Benefit Cost Analysis of Water Quality Improvement

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Mission of the Missouri Department of Natural Resources

The mission of the Missouri Department of Natural Resources is to protect our air, land, water, and mineral resources; preserve our unique natural and historic places; and provide recreational and learning opportunities, while promoting the environmentally sound operations of businesses, communities, agriculture, and industry for the benefit of all Missourians.

Water Protection Program

• Goal: To protect and preserve water quality through the prevention, abatement, and control of water pollution by all practical and economically feasible methods.
Statutes, Water Pollution, Section 644.058 RSMo

Water Quality Standards Revised, when evaluation to be conducted, when
Notwithstanding the provisions of section 644.026 to the contrary, in promulgating water quality standards, the commission shall only revise water quality standards upon the completion of an assessment by the Department finding that there is an environmental need for such revision. As part of the implementation of any revised water quality standards modifications of 25 percent or more, the Department shall conduct an evaluation which shall include the environmental and economic impacts of the revised water quality standards and criteria on a subbasin basis. This evaluation shall be conducted at the eight-digit hydrologic unit code level. The Department shall document these evaluations and use them in making individual site-specific permit decisions.

Working Approach and Policy - Balancing environmental integrity and economic development
Watersheds and Society

- A watershed is an area of land that catches rainfall and melting snow, which in turn drain into low lying bodies of water.
- Missouri has 4 big rivers; 66 large watersheds; 115,000 miles of streams; and 3,080 lakes.
- A watershed is a function of biophysical, hydrological, and economic drivers.
Why Value Water Resources?

• Increasingly vulnerable and threatened to both quality and quantity aspects: poor aquatic/terrestrial biodiversity

• Development practices have an impact on quality dimensions of Natural Resources

• Decreasing beneficial uses of water resources but increasing social and environmental costs: Pollution/Public Health

• Market failure to value water services/monetization of water-based ecosystem services

• Best-valued use promotes economic efficiency in the long run

• Balance between environment and economy
Water Resources Management Challenges

• Water pollution control: top environmental policy priority
• An area of significant state and federal regulation, and the focus of enormous public and private spending
• 46 percent of U.S. rivers and streams are in poor biological condition, 25 percent are in fair condition, and only 28 percent are in good condition (EPA, 2016).
• About 66 percent of lakes in Missouri are eutrophic
• Nonpoint Source pollution is complex and needs holistic approach
• 1 lb. Phosphorus and 1 lb. Nitrogen can sustain approximately 200 lbs. and 12.5 lbs. biomass, respectively
• Pollutant “cleaning” cost: NPS $35, $10 and $3
• Effects: Algal bloom, Dissolved Oxygen deficiency, dead zone, etc.
Value of Improved Water Quality

**USE Values (Direct)**
- Consumptive use: Drinking, Recreational and commercial fishing
- Non-consumptive use: Swimming, surfing, boating, health impacts, aesthetic

**USE Values (Indirect)**
- Avian habitat
- Aquatic habitat
- Aesthetic/scenic/health impacts.

**NONUSE Values**
- Option value: Wish water resource system to be available for offspring
- Bequest value: I don’t use water resource now, may want to sometimes in the future
- Altruistic value: Want water resources to be available for others in current generation
- Altruism towards nature: Derive value from knowing that ecosystem is in sound health
Economic Literatures

• “Noneconomic” motives are not valid measures of the economic benefits of environmental improvements (Kahneman and Knetsch, 1992)

• Economic valuation of natural resources is based firmly upon human preference (Gretchen and Ellison, 2003)

• Intuitive motivation arising from moral concerns for the environment are relevant to WTP (Tietenberg and Lewis, 2015)

\[ TWP = Use\ values + Option\ values + Nonuse\ values \]

• Nonuse (passive use) values are derived from motivation rather than personal use
Guiding Economic Theory

Water quality standards changes ensure improved water quality, welfare of the society and are measured through utility function

$$\text{Max.} \quad U(W_i, S_1, S_2, S_3, \ldots, S_n)$$

$$\text{s.t.} \quad C_{\text{wqs change}} + \sum_{i=1}^{n} P_i S_i \geq 0$$

- For long enduring water quality improvement program
- Discounting: Benefit and cost analysis.
  $$\text{Max } NPV = \sum_{n=1}^{n} NR_n (1 + i)^{-n}$$
- Present Value of Net Benefit (PVNB > 1)
Welfare Change: PS and CS

Fig. 1 Producer benefits in changing Marginal cost with a fixed price input

$MC_1$ (PE$_1Q_1O$) is greater than total revenue at $MC_0$ (PE$_0Q_0O$). This is due to reduced cost of additional unit of production.

Fig. 2 Producer and consumer surplus in changing Marginal cost with elastic demand

Area $P_2E_0E_1P_3$ is the total welfare change (benefit gain) due to the marginal cost of production shift from $MC_0$ to $MC_1$. 

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Increased bio-diversity

Effective governance

Capital investment

Decreased ex-ante future cost

Increased social safety

Decreased health expenditure

Increased Home and land value

Increased ecosystem services - tourist/scholarships

Increased tourism

Increased social security cost

Increased local revenue

Increased HH amenity

Increased tourism

Restaurant, lodging and related ancillary industries

Water Quality Improvement (Anthropogenic + Naturogenic)

Water Resources (Non-linear, Complex and dynamic to SES)

Fig. 1 Multi-layered impacts of water quality improvement project/program
(Inputs- Outputs-Outcomes of improved water quality)
Socio-economic Value of Missouri Watershed

• 61 percent of Missourians prefer outdoor recreation: increased by 2.65 percent
• Of the total, 77 percent involved for fishing related activities
• $665 million is spent annually on fishing alone
• Missouri recreation generates $14.9 billion consumer spending
• 133,000 jobs and $889 million State and local tax revenue.
• One million dollar investment in water resource - 15.5 jobs.
• Other benefits include property value appreciation
• Local business benefited
• Support other recreational activities, such as wildlife viewing
• GDP growth: 0.2 percent for every unit increase in Environmental Regulatory Action
Policy conclusion

- Economic benefits measured by changes WTP/CS/PS
- WTP is often approximated in terms of defensive expenditure or damage avoided from water quality enhancement rule
- Either policy we adopt, benefit would exceeds the cost
- Choice of policy options is time and space variant

- Wetland management adds up ecosystem services, BC ratio >1
- Nutrient trading-cost effective (point source N and P would pay $4.72 and $23.37 per pound while agriculture $0.45 and $1.08 per pound respectively)
- Upstream-downstream: Kaldor-Hick Compensation Criteria