

# The Wicked Problem of Water Quality in the Mississippi River Watershed

## Introduction

Water connects all elements of Earth's ecosystems, and human activities – biological, economic, and even recreational – change the chemical and biological nature of water. As such, maintaining the *quality* of water for humans and other organisms is a *wicked problem*, that is, a complex societal challenge that is impossible to fully solve. As we experience a growing world population, increasing consumption of resources, and global climate change, the problem of downstream water pollution becomes ever more complex. Many human activities impact water quality, including agriculture and food production in rural areas, sewage and wastewater disposal in urban areas, the generation of electricity, manufacturing and other industrial processes, and even the use of lifesaving pharmaceuticals that ultimately end up in our water.

Water supports life and is essential for our economy, but everything we do is likely to impact the quality of our water supply in some way. How do we provide for the water-related needs of a growing population, while ensuring an adequate supply of clean water for our neighbors and for future generations?

*Clean Water and Sanitation* is one of the [17 U.N. Sustainable Development Goals](#), the interrelated goals that help international policymakers identify targets and actions for ending poverty, reducing inequality, and protecting the planet. Sustaining resources and improving quality of life for more people on our planet requires planning that crisscrosses issues, time, and space. It is not difficult to imagine how clean water (Goal #6) is directly related to many of the other goals. Water is health, comfort, and security, and nobody on the planet can live without an adequate supply of clean water.



To begin to understand what makes water quality a “wicked problem, consider the **Mississippi River Watershed**. This vital region in the central U.S. is really a system of people living in cities, growing food, integrated with the natural environment, an essential player in regional and global trade, and a set of complex societal and environmental challenges that need to be solved. In this exercise, you will explore the way complex problems intertwine natural systems with human activities that provide for our physical health and economic well-being.

By the end of the exercise, you will be able to:

1. **Locate** and **describe** interactions between human and natural systems.
2. **Diagram** key components of a complex system focused on water quality and **identify** different stakeholder perspectives or interests associated with water use.
3. **Explain** how differing power dynamics among stakeholder creates conflict and the potential for social/environmental injustice.

*What do we mean by a “system”, and how can it help us analyze complex problems?*

A “system” is an interconnected group of parts that define a unified whole (Wikipedia). We can study ecosystems (interrelated organisms and the components of their natural environment), social systems (human communities and their physical infrastructure), economic systems (people and institutions involved in the production and distribution of goods and services) and many other types of natural and human-created systems. In order to analyze a system, you must be able to identify the critical (or key) components of the system and understand how they interact. You also need to have some idea of how a disruption in one part of the system causes a reaction in other parts of the system. We will explore this in more detail by looking at water pollution in the Mississippi River Watershed, a complex integration of natural and human systems.

### *The Mississippi River Watershed as a Complex System*

The Mississippi River system is vast. The headwaters of the Mississippi River begin in Minnesota and courses through 10 states, before it discharges into the Gulf of Mexico. The Mississippi River is the second longest river in the United States at 2,202 mi (3,544 km). The longest river is the Missouri River at 2,341 mi (3,768 km), but because it drains into the Mississippi, the Mississippi River *drainage basin* or *watershed*, is actually considered the largest. Covering an area over 1,245,000 mi<sup>2</sup> (3,220,000 km<sup>2</sup>), the Mississippi River watershed encompasses over 40% of the contiguous U.S. and is one of the largest drainage basins in the world. Practically, that means any rainwater (or melting snow) that falls in a 32 state area is carried downstream to the Gulf of Mexico.

Clearly such a large region contains lots of people, industry, and farmland, not to mention the major cities of Minneapolis, St. Louis, Memphis, and New Orleans. The sheer size of the Mississippi River watershed means that human activities — like the intensive agriculture required for our food supply, livestock, and global trade — are intimately connected to the natural and human systems that move water downstream and keep the water clean for the plants and animals inhabiting it. Since all water (for example, rainwater, snowfall, surface streams, groundwater, and water vapor in the atmosphere) is connected, the “fingerprint” from human activities like farming, waste disposal,



