Regulating Water

- Compared to air pollution, water quality has received less attention from economists
  - Air pollution health effects are direct and easier to monetize
    - Many of the benefits from controlling surface water pollution are for recreation or ecosystem health, rather than human health
  - Drinking water standards have existed for a long time, so less demand for new analysis
  - Market-based polices have been used less frequently

Regulating Water

- Water policy focuses on two goals:
  - Clean drinking water
    - This is primarily a question about infrastructure
    - Public provision (or regulation) justified by natural monopoly for water provision
  - Regulating ambient water quality regulation
    - When water not directly consumed, low benefits due to human health
      - Rather, benefits relate to recreational use and ecosystem health
    - More significant externalities than drinking water
      - May cross jurisdictions, so that transboundary issues are a concern

U.S. Water Regulations

- 1965 Water Quality Act required states to set ambient standards for water quality
- States had primary responsibility until 1972 Water Pollution Control Act Amendments
  - Set a goal of zero discharges by 1985
  - Increased the amount of money for municipal waste treatment plants.
  - Water bodies are classified into potential designated uses
    - Examples include: public water supply; protection and propagation of fish, shellfish, and wildlife; recreation; agricultural; industrial; navigation
    - Goal is to have fishable/swimmable uses

U.S. Water Regulations

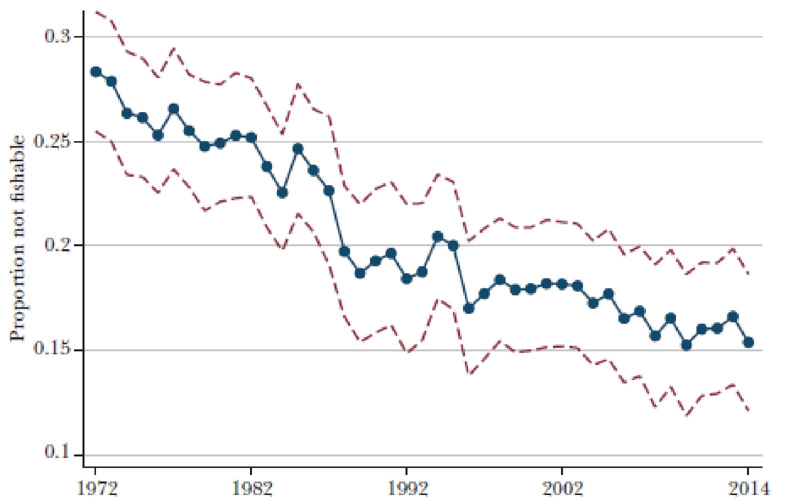
- 1972 CWA set specific federal standards
  - Performance: Used technology based effluent standards (TBES)
    - National Pollutant Discharge Elimination System (NPDES) specifies effluent limits for each pollutant and each point source. Each polluter receives a discharge permit issued by an EPA-backed state permitting program.
    - Phase I: EPA determines the "best practicable technology" and sets standards assuming that firms are using that standard.
    - By 1983 (Phase II), firms were to use "best available technology."
    - The 1977 Clean Water Act changed this to "Best Conventional Technology" by 1984
      - Places more emphasis on costs when judging technologies
  - Ambient: states must develop Total Maximum Daily Loads (TMDLs) for water bodies that do not meet certain ambient concentration goals
    - Must identify all point and non-point sources polluting the water body
    - Allocate a total daily load among the relevant sources

U.S. Water Regulations

- Water pollution has fallen as a result

Figure 2

US Surface Water Pollution, 1972–2014



Source: The graph summarizes 14.6 million pollution readings from 265,000 monitoring sites from the Environmental Protection Agency's STORET ("STOrage and RETrieval") Legacy, Modern STORET, and the National Water Information System. See Keiser and Shapiro (2019) for details on the data cleaning procedure.

Note: The graph shows year fixed effects plus a constant from regressions that also control for monitoring site fixed effects, a day-of-year cubic polynomial, and an hour-of-day cubic polynomial. Each observation in the regression is an individual pollution reading at a specific monitoring site; the dependent variable in the regression takes the value one if it violates the fishable standard and zero otherwise. Connected dots show yearly values, dashed lines show 95 percent confidence interval, and 1972 is the reference category. Standard errors are clustered by watershed.

