would it be helpful to know?”

The Importance of Data Management

An often overlooked but important first step in the data collection and analysis process is data management. Data management involves organizing and storing the data you have gathered so that it can be easily accessed and integrated by various analytical tools. While time-consuming and tedious, this is a very important part of the data analysis process.

Common approaches to organizing data include:

- Source repositories for data:
    - Flow (USGS's NWIS database, HYDSTRA)
    - Water quality (EPA's STORET, MPCA's EDA, MCES database)
- Spatially oriented data bases (e.g. GIS)
- Project-specific data bases and spreadsheets

Be certain that you are familiar with relevant data repositories, including those managed by MPCA and MDNR, US Geological Survey, etc. **Also be aware of MPCA's protocols for storing data in STORET and HYDSTRA databases.**

Work with your technical team to determine the best place(s) for your data.

Common Principles of Data Analysis

Consider these common principles of data analysis before you begin to work with your data (**Shilling, et. al., 2005**).

- **Personal bias must be left behind.** Let the data lead you to the proper conclusions.
- **Your conclusions can only be as good as your study design, the accuracy and number of measurements, and the appropriate application of statistical analysis.** Carefully consider these factors early in the process.
- **Know the chemical and physical properties of the pollutants you are studying.**
- **Describe the assumptions and methods you used to draw your conclusions** from the data. Documentation is vitally important to your project.

Reducing Uncertainty When Analyzing Data

Data analysis really begins during the early stages of a TMDL project. Before any new data was gathered, your technical team should have carefully considered what analytical tools would likely be used later in the process. In turn, data collection goals should have reflected the data needs of these tools. If you now have the right kinds and amounts of data in hand, analytical tools should ultimately provide useful and statistically reliable information.

With good quality information, you are more likely to be able to answer important questions about the impact of pollutants on your waterbody.

To reduce uncertainty in the data analysis process, review your team's decisions and actions to date **one last time**:

- Do we have "good" and "enough" data?
- Was the appropriate level of scientific rigor applied during the monitoring and data gathering process?
- Were all Quality Assurance and Quality Control (QA/QC) protocols followed when data was collected and stored?
- Do you have a diverse technical team to help you analyze?
- Are we knowledgeable about the history of the waterbody so that you can see the data in perspective?

If you answered no to any or all of these questions, your conclusions may be erroneous. If there are problems with your data or procedures, take the time to address them now before proceeding further. Ideally, the technical team should have asked these questions during the project's design phase rather than having to address them "after the fact."

Commonly used Analytical Tools for TMDL Studies

When analyzing your data, you will typically begin by using broad analysis techniques, and then apply increasingly complex techniques (as needed). The following data analysis tools are commonly used in TMDL studies. One, several or all may be applied to any one project. It is often best to start with the simplest tools, and then apply the more complex ones as needed, to provide the required information.

1. Summary Statistics
2. Duration Curves (including Flow, Concentration, Load)
3. Comparative Analysis (relationships between precipitation, flow, water quality data, and various statistical tests)
4. Load Computation and Analysis (FLUX, Estimator)
5. Visual Discovery and Verification
6. Predictive Models

This chapter presents simple examples of ways in which each of these tools could be applied within the context of a TMDL study. The idea is to familiarize technical team members with the analytical tools, not to make all members proficient at applying them.

TMDL Analytical Tools Vary in Their Complexity

Increasing Level of Complexity

Type of Data	Low	Moderate	High
Water Quality Stream Data (e.g. chemistry, flow)	**1. Summary Statistics** (e.g. minimums, average, maximum) for each watershed station.	**1. Duration Curves** **2. Comparative Analysis** **3. Load Analysis** **4. Spatial analysis** of water quality using instream water quality data and GIS information. **5. Visual Discovery and Verification**	1. **Spatial and temporal analyses of multiple instream parameters and GIS data often combined with modeling** and supplemental monitoring.

Overview of Analytical Tools

Summary statistics

Sources of Information:

- *305(b) Report*
- *303(d) lists*
- *314 studies*
- *Clean Water Partnership studies*
- *Other sources and reports*

Summary Statistics is a set of mathematical tools that you will use to summarize and interpret your data. Statistics also provide a way to assess how reliable your conclusions are when drawn from a particular data set (Shilling, et. al, 2005). Summary statistics can be used to***:***

- Compare acute and chronic water quality criteria with water quality conditions
- Identify data characteristics (i.e., the mean, median, standard deviation, minimum, maximum, etc.)
- Identify the percentage of samples that violated water quality standards over time
- Document how many times and by how much the standard was exceeded

Next, graph your data compared to the acute and chronic water quality criteria that pertain to your waterbody. This will create a visual display of the data that will allow you to see the number of times and by how much the waterbody has exceeded water quality standards.

On the same graph, plot the times of year (season, month) when the impairments are occurring. Occurrences may coincide with specific activities in the watershed at certain times of the year. This step may help to narrow down possible sources of pollution in the watershed.

The following examples illustrate several ways that summary statistics can be used to shed some light on the possible causes and sources of the impairment being studied.

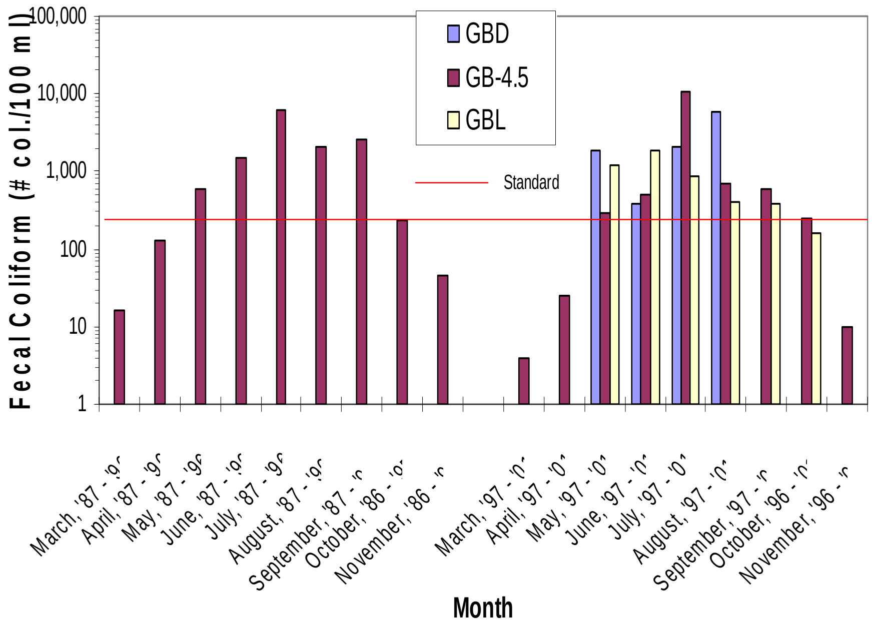


Figure 1: Monthly geometric means for fecal coliform versus the water quality standard.