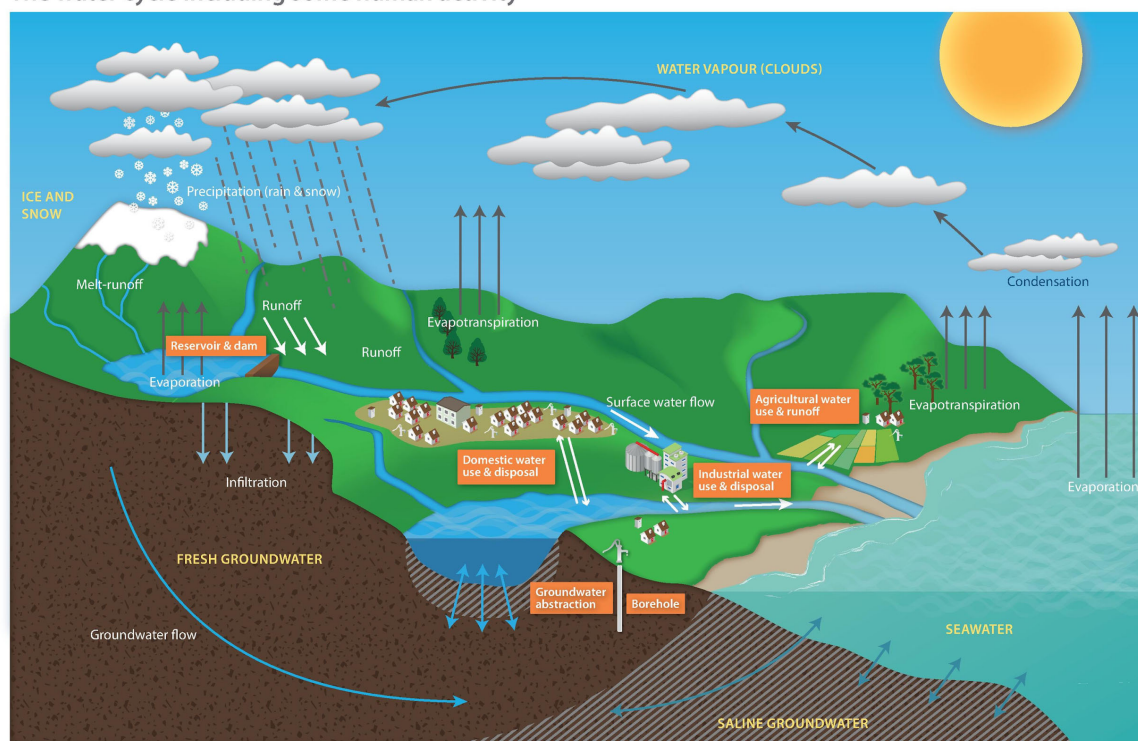
transportation, or even just urban street runoff, all moves downstream. When the chemical or biological fingerprint has a negative impact, that's downstream pollution.

### *The Water Cycle and Mercury in the Mississippi River Valley*

To illustrate the “wicked” nature of maintaining water quality downstream, we are going to zero in on a significant pollutant in the Mississippi River system: *mercury*.

Before we identify how and where mercury problems arise from human activities, we need to understand where those activities interact with the *water cycle*. You have probably been learning about water and the water cycle since you were a child. The diagram below illustrates the movement and change of water and several ways that the natural movement of water intersects with human activities. It's clear that there are many opportunities for human systems and natural systems to interact around water.

The water cycle including some human activity



1. [Watch this video](#) for a quick refresher on the water cycle, and [this video](#) on human aspects of the water cycle.

### *Sources of Mercury in Waterways*

Mercury finds its way into our waterways mainly from burning coal (Figure 2). When coal is burned mercury trapped in the coal is released into the atmosphere where it gets deposited into the waterways downwind from the plants. In aquatic ecosystems, some inorganic mercury is converted to methylmercury, which is the toxic version of mercury. Methylmercury bioaccumulates when it enters aquatic food webs, at which point it is taken up by algae and other microorganisms (Figure 3). Methylmercury concentrations increase with successively higher trophic levels in the food web via a process called bioaccumulation. In general, fish at the top of the food web that consume other fish tend to accumulate the highest methylmercury concentrations. Mercury also enters the water cycle when coal ash from coal combustion is stored at locations near power plants.