Source: Keiser and Shapiro (*JEP*, 2019)

U.S. Water Regulations

- Efficiency of the TBES
  - Studies find that benefits and costs of water regulations lower than other environmental regulations (Keiser and Shapiro, 2019)

Table 1

Benefits and Costs of Federal Regulations

	Surface water (1)	*Drinking water (2)*	*Air (3)*	*Greenhouse gases (4)*	*All other (5)*	*All (6)*
A: Total US expenditures (trillions of 2017 dollars)						
1970 to 2014	2.83	1.99	2.11	–	–	–
1973 to 1990	0.94	0.49	0.85	–	–	–
B: Estimated benefits and costs of regulations analyzed in years 1992–2017						
Total benefits / total costs	0.79	4.75	12.36	2.98	1.97	6.31
Mean benefits / mean costs	0.57	8.26	15.18	3.64	21.79	16.17
Share with benefits < costs	0.67	0.20	0.08	0.00	0.19	0.15

Source: Authors. For years after 2004, data are from table A-1 of the "Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities." For earlier years, data are from various tables of predecessor reports.

U.S. Water Regulations

- Efficiency of the TBES
  - Studies find that benefits and costs of water regulations lower than other environmental regulations (Keiser and Shapiro, 2019)
  - Why might water standards be inefficient?

U.S. Water Regulations

- Efficiency of the TBES
  - Studies find that benefits and costs of water regulations lower than other environmental regulations (Keiser and Shapiro, 2019)
  - Why might water standards be inefficient?
    - Standards were uniform for the entire nation
    - Same standards applied to all firms
    - Moreover, by focusing on end-of-pipe solutions, discourages firms from generating less pollution through recycling
    - Little incentive for innovation, since standards are technology based.
    - Allocation of pollution across sources
      - Focuses on point sources, so little attention paid to pollution from agriculture
      - 2005 Energy Policy Act exempted fracking from some portions of the Safe Drinking Water Act, but fracking is still subject to the Clean Water Act
    - Surface waters may be more substitutable than clean air (e.g. can go fish or swim at another lake)

U.S. Water Regulations

- Efficiency of the TBES
  - Key question: are these studies accurate? Why might they underestimate benefits?
    - Non-use values difficult to measure
    - Many studies ignore health benefits
      - Studies assume treatment plants purify drinking water anyway

U.S. Water Regulations

- The Safe Drinking Water Act (SDWA), passed in 1974, established the first set of federally enforceable standards for drinking water
  - Before, the Public Health service published standards, but compliance was voluntary.
  - Congress strengthened the SDWA in 1986
- 1996 amendments to the SDWA provide the EPA with more flexibility to consider costs and benefits in setting standards
  - Allows for exceptions for localities that find it costly to meet the standards

U.S. Water Regulations

- Setting the standards
  - The EPA sets maximum contaminant level goals (MCLGs) that are nonenforceable, but represent the level at which no known or anticipated health affects occur
  - Then, the EPA sets the maximum contaminant level (MCL)
    - An enforceable standard set as close to the MCLG as is affordable to large water systems with relatively clean water.
    - Variances available for:
      - Systems serving 10,000 people or less if unable to afford to meet MCLs and health will still be adequately protected.
      - Places with very dirty water, if not able to meet standards even with best technology available
    - Considering costs was not allowed until 1996
    - In practice, variances rarely used

U.S. Water Regulations

- How treatment methods are chosen
  - Least-cost method varies by system. Factors include:
    - Size of system
    - Initial level of contamination
    - Existing equipment
  - EPA only judges compliance based on whether standards are met. Treatment method does not matter.
  - However, local water systems need state approval for control technology, which often limits the use of less conventional technologies.
    - To help alleviate this problem, the 1996 amendments require the EPA to list feasible and affordable treatment technologies for four sizes of systems, not just large ones

U.S. Water Regulations

- Example: Per- and Polyfluoroalkyl Substances (PFAS)
  - In April 2024, the EPA announced drinking water standards for six PFAS
    - Public water systems must complete initial monitoring and inform public by 2027
    - Systems in violation must begin treating water by 2029

Note: EPA determined these are likely carcinogens with no save level. MCL set at lowest feasible limit for water systems to implement

Compound	Final MCLG	Final MCL (enforceable levels)[1]
PFOA	Zero	4.0 parts per trillion (ppt) (also expressed as ng/L)
PFOS	Zero	4.0 ppt
PFHxS	10 ppt	10 ppt
PFNA	10 ppt	10 ppt
HFPO-DA (commonly known as GenX Chemicals)	10 ppt	10 ppt
Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	1 (unitless) Hazard Index	1 (unitless) Hazard Index

[1] Compliance with MCLs is determined by running annual averages at the sampling point.

