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A WORKING PAPER IN REGULATORY STUDIES

THE COST OF REGULATIONS IMPLEMENTING THE CLEAN WATER ACT

by

Joseph M. Johnson, Ph.D.

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GEORGE MASON UNIVERSITY

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I. Introduction

The year 2002 marked the thirtieth anniversary of the Clean Water Act of 1972 (CWA), the nation's main environmental legislation addressing water pollution. After thirty years experience with regulating water quality at the Federal level, it is worth taking a retrospective look at its impacts. What water quality benefits has the Act produced? What has it cost? Are there unintended consequences associated with its implementation?

Unfortunately, any retrospective examination is limited by a dearth of information on the quality of waterways, lakes, and coastal waters. On the 30th anniversary of the CWA, the Environmental Protection Agency (EPA) and numerous environmental interest groups issued statements and reports praising the progress brought by the Act's provisions and regulatory mandates, while arguing that more remains to be done. As in 1972, advocates of water quality regulation point to an event in 1968, when the Cleveland, Ohio, Cuyahoga River caught fire,[1] to illustrate the unsatisfactory state of the nation's waters at that time. However, it was difficult to ascertain the quality of water then except through such anecdotes because little work had been done to assess water quality around the country. Unfortunately, we are not much better informed today, as little quantitative effort has been made since 1972 to catalog the state of waterways, lakes, and coastal waters.[2]

While EPA periodically issues reports assessing water quality progress, these reports are based on little hard evidence, but rather on hypothetical models that estimate progress based on scenarios of how bad water pollution would be today without the CWA.[3] Indeed, one fundamental problem with centralizing authority at EPA is that states have no independent incentives to assess their particular water quality needs, because they lack the flexibility to implement plans that do not follow rigid EPA mandates.

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[1] For more information on this event, see the Academy of Natural Sciences "The Clean Water Act: Thirty Years Later." Available at (http://www.acnatsci.org/research/kye/kye102002.html)

[2] The reason for this dearth of information may be several-fold. First, the CWA set an ambitious goal of zero pollutant discharge, directing both EPA and the states to meet that goal initially through mandated technology-based limitations on industrial dischargers, and a standard of secondary treatment for publicly owned treatment works (POTW). Since the initial regulatory strategy to achieve the requirements of the 1972 Act focused on inputs (pollution control technologies applied at point sources), rather than outcomes (i.e., the quality of the water), it provided little incentive initially to measure water quality outcomes.

Second, the delegation of authority between the federal EPA and the individual states may limit incentives to gather water quality data. The CWA directed EPA to issue technology-based regulations for the control of industrial wastewater effluents, but assigned to the states the responsibility for implementing those mandates and for assessing water quality. While the states developed a limited database on water quality in connection with the issuance of point-source discharge permits, it was not until Congress passed the 1987 Amendments to the CWA that EPA refocused its regulatory attention on assessing the effectiveness (in terms of water quality) of the technology-based regulations.

[3] The EPA assessed the benefits of the CWA since 1972 in "A Benefits Assessment of Water Pollution Control Programs Since 1972: Part 1, The Benefits of Point Source Controls for Conventional Pollutants in Rivers and Streams," (EPA Document No. 68-C6-0021, January 2000). The benefits attributed to the CWA were based upon simulation modeling showing what water conditions would be without the CWA, which is, of course, largely speculative and open to criticism.

Because so little solid data exists on the present state of water quality or how it has changed over the last thirty years, this paper focuses on the costs of implementing the CWA, and not the benefits. There are several reasons why focusing on the costs of regulation is valuable. Often, the desired benefits of regulation are the force behind legislative initiatives that create them, and the benefits of regulation are often better understood, qualitatively, at least, than the costs. Second, as private sector managers have long recognized, that which goes unmeasured, goes unheeded. This is why companies maintain internal cost accounting systems to track expenditures for different purposes. It is also why the federal government tracks on-budget expenditures for its various purposes. Though the benefits that correspond to these expenditures are recognized at the micro decision-making level (to determine whether a particular project is worth the cost), no one would deny that an overall understanding of expenditures or budgetary costs is also essential for reasoned decision-making.

Thus, this paper updates and extends past estimates to estimate the costs water pollution control regulations impose on American citizens (as consumers and taxpayers). Utilizing a cost estimation method similar to that used in the past by EPA, I estimate that the costs of water quality regulation totaled $93.1 billion in 2001. While this figure is based on conservative estimates of regulatory costs, it is significantly larger than the cost and benefit estimates produced by EPA.[4]

The remainder of this paper examines the regulations of the CWA, and documents the cost estimate. Section II provides an overview of the legislative and regulatory history of Federal water pollution control programs and highlights recent regulatory initiatives. Section III discusses the concept of economic costs and reviews available analyses and data. Section IV combines available data with new analysis to estimate the costs of compliance with Federal water quality programs. Section V concludes the paper.