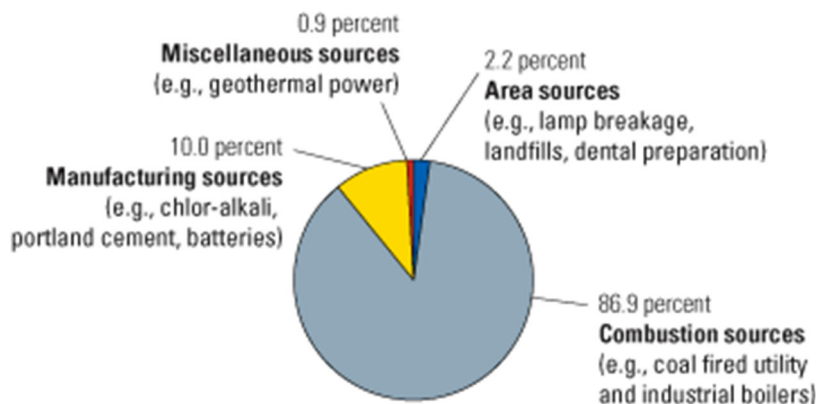


Figure 2. Combustion from coal-fired utilities and industrial boilers accounts for more than 85 percent of the transmission of inorganic mercury to the atmosphere (U.S. Environmental Protection Agency, 1997). (<https://pubs.usgs.gov/fs/fs-016-03/>)

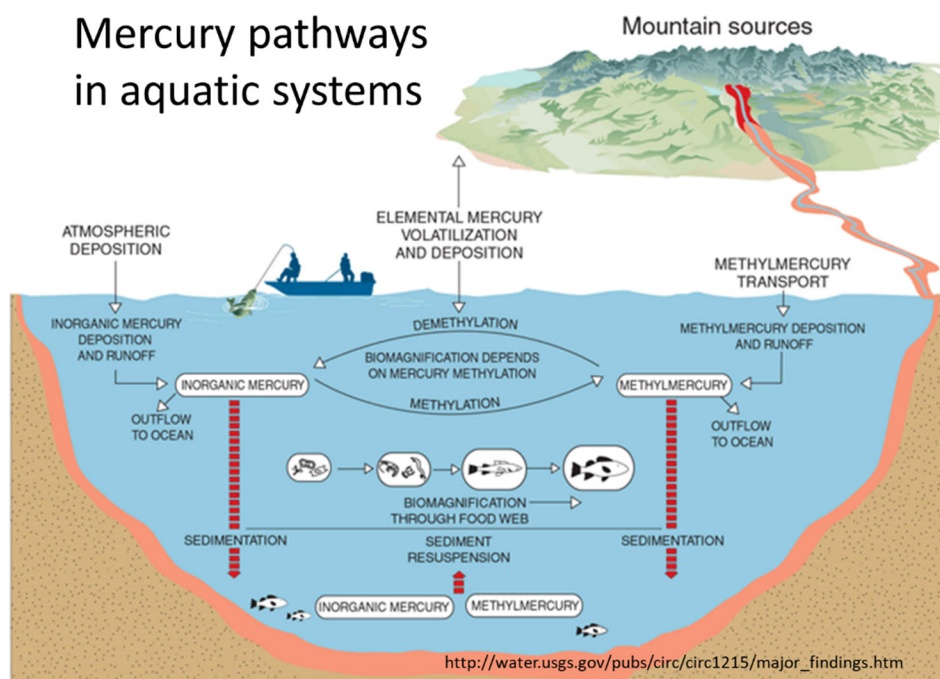


Figure 3. Mercury pathways in aquatic systems.