Figure 1 depicts an average number of fecal coliform bacteria found in samples gathered during each month of the year, over a period of years. Note that the highest geometric mean of bacteria was measured between May and October of each year. The elevated concentrations in these months may provide a clue about possible sources of pollution. In this case, one might speculate that manure spreading, livestock grazing, or wastewater stabilization pond discharges are the more likely sources of bacteria, since these potential sources would be active during these months only.

Summary statistics also allow us to compare pollutant loads across watersheds or basins. Figure 2 compares the average Total Suspended Solids (TSS) and turbidity levels for different watersheds in Minnesota: the Mississippi, Minnesota, and St. Croix River basins.

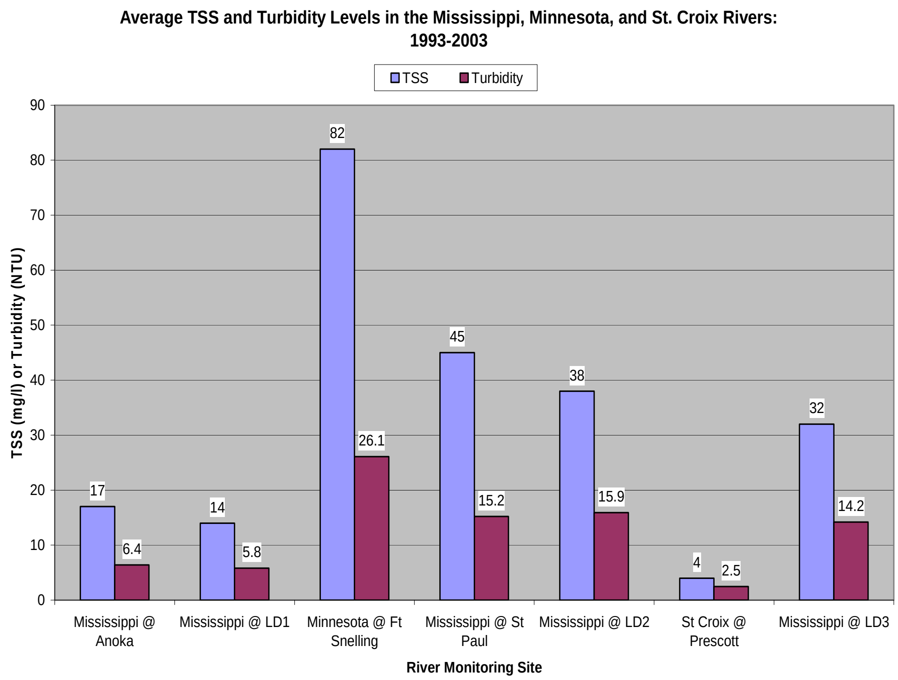


Figure 2

Summary statistics can be used to present data in many other ways, providing basic, but often useful information upon which to begin an analysis. Using summary statitics to analyze data is a good place to start, realizing that much additional analytical work will probably be necessary.

Duration Curves

Duration curves help to summarize water quality data against a long term flow record in such a way that we can understand the patterns of impairment. Duration curves help to visualize relationships between flow and pollutant concentrations over different flow conditions. As a result, duration curves can sometimes be useful when targeting restoration efforts, helping us to identify the most likely sources and flow conditions under which impairment occurs (Cleland, 2003).

Duration curves are useful when considering the impact of nonpoint sources on a particular waterbody. Since non-point source (NPS) pollution is often driven by runoff (flow) events, it important to understand how differences in flow can affect water quality conditions. Duration curves can be developed for flow, concentration, and load. Flow and load duration curves are most commonly used for TMDL projects.

Flow Duration Curves

Flow duration curves help to determine general hydrologic conditions (amount of time conditions are considered wet versus dry and to what degree) as well as the percentage of time that specific flows are equaled or exceeded.

Flow duration curves:

- Analyze cumulative frequency of historic flow data over a certain period of time
- Relate flow to the percent of time those values have been met or exceeded. Thus, low flows are exceeded frequently and floods are exceeded infrequently.
- Can be grouped into several zones to provide additional insight about patterns associated with impairments
- Typically include these zones: 1) High flows 2) Moist conditions 3) Mid-range flows 4) Dry conditions 5) Low flow

(Cleland, 2003)