Source: https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas

U.S. Water Regulations

- Example: Per- and Polyfluoroalkyl Substances (PFAS)
  - In April 2024, the EPA announced drinking water standards for six PFAS
    - Public water systems must complete initial monitoring and inform public by 2027
    - Systems in violation must begin treating water by 2029
    - Standards developed in response to new evidence linking "forever chemicals" (PFAS) to health risks, including cancer
      - 2022: EPA found PFAS could cause harm at levels "much lower than previously understood"
      - 2023: PFAS detected in nearly half of US tap water

U.S. Water Regulations

- Example: Per- and Polyfluoroalkyl Substances (PFAS)
  - Costs and benefits
    - EPA estimates:
      - $1.5 billion annual benefits
      - $1.5 billion annual compliance costs

Summary of Annual Costs and Benefits of Final PFAS NPDWR. Table 1.

	How Much?	What From?	The Potential Impact
Costs	$1.5 Billion per year	Monitoring, communicating with customers, and if necessary, obtaining new or additional sources of water or installing and maintaining treatment technologies (Table 2).	States, Tribes, and territories with primacy will have increased oversight and administrative costs. 66,000 regulated water systems will have to complete monitoring and notifications. 4,100 – 6,700 water systems may have to take action to reduce levels of PFAS.
	Non-quantified*	Costs for some systems to comply with the Hazard Index, HFPO-DA, and PFNA MCLs.	
Benefits	$1.5 Billion per year	The rule results in fewer cancers, lower incidence of heart attacks and strokes, and fewer birth weight-related deaths. Actions taken to implement the rule may also lead to associated health benefits from reductions in other PFAS and unregulated disinfection byproducts. Benefits will prevent over 9,600 deaths and reduce approximately 30,000 serious illnesses (Table 3).	83 – 105 million people will have improved drinking water as a result lower levels of PFAS
	Non-quantified*	Increased ability to fight disease, reductions in thyroid disease and impacts to human hormone systems, reductions in liver disease, and reductions in negative reproductive effects such as decreased fertility.	

*Non-quantified benefits and costs are those that the EPA could not assign a specific dollar amount to as part of its national level quantified analysis, but it doesn't mean their benefits or costs are less important than those with numerical values.

Source: EPA Fact Sheet: "Benefits and Costs of Reducing PFAS in Drinking Water"

U.S. Water Regulations

- Example: Per- and Polyfluoroalkyl Substances (PFAS)
  - Costs and benefits
    - EPA estimates:
      - $1.5 billion annual benefits
      - $1.5 billion annual compliance costs
    - Utilities argue costs could be twice as high
    - ***Question****:* why are costs so high?

U.S. Water Regulations

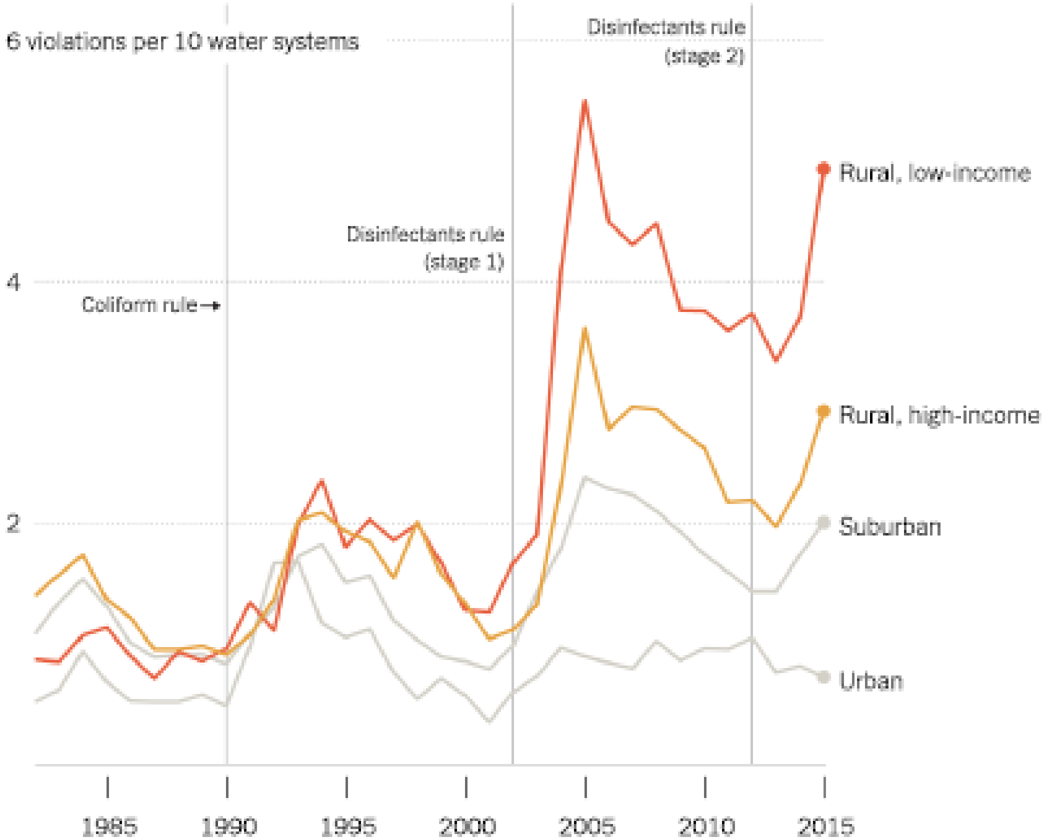
- Example: Per- and Polyfluoroalkyl Substances (PFAS)
  - Costs and benefits
    - EPA estimates:
      - $1.5 billion annual benefits
      - $1.5 billion annual compliance costs
    - Utilities argue costs could be twice as high
    - ***Question**:* why are costs so high?
  - Who pays?
    - EPA announced $1 billion in funding to help local governments implement testing and treatment
    - Small systems allowed to test less frequently