II. Overview: Legislative and Regulatory History of Federal Water Pollution Control Programs

Throughout this document I define water pollution control as the set of federal government programs[5] designed to regulate the level of pollution in American rivers, streams, lakes, estuaries, wetlands, and coastal areas. As described below, several programs preceded the

[4] In 1997, EPA estimated the costs of the 1972 CWA at $15.8 billion per year. ["A Retrospective Assessment of the Costs of the Clean Water Act: 1972 to 1997," Environmental Protection Agency, October 2000, (EPA Contract # 67-W7-0018)] In 1987, a decade earlier, EPA had placed the costs at $44.6 billion per year. ["Environmental Investments: The Cost of a Clean Environment," U.S. Environmental Protection Agency, EPA 230-11-90-083.] In a 2000 report, EPA estimated that Americans receive benefits on the order of $11 billion per year from regulations issued under the CWA. These benefit estimates are not based on actual monitoring of water quality in water bodies around the nation, but on models that estimate not only what water quality would have been in the absence of the Act, but of what water quality actually is today in many cases. ["A Benefits Assessment of Water Pollution Control Programs Since 1972: Part 1, The Benefits of Point Source Controls for Conventional Pollutants in Rivers and Streams," (EPA Document No. 68-C6-0021, January 2000).]

[5] State and local governments also figure heavily into the nation's water pollution control programs, largely because the federal government with the 1972 Clean Water Act usurped their authority while they were required to continue assuming much of the day-to-day activities of water pollution management.

1972 CWA Amendments, but the shape of modern regulatory activity surrounding water pollution follows from the 1972 Act and its subsequent amendments. Therefore, the costs I attempt to describe and quantify in the second half of the paper are those largely attributable to the 1972 Act and subsequent amendments. Henceforth when I employ the term "CWA" or "Clean Water Act," I refer to the 1972 Act and its amendments, unless otherwise noted.

A. Legislative History of the Clean Water Act

Table 1 outlines the legislative history of water pollution control in the U.S.

Table 1. Clean Water Act History[6]

Year	Act
1948	Federal Water Pollution Control Act
1956	Water Pollution Control Act of 1956
1961	Federal Water Pollution Control Act Amendments
1965	Water Quality Act of 1965
1966	Clean Water Restoration Act
1970	Water Quality Improvement Act of 1970
1972	Federal Water Pollution Control Act Amendments[7]
1977	Clean Water Act of 1977
1981	Municipal Wastewater Treatment Construction Grants Amendments
1987	Water Quality Act of 1987

The Federal Water Pollution Control Act, or Clean Water Act, was first enacted in 1948. However, it was not until the major 1972 amendments that a new federal government agency, the Environmental Protection Agency (EPA), assumed control of water pollution programs, shifting authority away from the States. Environmental advocates argued that the states were not fulfilling their mandate, encoded in earlier legislation, to protect the nation's waters. Importantly, the original 1948 legislation specifically recognized water pollution as a state and local problem. It sought therefore to provide state and local governments with funding that was earmarked for technical assistance to address pollution. There were no federally mandated objectives, limits, or enforcement strategies. The federal government was only involved in matters involving interstate waterways. Despite these vast differences with today's federally run water quality regulatory program, the 1948 legislation still began the path down the road to greater and greater levels of federal involvement.

[6] Source: "Clean Water Act: A Summary of the Law," Claudia Copeland, Congressional Research Service Report No. RL 30030.
[7] I do not discuss the Marine Protection, Sanctuaries and Research Act of 1972, enacted as a companion to the 1972 Clean Water Act Amendments.

The early days of water quality policy were important in that they allowed states and localities latitude in dealing with problems in ways most suited to their unique conditions. Meiners and Yandle (1992) discuss the importance of addressing water pollution problems as unique cases in their analysis of how common law solutions were not only more economically efficient but also produced superior environmental quality. Indeed, much criticism of modern water pollution regulation under the CWA regime is due to the complete absence of problems being addressed at the local level of the affected water body.

As the 1950s and 1960s wore on and the environmental movement gained steam in America, the provisions of the 1948 legislation were seen as inadequate. Newly emerging environmental interest groups sought to supplant local authority with command and control style federal authority when they saw some local initiatives as inadequate. More importantly, national environmental groups concerned themselves with the waterways of the entire United States and generally had no real local interest in water quality. Thus, they achieved massive economies of scale in lobbying for initiatives and programs they desired in a one-stop shopping trip to the federal authorities. Furthermore, a federal regulatory body is always less in tune with the vast number of local concerns and is always ripe for capture by national interest groups.[8]

It is interesting to note that despite cries of eroding national water quality, often measured by anecdotal episodes like the 1969 Cuyahoga River burning, expenditures for increased wastewater treatment by municipal governments rose dramatically after 1948.[9] This rise in expenditures was due largely to a series of amendments to the 1948 Act throughout the 1960s that began the shift of authority to the federal government. This shift in priorities closely mirrored the rise of environmental interest groups as political actors. In fact, it was the 1965 Water Quality Act that began the practice of requiring states to set water quality standards, albeit only for interstate waters.