Example of Flow Duration Curve

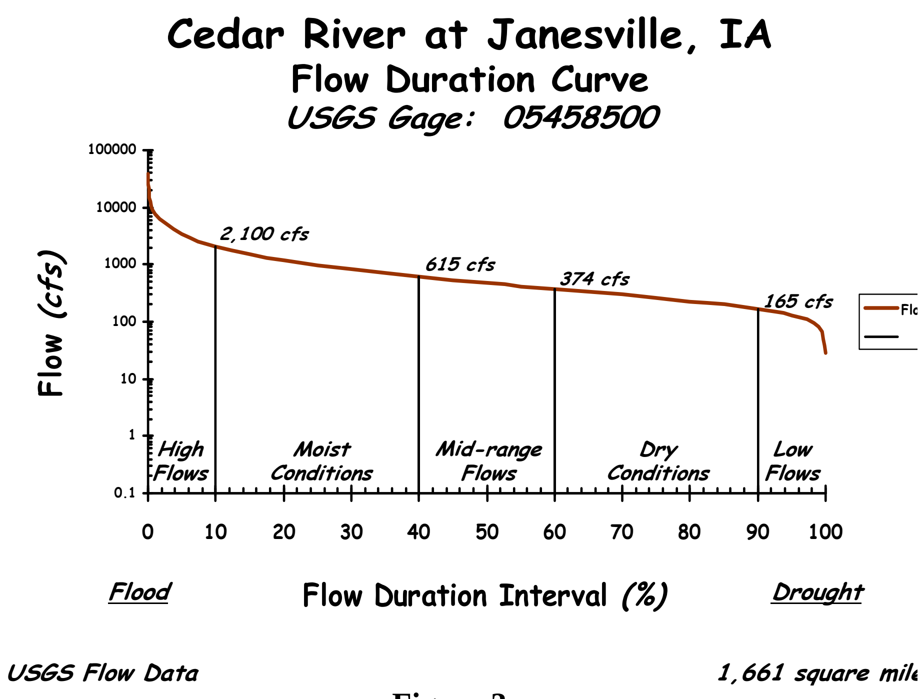


Figure 3

The flow duration curve typically uses daily average discharge rates which are sorted from the highest to the lowest.

Using this approach, flow duration intervals are expressed as a percentage, with zero corresponding to the highest stream discharge in the record (flood conditions), and 100 being the lowest (i.e. drought conditions).

Therefore, using this flow duration curve, a flow duration interval of 60 implies that 60 % of all stream discharge values equal or exceeds 374 cubic feet per second (Cleland, 2003).

Load Duration Curves

Load duration curves describe water quality conditions (patterns) associated with impairment. Load duration curves combine flow parameter concentrations.

Load duration curves:

- Depict how existing conditions compare with desired water quality targets.
- May be used as a diagnostic tool in simple conditions.
- Can be used to determine the load reductions needed to meet the TMDL for a specific waterbody.

Example of Load Duration Curve

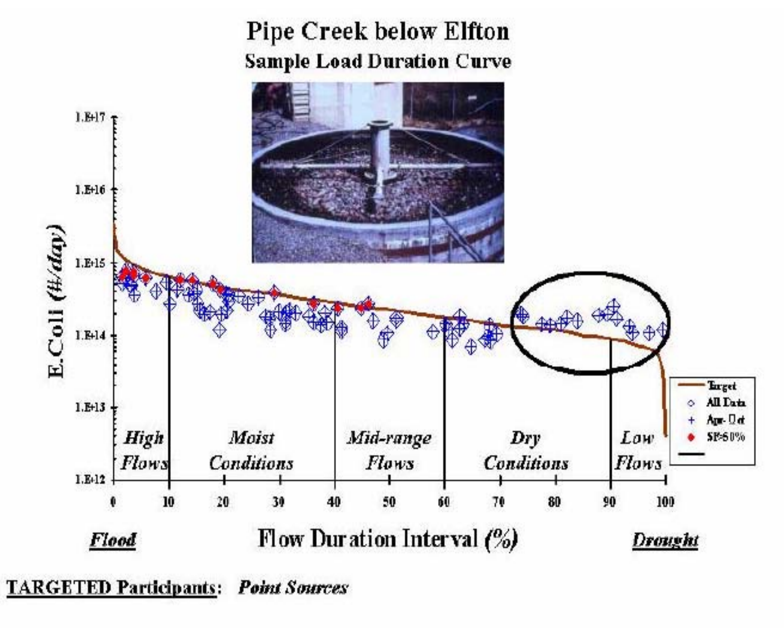


Figure 4: Load Duration Curve (Source: B. Cleland, 2003)

The relationship between flow and instream water quality concentrations can sometimes reveal the types of pollutant sources that may dominate instream impairments and can be helpful in identifying critical conditions causing the impairment.

The load duration curve shown in Figure 4 implicates point sources as those that may be causing the impairment, since water quality numeric criteria violations typically occur (see circle) during periods of low flow when nonpoint source contributions to the river are typically very low.

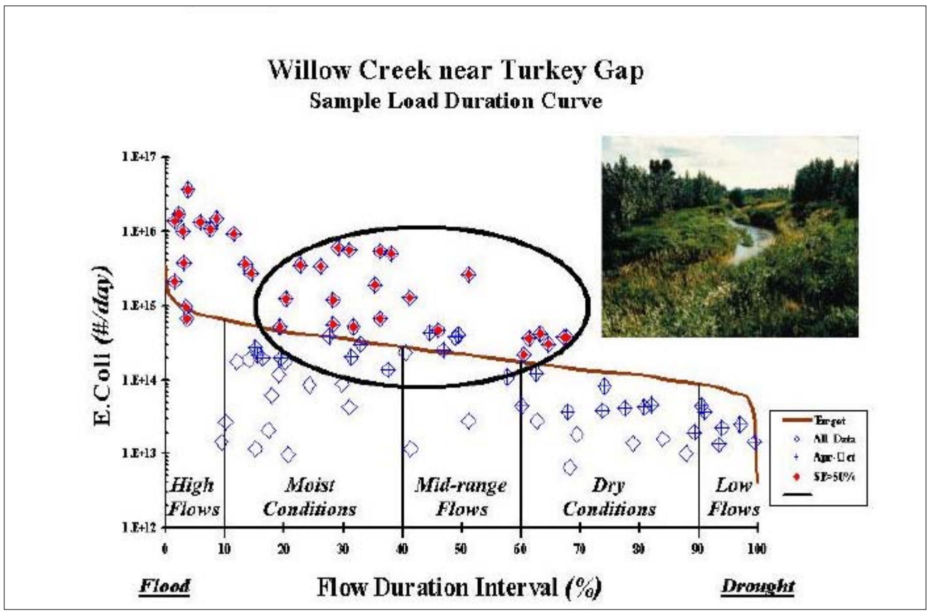


Figure 5: Sample Load Duration Curve

On the other hand, the load duration curve shown above in Figure 5 would appear to implicate nonpoint sources as the major sources of impairment, since water quality numeric criteria violations appear to be related to periods of flow greater than base flow.

Comparative analysis involves a visual or statistical analysis of data, examining relationships between flow, water quality conditions and precipitation. Comparative analysis assists in understanding the time, sources, and conditions under which pollutants are delivered.