Mercury is a potent neurotoxin that bioaccumulates in fish to levels concerning for human health and the health of other wildlife consuming fish. This is the primary reason for issuing fish consumption advisories. In the first half of the last century, mercury was released by the Chisso Corporation from wastewater in the bay in Minamata, Japan. The fish and shellfish in the bay were the primary sources of protein in diet for the small town, and their consumption resulted in mercury poisoning among the residents. The resulting neurological diseases caused the deaths of cats, dogs, pigs, and humans for up to 36 years after the release. (Japan's Minamata Disease- Mercury poisoning of a town: <https://www.youtube.com/watch?v=oJ3X-57bM48>)

Watch these brief videos



## STUDENT GUIDE – MERCURY

- Coal 101: Basic Information on Coal: [https://www.youtube.com/watch?v=iN6LvH\\_4Q3g](https://www.youtube.com/watch?v=iN6LvH_4Q3g)
- How Does Mercury Get Into Fish? <https://www.youtube.com/watch?v=Q1ZA8ZrK3U4>

### Other Resources

- USGS Report on Mercury in our Nations Streams: <https://pubs.usgs.gov/circ/1395/pdf/circ1395.pdf>
- Mercury and health: <https://www.who.int/news-room/fact-sheets/detail/mercury-and-health>
- Low-income communities are the hardest hit but mercury:
  - <https://earthjustice.org/news/press/2011/communities-of-color-poverty-bear-burden-of-air-pollution>
  - <https://news.umich.edu/targeting-minority-low-income-neighborhoods-for-hazardous-waste-sites/>
- Coal 101: What's Wrong with Coal: <https://www.youtube.com/watch?v=9Wv2GKaukZU>
- Agency for Toxic Substances and Disease Registry – Mercury: <https://wwwn.cdc.gov/TSP/substances/ToxSubstance.aspx?toxid=24>
- Agency for Toxic Substances and Disease Registry – Mercury and Your Health: <https://www.atsdr.cdc.gov/mercury/index.html>
- Agency for Toxic Substances and Disease Registry – ToxZine Mercury: [https://www.atsdr.cdc.gov/sites/toxzine/mercury\\_toxzine.html](https://www.atsdr.cdc.gov/sites/toxzine/mercury_toxzine.html)

### Part 1: Drafting a Stakeholder Map for Mercury in Water Cycle

It should be apparent now why so many people in the Mississippi River Watershed are connected. In the next part of this exercise, we are going to define how these interests are related, that is, how they overlap and how they may conflict based on the perspective of the *stakeholder*. A stakeholder is any individual or group that has an impact on or is affected by the system of interest. They are components in a system.

**Goal:** After reviewing the introductory materials map the stakeholders involved in mercury pollution in the Mississippi River Watershed, and the relationships among those stakeholders.

**Materials and constraints.** Use pencil, pen, or permanent marker and a blank white 8.5 x 11 or larger paper to create your stakeholder map (or use an online mapping program, if directed by your instructor). Write in uppercase/capital letters only, as this tends to make handwriting easier for others to read. Sticky notes can also be used for some of the components.

Your instructor will provide detailed directions on how to construct your stakeholder map.

## Part 2: A Town Meeting on Mercury in Mississippi River

In this role-playing game you will be assigned a stakeholder group to explore specific issues related to mercury in the Mississippi River watershed in the fictional town of Misiziibi (the Ojibwe Native American name for the Mississippi river, meaning "Great River"). This will take place in a mock town meeting where the Mayor (your instructor) is requesting input for how to address the challenges, and your input will reflect consideration of your stakeholder interests. Please review the rubric so that you are fully prepared.

**Goal:** Make a case for water decisions that reflect your stakeholder perspective. Note that you will also need to take notes on the interests of other stakeholders, so that you understand how interests of some stakeholders may result in vulnerability, or challenges of environmental injustice for other stakeholders or community members not present (i.e., when poor communities, communities of color, or other marginalized groups are disproportionately impacted.) Each group should appoint an “advocate” that keeps the group cognizant of power dynamics among the stakeholder groups that can lead to various forms of social or environmental injustice.

Each group of stakeholders will select one spokesperson to make their statement. The other group members should help in answering questions. Groups represent their stakeholder’s interests and perspectives throughout the exercise and hold their questions until all groups have presented.

Each group will have 5 minutes to present their position.

### Roles

*Group 1:* You represent the fisheries industry that relies on fish harvest from the Gulf of Mexico. While you live in Misiziibi, you work on fishing boats in the Gulf. In addition to the risky nature of the business, costs of maintaining a fishing business are high, between permits, boats, labor, and fuel. Competition with imports is also a looming challenge, as countries with less rigorous fishery and aquaculture laws are able to out-produce American seafood businesses and drive prices down. Issues with bioaccumulation of mercury in the fish has resulted in consumers questioning the safety of your produce.