U.S. Water Regulations

- ***Question:*** Do national standards make sense for drinking water?

Rural Areas Have More Violations

Low-income, rural communities have especially struggled to comply with new water quality regulations.



Notes: The first stage of the disinfectants rule went into effect in 2002 for water systems that serve more than 10,000 customers, and in 2004 for smaller systems. Implementation of the second stage was staggered between 2012 and 2013. • Source: Allaire, Wu, and Lall, PNAS • By The New York Times

Source: Plumer, Brad and Nadja Popovich, “Poor Americans Exposed to Unsafe Water, study Shows,” *The New York Times*, February 13, 2018, A10.

Water Trading Examples

- Fisher-Vanden and Olmstead (2013) review 21 active water pollution permit trading programs in place at the time of their article
  - Two categories:
    - Trading programs (13): include multiple recipients and sources
    - Offset programs (8): involve a single recipient of water quality credits from one or multiple sources
      - The offset recipient typically invests directly in the credit-generating projects, rather than buying permits

Water Trading Examples

- Trading programs
  - Most started since 2000
  - Except for Hunter River program, all trade nutrients (nitrogen and/or phosphorous) or a combination of nutrients and sediment
  - Three market structures
    - Bilateral: participants engage in individual negotiations to arrange trades or offsets
      - Higher transaction costs
    - Clearinghouse: A single broker or intermediary generates credits
    - Exchange markets: Buyers and sellers trade uniform credits at transparent prices
  - Participants
    - All but one include a municipal wastewater treatment plant
    - Several also include industrial point sources
    - Non-point sources are almost always agriculture
  - Trading activity limited in most programs. Their article describes the five most successful.

Table 1

Active Water Quality Trading and Offset Programs

Program name	*Year est.*	*Location*	*Types of trades/ offsets*	*Pollutants*	*Trading or offset structure*
Trading programs					
Tar-Pamlico Nutrient Trading	1990	NC, US	PS-PS/NPS	N/P	Bilateral/ Clearinghouse
South Creek Bubble Licensing	1996	NSW, Austr.	PS-PS	N/P	Bilateral
Cherry Creek Reservoir Watershed Phosphorus Trading	1997	CO, US	PS-PS/NPS	P	Clearinghouse
Chatfield Reservoir Trading	1999	CO, US	PS-PS/NPS	P	Bilateral/ Clearinghouse
South Nation River Watershed Trading	2000	ONT, Can.	PS-NPS	P	Clearinghouse
Long Island Sound Nitrogen Credit Exchange	2002	CT, US	PS-PS	N	Clearinghouse
Neuse River Basin Total Nitrogen Trading	2002	NC, US	PS-PS/NPS	N	Bilateral/ Clearinghouse
Hunter River Salinity Trading	2004	NSW, Austr.	PS-PS	Salinity	Exchange market
Great Miami River Watershed Trading Pilot	2006	OH, US	PS-NPS	N/P	Clearinghouse
Minnesota River Basin Trading	2006	MN, US	PS-PS	P	Bilateral
Maryland Water Quality Trading	2008	MD, US	PS-PS/NPS	N/P/sediment	Exchange Market/ Bilateral
Pennsylvania Nutrient Credit Trading	2010	PA, US	PS-PS/NPS	N/P/sediment	Exchange Market/ Bilateral
Chesapeake Bay Watershed Nutrient Credit Exchange	2011	VA, US	PS-PS/NPS	N/P	Clearinghouse/ Bilateral
Offset programs					
Rahr Malting	1997	MN, US	PS-NPS	CBOD5	Bilateral
Pinnacle Foods	1998	DE, US	PS-NPS	N, P	Bilateral
Southern Minnesota Beet Sugar Cooperative	1999	MN, US	PS-NPS	P	Clearinghouse
Bear Creek	2001	CO, US	PS-PS	P	Bilateral
Piasa Creek Watershed Project	2001	IL, US	PS-NPS	Sediment	Bilateral
Clean Water Services/Tualatin River	2005	OR, US	PS-PS/NPS	BOD/NH4/temp.	Bilateral
Red Cedar River Nutrient Trading Pilot	2007	WI, US	PS-NPS	P	Bilateral
Alpine Cheese Company/Sugar Creek	2008	OH, US	PS-NPS	P	Bilateral