The High Island Creek Watershed TMDL study will be used as an example to illustrate the ways in which comparative analysis tools can be applied to better understand pollutant delivery dynamics. Remember, you will have to develop your own unique approach to applying these tools, depending upon the nature of your project and the questions you need to answer.

Comparative Analysis

High Island Creek Watershed is located in the eastern portion of the Minnesota River Basin. The river is currently on the Section 303 (d) List for turbidity impairment. Early stakeholder discussions about High Island Creek water quality identified upland and bluff erosion as the most likely causes of the turbidity impairment.

Case Example

Comparative analysis tools were instrumental in helping project staff pinpoint the most probable causes and sources of the turbidity impairment.

Figure 6: High Island Creek Watershed

When studying turbidity impairment, it is vitally important to know where the largest sediment loads are coming from within the watershed and the conditions under which they are delivered to the river.

Using instream monitoring data and the FLUX model, project staff was able to determine existing pollutant loads from select subwatersheds. Analysis indicates that the highest sediment loads come from the eastern portion of the watershed, although western portions also contribute measurable sediment loads as well.

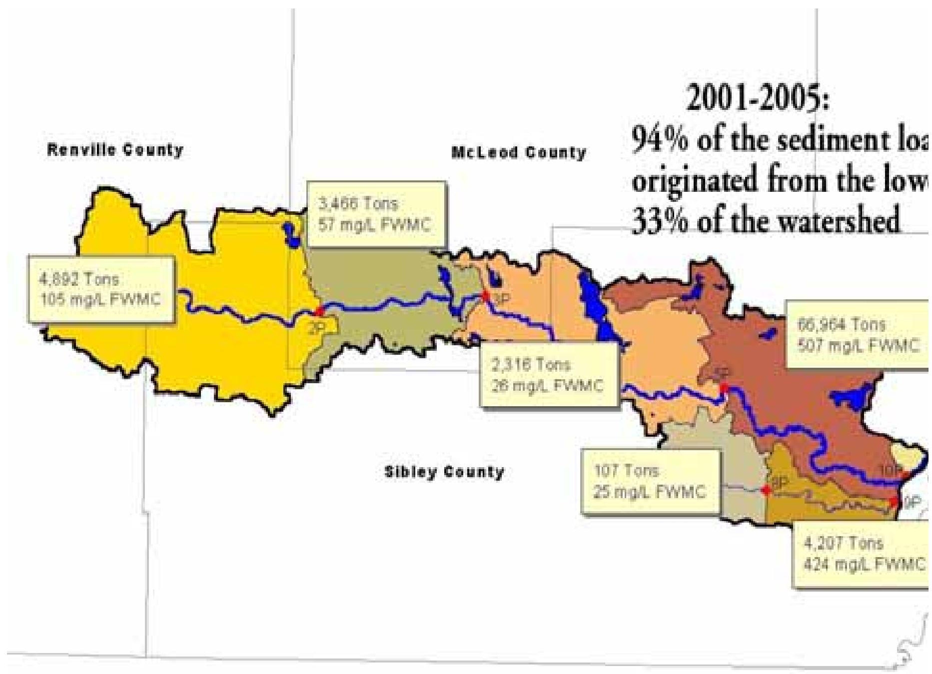


Figure 7: Sediment Loading Rates in the High Island Creek Watershed

Why were there significant differences in sediment loading rates across the subwatersheds? Were differences due to land use, geology, or some other factor(s)? The team knew that land use in the watershed was primarily agricultural row crop production. However, this fact alone was not enough to pinpoint the causes and sources of the impairment.

Landscape across the entire watershed is mostly quite flat. Most of the watershed (96%) has slopes < 3%. The only portion of the watershed with steeper slopes in along the eastern end of the watershed, near High Island Creek's confluence with the Minnesota River. With additional data from multiple sampling sites, staff was able to provide answers to these questions.

Hydrographs can Provide Valuable Insights

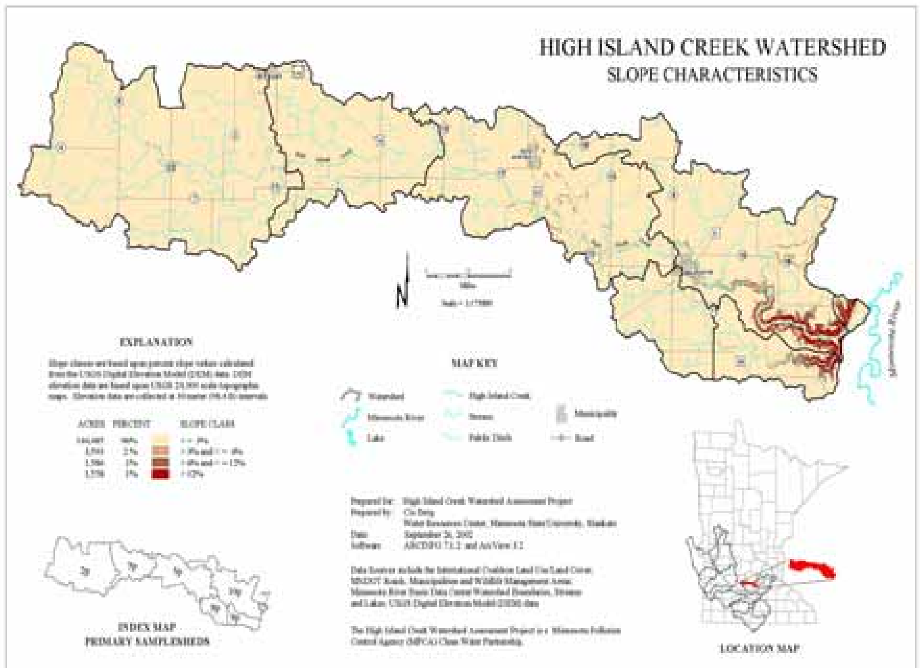


Figure 8: High Island Creek Watershed Slope Characteristics

The subwatersheds in the eastern half of the watershed typically have flat, low-sloped uplands as well. However, in the extreme eastern portion of the watershed, where the Hawk Creek meets the Minnesota River, slopes begin to increase significantly. In this portion of the watershed, stream energy and overland flow velocities begin to increase as the creek and tributaries cut deeper into the landscape. Consequently, streambank and upland erosion increases significantly. Gulley erosion also becomes a possible source of high sediment loads.