Use these resources to learn more:

- Commercial fisheries’ domestic landings (in metric tons): <https://arcg.is/1CTXGX>
  - Commercial fishing is the activity of catching fish and other seafood for commercial profit, mostly from wild fisheries.
- Aquaculture sales totals (in USD): <https://arcg.is/1DvjWD1>
  - Aquaculture is a broad term used to refer to any *farmed* aquatic species, from freshwater trout to saltwater shellfish. Farm-raised catfish is the largest aquaculture industry in the U.S. Aquaculture production also includes bivalve mollusks such as oysters, clams, and mussels, as well as salmon and shrimp.
- Gulf of Mexico Dead Zone-The Last 150 Years. USGS FactSheet 2006-3005: <https://pubs.usgs.gov/fs/2006/3005/fs-2006-3005.pdf>

*Group 2:* You represent the workers at the coal power plant located upstream of Misiziibi. The plant was constructed in the 1940s and burns coal to produce electricity in the region. You and your family have been working in the plant for many generations and, it has provided good jobs. The company wants to expand its facility to provide even more jobs for the community. The expansion will also increase their local taxes, which will benefit your community.

*Group 3:* You represent citizen of low-income community that lives near the coal power plant and coal ash disposal facilities. The coal plant wants to expand the size of the disposal facility near your community. Your community is already experiencing many health issues associated with the coal plant from asthma and other neurological effects.

*Group 4:* You represent the citizens of Misiziibi, and you have seen your rates for water and sewage increase over the last 10 years, yet you still hear a lot about mercury pollution in the Misiziibi water supply and are worried about the health effects. Employment in the area has not been consistent in recent years. Many of your friends and family are barely getting by and have poor health. You would welcome more well-paying jobs and stable health insurance coverage for your family and friends. You want the town to do a better job with purifying the drinking water supply.

Use these resources to learn more:

- Percent of population with no health insurance coverage (at the county level): <https://arcg.is/0jDumG>
- Percent of population below poverty level (at the county level): <https://arcg.is/KvDvu>
- Median household income (in USD, at the county level): <https://arcg.is/1nCONm>
- Percent of population that are nonwhite (at the state level): <https://arcg.is/0rW0Lv>

*Group 5:* You represent a local non-governmental organization (NGO) that wants to protect local endangered aquatic plants and habitat for riparian zone (riverside and floodplain) flora and fauna. You have seen excess mercury in water harming the protected plants and animals already. You want the town to impose restrictions on emissions from the coal power plant, upgrade the wastewater and drinking water treatment facilities, restore or enhance riparian buffers, and take a tougher stance on commercial businesses that contribute to the problem.

Use these resources to learn more:

- NPR. 2020. Absentee Landlords Interfere with Farmers Protecting Water, Soil: <https://www.npr.org/2020/07/14/890716855/absentee-landlords-interfere-with-farmers-protecting-water-soil>
- Nutrients in the Nation's Streams and Groundwater, 1992–2004: <https://pubs.usgs.gov/circ/1350/>
- Riparian buffer zones affect the quality of midwestern streams and rivers: [https://mn.water.usgs.gov/nawqa/umis/pdf/nest\\_RiparianPage.pdf](https://mn.water.usgs.gov/nawqa/umis/pdf/nest_RiparianPage.pdf)



### Part 3: Creating a Revised Stakeholder Map for Mercury in the Mississippi River Watershed (whole class)

**Goal:** Create a *single* map with your entire class that reflects your collective and revised understanding of the wicked problem based on the role-playing activity in Part 2.

#### *Instructions*

1. **Preparation.** The instructor will open a shared board on [Mural](#) (or other online mapping program).
2. **(Individually).** Convert each of the items from your original map to separate post-its in the shared Mural board. If appropriate, add or remove items and relationships based on the role-playing exercise/debate.
3. **(As a Team or As a Class).** Work together to create a unified map as a class. Move items around, group together or combine similar items as needed, and add new relationships based on your revised understanding of the wicked problem following the role-playing exercise/debate.
4. **(Optional)** Use the [Noun Project](#) to enhance your map with icons.