Notes: Abbreviations in column 4 refer to point sources (PS) and nonpoint sources (NPS). In column 5, abbreviations refer to nitrogen (N), phosphorus (P), biochemical oxygen demand (BOD), 5-day carbonaceous biochemical oxygen demand (CBOD5), ammonia (NH4), and temperature (temp.).

Source: Fisher-Vanden and Olmstead (2013)

Water Trading Examples

- Conestoga Reverse Auction
  - Used in Pennsylvania's Conestoga Watershed in 2005 & 2006
  - Rather than the government providing funds to support agricultural best management practices (BMP), farmers sell credits that can be purchased by other regulated polluters
    - Via the reverse auction, they are first sold to individual credit aggregators or credit banks who then sell these to third party polluters

Water Trading Examples

- How the reverse auction works
  - Rather than bidding to buy, bidding to sell
  - Farmers offer to implement a BMP to reduce phosphorus (P) for a specific price.
  - Projects are ranked on the cost per pound of P reduced.
  - Options for choosing projects
    - Spend a specified budget
      - In this case, the cutoff price determined by the state, which allocated a budget of $490,000
      - Few projects in first auction, so a second auction held to exhaust the budget.
    - Set a break even price and only select projects below that price
      - Helps to ensure cost-effectiveness, but means there cannot be a time limit on the budget.

Water Trading Examples

- Results
  - Reverse auction awarded $486,000 to farmers to reduce over 92,000 pounds of phosphorus
  - There was a wide variation in bids
    - Ranged from $2.36/lb-$157.49/lb
  - Auction is useful to help reveal what farmers are willing to accept to implement BMPs

BMPs Implemented	Lifespan of BMP (yrs)	Sum of Farmer's Bids	Pounds Reduced (lifespan)	Price per Pound ($/lb P)
Successful Bids				
Stacking Pad, Nutrient Management Plan	15	$84,000	35,576	$2.36
Stacking Pad, Nutrient Management Plan	15	$143,000	24,350	$2.42
Grassed Waterway	10	$144,679	590	$2.84
Waste Storage Facility	15	$181,451	12,886	$2.85
Underground Outlet in Heavy Use Area	10	$184,635	428	$7.43
Contour Stripcropping	5	$186,635	215	$9.30
Stacking Pad, Nutrient Management Plan	15	$292,635	6,742	$15.72
Stacking Pad, Animal Composting	15	$396,775	6,198	$16.80
Streambank Stabilization, Crossing	20	$398,275	78	$19.29
Terraces, Tile Drains	10	$407,739	282	$33.54
Terraces, Tile Drain Repair	10	$412,239	129	$34.90
Stacking Pad, Animal Composting	15	$443,290	785	$39.57
Grassed Waterway	10	$446,990	68	$54.33
Unsuccessful Bids				
Grassed Waterway	10	$452,116	94	$54.35
Grassed Waterway	10	$465,500	245	$54.73
Animal Composting	15	$498,012	497	$65.40
No-Till	3	$499,512	19	$78.39
Grassed Waterway	10	$505,312	74	$78.76
Animal Composting	15	$528,841	281	$83.66
Grassed Waterway	10	$533,616	54	$88.18
Waste Storage Facility, Heavy Use Area Protection	15, 10	$635,606	859	$118.70
Grassed Waterway, Rock Chute Outlet, Tile Drain	10	$646,106	67	$157.49

Water Trading Examples

- Minnesota River Basin Trading
  - Began in 2005
  - Minnesota Pollution Control Agency issued a single National Pollutant Discharge Elimination System permit for phosphorous discharges in the Minnesota River
    - Applies to 47 permitted sources (mostly wastewater treatment plants and industrial point sources)
    - Sources can trade through bilateral negotiation
    - In 2011, 17 facilities participated in trades
  - Trading ratios are applied

Water Trading Examples

- Discuss:
  - Why is trading used less frequently for water?
  - When is trading likely to be successful?