In the eastern portion of the watershed, upland erosion is probably not the main sediment source (even though it may be a significant issue) because we did not see this degree of sediment transport in the western subwatersheds which also have flat upland areas.

However, in the lower subwatersheds, waters draining from flat uplands are often channelized into gullies before they traverse the steeply sloped landscape leading to the river.
Very large amounts of sediment were believed to be transported to High Island Creek through gullies in the lower subwatersheds.

The technical team speculated that gulley and/or stream bank erosion may, in fact, be the major contributors of sediment to High Island Creek.

Plotting Parameters With Hydrographs

As a next step in their analysis, the team analyzed the hydrograph for High Island Creek. The hydrograph plots changes in flow over time.

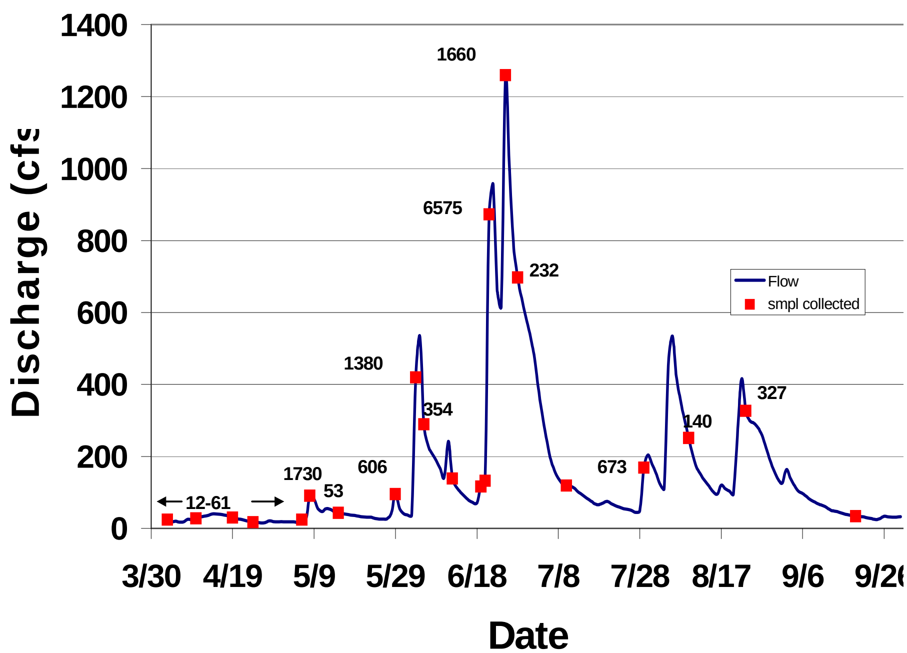


Figure 9: High Island Creek Daily Average Discharge and Sediment Concentrations (2002)

Note the peaks on the hydrograph during a large storm event in mid-June. Also note the significant differences in sediment concentrations on the rising and recession limbs of the hydrograph. On the rising limb, Total Suspended Solids (TSS) concentrations were very high at 6575 mg/l. On the recession limb, at a similar flow, TSS was measured at 232 mg/l. Why would the TSS concentration be so different given that the energy from stream flow through the system was nearly the same?

This graph, combined with previous analyses pointed to streambank, upland, and gulley erosion as the sources responsible for very high TSS concentrations on the rising limb. On the recession limb, the major sediment source was determined to be streambank erosion, since upland erosion and subsurface tile flows are minimal in the lower part of the watershed.

Figure 10 analyzed the relationship between precipitation and flow. At this point in the analysis, project staff determined that flow alone was not responsible for the measured differences in sediment concentrations in High Island Creek. By looking at rainfall data (both daily totals and hourly rainfall intensities), the analysts gained a better understanding of how overland flow influences sediment concentrations. Both antecedent soil moisture levels and rainfall intensity are known to influence runoff and sediment erosion rates.

High Island Creek Daily Average Discharge and Daily Rainfall (2003)

In-depth Analysis of Parameters

May reveal conditions under which pollutants are delivered and pollutant sources

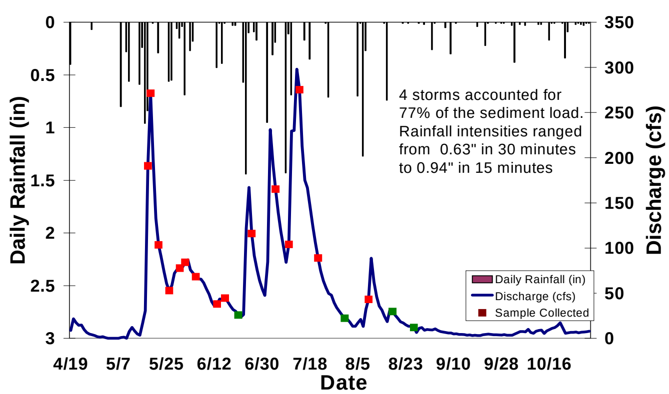


Figure 10: Analysis of Parameters

Temporal analysis of water quality conditions

The project staff then plotted rainfall on the hydrograph. It was clear that rainfall influenced discharge and measured sediment concentrations; however, more information was still needed. Project staff surmised that if the highest sediment concentrations were occurring during the storms with the highest rainfall intensities, then overland flow was eroding sediment from uplands and streambanks. In addition, gulley erosion was still likely to be a major source of sediment.

By taking a closer look at Figure 10, project staff was able to ascertain that four major high intensity storms, during the period of spring to mid-summer were responsible for the majority (77%) of the measured sediment load to High Island Creek.

The project staff then plotted rainfall on the hydrograph. It was clear that rainfall influenced discharge and measured sediment concentrations; however, more information was still needed. Project staff surmised that if the highest sediment concentrations were occurring during the storms with the highest rainfall intensities, then overland flow was eroding sediment from uplands and streambanks. In addition, gulley erosion was still likely to be a major source of sediment.

This table leads to a number of questions. Why are loads so variable? Did climatic factors play a part? Or were there some other factors? In this particular case, weather conditions were drier than normal during years 2000, 2002 and 2003. This graph illustrates the importance of having several years of load data to account for climatic differences from year to year.

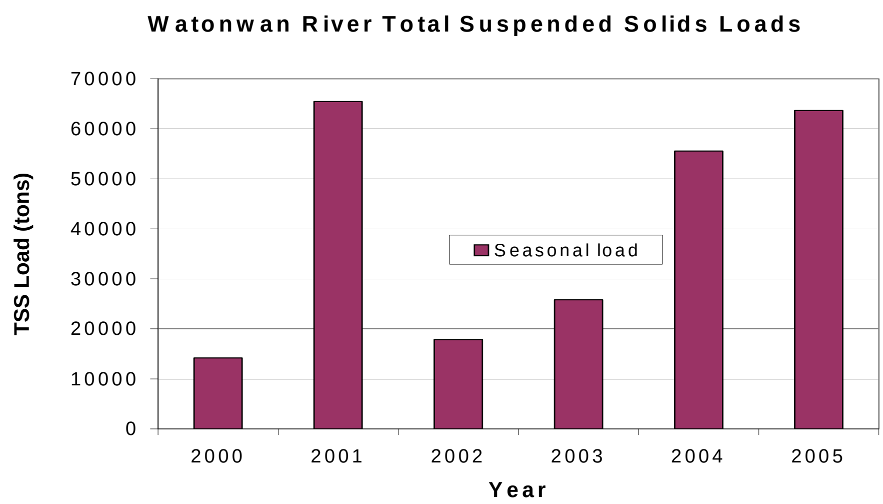


Figure 11: Total Suspended Solids Loads

Figure 12 presents the flow-weighted mean concentrations in Hawk and Beaver Creeks over a period of 8 years. A flow–weighted mean concentration provides the average concentration of a pollutant in a river over the range of flow conditions sampled. Flow–weighted mean concentrations provide a more accurate picture of pollutant levels over time than simple (arithmetic) averages.
Flow-weighted mean concentrations provide a more accurate picture of pollutant levels with respect to water quality conditions over time, since it accounts for variability in flow over a given time period. Temporal analysis shows a 45-50% reduction in the flow-weighted mean concentrations of TSS in these two watersheds over this time period. A logical explanation for this reduction is that a significant effort was made to enroll many acres of farmland in the Conservation Reserve Enhancement Program (CREP) during these years.

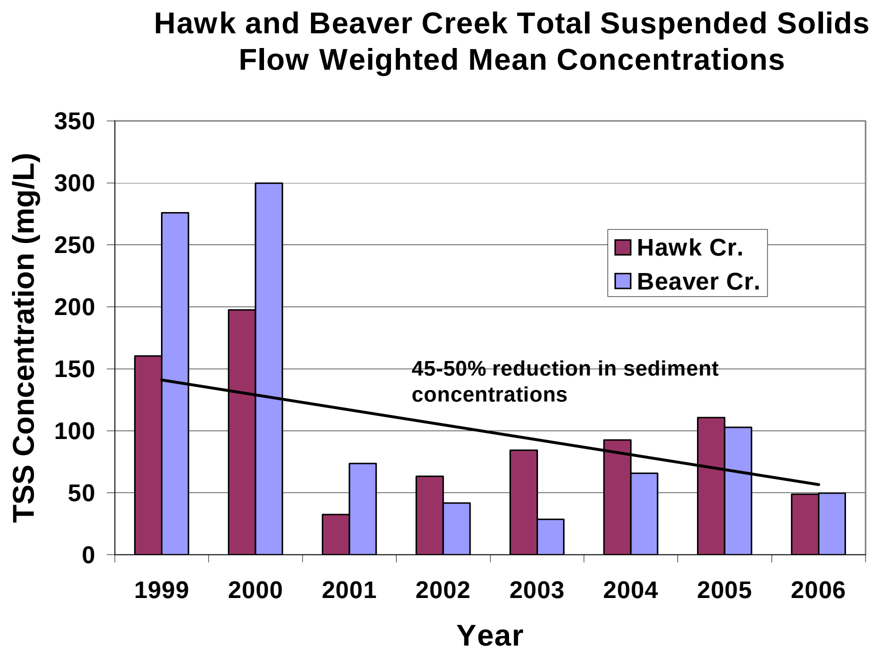


Figure 12

Temporal analysis of data by months or seasons indicate the existence of a source active only during those times. This allows the analyst to narrow down sources to those most likely to be contributing to water quality standards violations.

Figure 13 illustrates such a temporal difference in water quality. The greatest phosphorus loads to the LeSueur River occur during the period of highest stream flow during a 3 month time period – May, June and July. The data shows that this process holds true over two different monitoring seasons.

During the months of May –July, soil is exposed to the erosive potential of rainfall events. During these months, crops have either just been planted are getting established, providing little protection to soil particles during storm events. Not surprisingly, sediment transport to the river through overland flow was shown to be greatest during these months of the year.

Le Sueur River – Monthly Total Phosphorus Loads

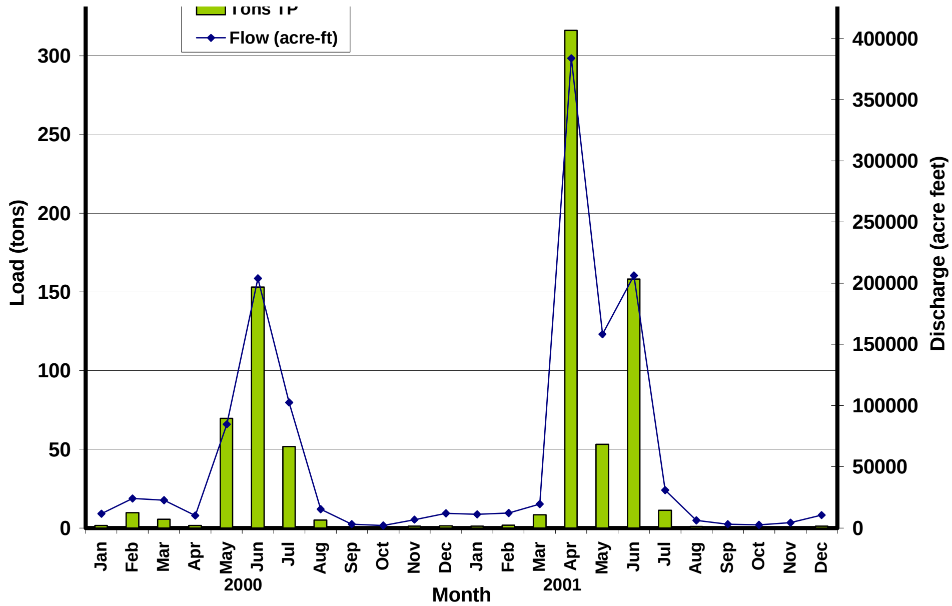


Figure 13: Monthly Total Phosphorus Loads

Different land use activities or natural conditions within a watershed may cause differences in the amounts of pollution those areas yield. For example, intensive land uses such as urban development or row crop agriculture will typically yield higher levels of pollutants to a waterbody than an undisturbed natural area would. Spatial analysis allows you to determine whether impairments are found throughout the watershed or only in certain areas.

Spatial Analysis

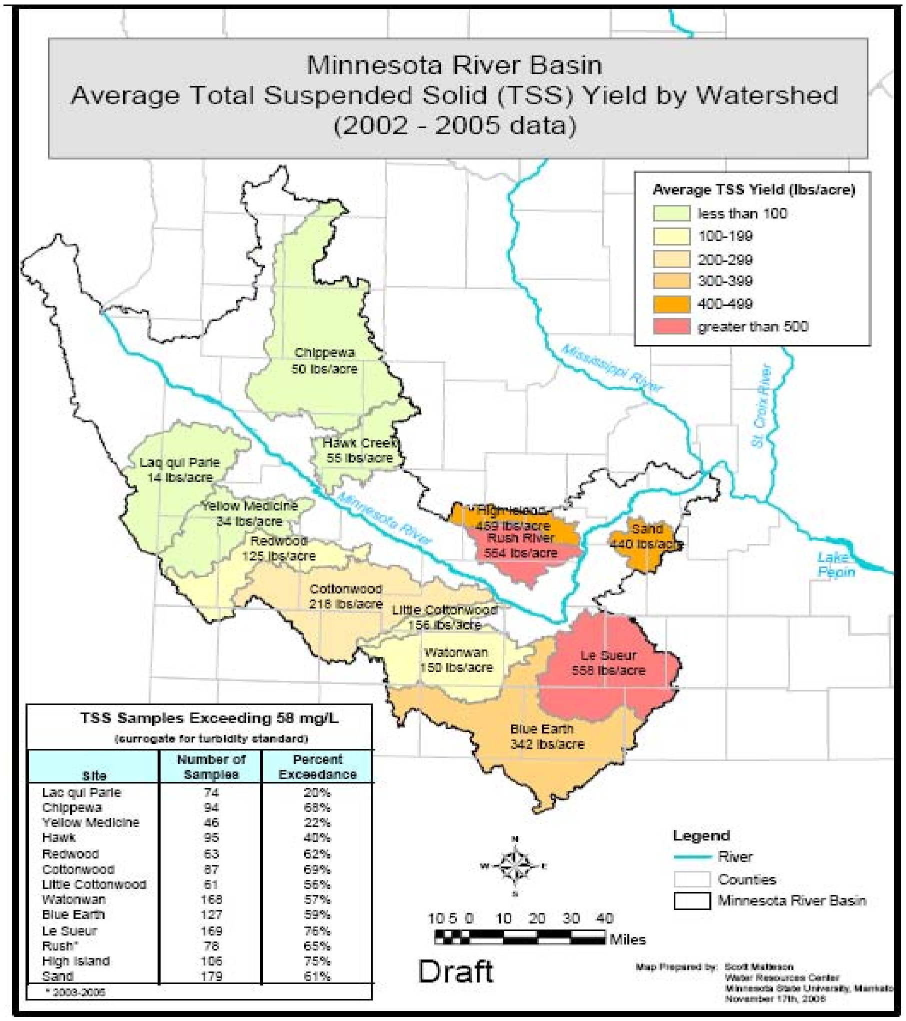
Spatial analysis can help to identify:

- Areas of concern within the watershed or potential major sources of pollution
- The impact of a specific source (in some cases)
- The effect of a management practice or control effort on water quality

If you have multiple water quality sampling locations within your watershed and the summary statistics indicate that water quality varies with the location of the station, a more focused analysis of the data is needed to determine why there are differences (EPA, 2005).

GIS can be used to present and evaluate spatial variations in water quality conditions. Using GIS to present water quality summaries by station throughout a watershed allows for identification of corresponding watershed conditions or sources that might be causing the differences, such as land use activities and the location of point sources.

Even if sufficient water quality monitoring data is *not* available to adequately evaluate spatial variation in water quality, you can examine land use, soils, point sources, and other relevant data to understand watershed characteristics that are likely influencing water quality conditions. GIS is a powerful tool for displaying and evaluating these kinds of data (EPA, 2005). Figure 14 presents a graphical display of different TSS yields throughout the Minnesota River Basin.



TSS Samples Exceeding 58 mg/L (surrogate for turbidity standard)

Site	Number of Samples	Percent Exceedance
Lac qui Parle	74	20%
Chippewa	94	68%
Yellow Medicine	46	22%
Hawk	95	40%
Redwood	63	62%
Cottonwood	87	69%
Little Cottonwood	61	56%
Watonwan	168	57%
Blue Earth	127	59%
Le Sueur	169	76%
Rush*	78	65%
High Island	106	75%
Sand	179	61%

* 2003-2006

Figure 14

Visual Discovery and Verification

After your analyses have been completed and you have come to some conclusions about causes and sources of the impairment, it is a good idea to get out into the field to confirm that those conclusions make sense.

Sometimes things are not what they seem to be on paper. There is no substitute for your eyes and what can be observed visually in the field. Once you spend some time outside, you may find yourself wondering if your initial conclusions are correct.

If visual observations corroborate your analysis, you can take the opportunity to further document your findings with photographs. These will be helpful when communicating your findings to the public and stakeholders.

Analyze MPCA's STORET Data First, then Broaden Your Analysis

Begin by looking at MPCA's STORET data that was used to assess the waterbody and determine that it was impaired. Evaluate and describe the water quality impairments that led to the placement of your waterbody on the Impaired Waters List [(303] (d) list]. The intent is to understand how data was used to list the waterbody and to answer, if possible, more specific questions you may have about water quality in your waterbody.

MPCA recommends analyzing water quality monitoring data first before other types of data. This is especially important when looking at certain kinds of impairments, specifically toxics, ammonia, and in some cases, low dissolved oxygen. In these cases, by analyzing water quality monitoring data first, you may be able to identify specific point source discharges that are solely responsible for the exceedances of water quality standards. If these kinds of sources can be identified, no further analysis of the data may be needed.

Separate your instream water quality data from watershed data. First analyze water quality data, then determine whether other kinds of data (soils, climate, land use, etc.) are needed to develop a meaningful analysis of cause and effect within the watershed.

Describe relationships between pollutants

Worksheet 9-1 takes you through possible steps of a data analysis exercise. Some or all of the steps outlined within the worksheet may be relevant to your project. Be certain to document your thought processes and the tools you used for your data analysis. Be certain to create an electronic file including all analytical tools used and the results from those analyses. It will also be important to correlate instream concentrations (and loading) of pollutants to other parameters that represent the same impairment or are likely being contributed by similar sources. For example, phosphorus is often attached to sediments, resulting in increased phosphorus loading during storm events and periods of high sediment erosion and runoff.

Summarize, Document and Communicate Your Findings

Understanding these relationships is important when establishing load reduction goals and selecting best management practices or other water pollution controls in the watershed (EPA, 2005).
When all is said and done and you have finished your analyses, ask yourself: Do the results make sense? Are we comfortable with our conclusions? Will stakeholders and the public believe and understand the results?

Generally speaking, data sets are not large enough to allow you to give definitive answers to questions about impairments. If this is the case, openly state that there is some amount of uncertainty in the data or that you are unsure that specific conclusions can be drawn. Be honest and open about limitations of the data when discussing your results with the public.

Finally, think carefully about how you will communicate the results to the public and your Stakeholder Advisory Committee. What are the key points you want to convey? How can you graphically display the information to make it understandable for all audiences? What do you want them to do with the information? How can you provide it to them to make it most useful?

Summarize what you have learned about:

- The number of times the water quality standards were exceeded
- Source types causing impairment (point, nonpoint)
- Seasonality of loads
- Timing of loads
- Magnitude of loads

Tips for Communicating Your Findings

When crafting your message for the public and stakeholders:

- Think carefully about the key points you want to be certain they understand.
- Be honest about uncertainty in the data.
- Give adequate thought to the display of information so that it can be understood by all parties (keep it simple!!). Tell stories; don't overwhelm people with data; be thoughtful about the level of information you share!
- Consider suggesting action steps for improving water quality. What might be needed to restore water quality?

Session 9: Analyze Water Quality Data to Characterize the Watershed and Pollutant Sources

Summary

- Before you begin to analyze your data, ask yourself one last time if you have enough of the right data and good quality data to begin.
- Think about the goals you have for data analysis – what questions must you answer?
- Take the time to organize and store your data before any analytical work is done.
- Do whatever you can to reduce uncertainty when analyzing data.
- Begin by using broad, simple analytical techniques, and then apply increasingly complex tools.
- Analyze water quality data first before relying too quickly on complex and expensive models. A point source may present itself quickly as the cause of the impairment, saving significant time and effort in your analysis.
- Once your analysis is complete, take the time to get out into the field to verify that your conclusions make sense – things are not always what they appear to be.
- Think carefully about how you want to communicate the results of your analysis to the public.

Contacts

Pat Baskfield, Southern MN Monitoring Coordinator 507-389-1648

Mark Evenson, Northern MN Monitoring Coordinator 218-828-6074

Greg Johnson, Monitoring Technical Assistance, St. Paul 651-296-6938

References

Cleland, Bruce, TMDL Development From the "Bottom Up" –Part III: Duration Curves and Wet Weather Assessments**,** America's Clean Water Foundation, 2003, Washington, DC, pp. 1-12.

Shilling, F., S. Sommarstrom, R. Kattelmann, B. Washburn, J. Florsheim, and R. Henly. California Watershed Assessment Manual: Volume I. May, 2005. Prepared for the California Resources Agency and the California Bay-Delta Authority **pp. 137, 144, 145, and 155.**

United States Environmental Protection Agency, "Handbook for Developing Watershed Plans to Restore and Protect our Waters", 2005, Washington, DC, Chapter 7, **pp-7-8**.

Worksheet 9-1

Once you have applied analytical tools to your data, document your findings below.

Recognize that there are some similarities between this worksheet and previous worksheets you have completed. This worksheet is intended to capture new information you have after you have done your analyses. Document what you have learned here for future reference.

Step 1: Understand impairments - be brief!

(a) How often are water quality standards being violated?

(b) What times of the year are violations occurring?

Step 2: Document causes and sources of impairment(s)

(a) What are probable causes and sources of pollution? (Use Information Protocol to help you respond)

(b) How should sources be grouped to facilitate load estimation and allocation?

Step 3: Document where impairments occur using spatial analysis techniques

(a) Where do the impairments occur? Are they found throughout the watershed or only in certain areas?

(b) What analysis technique did you use to determine where impairments are occurring?

(c) If you only have one or a few monitoring stations to determine locations of impairment, what have you done to account for that in your analysis?

Step 4: Identify when the water quality violations occur using temporal analysis

(a) When are water quality standards typically violated? Year-around, seasonally or sporadically?

(b) Is there a time of day when violations typically occur?

Step 5: Document the conditions under which violations occur using temporal analysis

(a) What analytical tool did you use to examine your data?

(b) Do violations occur only under certain conditions, such as during spring runoff events, during or after manure spreading operations, high flow, etc?

Step 6: Using flow data

(a) Describe use of flow data in TMDL study

(b) Describe how results will be communicated to the Public and Stakeholders