Water quality standards were meant to be a centerpiece of the 1972 CWA. They require a profile for a waterway that determines the pollutant levels that the waterway is able to bear across the entire spectrum of identified pollutants. By establishing a water quality standard for a particular waterway, one should be able to measure the actual level of pollutants in the water to determine if the water body meets the standard, and its proximity to compliance. Since 1972, however, little progress has been made in actually establishing water quality standards, and even less progress has been made in measuring pollutant levels and monitoring them over time. This is an important policy issue currently because it is a centerpiece of EPA's Total Maximum Daily Load (TMDL) program, which is currently under examination.[10]

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[8] See, for example, George Stigler, "The Economic Theory of Regulation," *Bell Journal of Economic and Management Sciences* 2, 1 (1971) : 3-21. Available at (http://www.ipcreators.org/pdf-files/Stigler%20on%20regulation.pdf) and Sam Peltzman, "Toward a More General Theory of Regulation," *Journal of Law and Economics,* 19, 2 (1993) : 211-40.

[9] See "A Retrospective Assessment of the Costs of the Clean Water Act: 1972 to 1997," *supra* note 4.

[10] On March 19, 2003 EPA withdrew the July 2000 final TMDL rule (68 FR 13607).

The 1972 CWA established strict technical requirements for all point sources that discharge pollutants into the nation's waterways. Industrial dischargers face a permitting system that requires them to control loadings of regulated pollutants in wastewater discharges to levels specified by categorical effluent limitations and standards (now codified at 40 CFR 401 to 471). While the limitations and standards for each industrial category were based on actual performance data of a particular treatment technology, or combination of technologies, the treatment technology a permitee may use to achieve compliance with the regulation is not prescribed. In fact, EPA has encouraged the use of innovative technology to achieve compliance.

Municipal point source dischargers (POTWs) also face a permitting system that requires them to achieve levels of regulated pollutants commensurate with secondary (biological) treatment of sanitary (domestic) wastewater. A major component of the CWA was a federal grant system assisting states and localities in constructing wastewater treatment facilities to meet these federal guidelines. Part B below discusses the main regulatory programs of the 1972 CWA.

The 1977 CWA Amendments made discharge standards for some already-regulated pollutants more stringent. At the same time, they extended the list of pollutants covered by the CWA permit system by adding a list of chemicals designated as "toxic pollutants" which originated from a lawsuit that was settled the previous year. The 1987 Water Quality Act, which was the most recent amendment to the CWA, realigned the federal wastewater capital construction grant program. More significantly, it strengthened the regulatory requirements for nonpoint sources of pollution, which are runoff from diffuse sources that impair water quality. Major nonpoint sources are runoff from animal feeding operations, agriculture, forestry, and mining operations. Other nonpoint sources are water conservation programs and highway erosion control. In the 1990s, a major source of nonpoint source regulatory activity was storm water discharge. (EPA extended National Pollutant Discharge Elimination System (NPDES) permitting to storm water discharges, as discussed below.)

B. Regulatory History of the Clean Water Act

1. The 1972 Act required EPA to set effluent guidelines based on "best practicable technology"

The 1972 CWA Amendments established a novel new program in federal water pollution regulation. The federal government, largely through the executive branch enforcement arm of the Environmental Protection Agency, would implement a command and control regulatory structure, to which the state agencies were largely subordinate. EPA would issue regulatory mandates to meet the requirements of legislative actions, such as the CWA.

The main thrust of the 1972 CWA was the establishment of effluent guidelines for all industrial and municipal point sources of wastewater. In other words, any discharge of wastewater that contained any of a number of specified pollutants was to be regulated by the federal government, through the various states and localities. Furthermore, the initial regulation of wastewater effluents was to be technology-based, rather than on the overall effect on the quality of the affected body of water. This is the main problem with the command and control structure of federal environmental regulation: it ignores outcomes and focuses only on process. The unfortunate result of this structure is that goals and plans to achieve them are never clearly stated and quantified.

The quality of surface waters can be affected by wastewater coming from point sources or nonpoint sources. The former is the most significant, and indeed the vast majority of EPA's efforts in controlling water pollution have been directed at point source dischargers since 1972. Point sources include: (1) industrial dischargers; and (2) municipal wastewater treatment plants, or Publicly Owned Treatment Works (POTWs). Both of these point sources are regulated by permits issued under the National Pollutant Discharge Elimination System (NPDES).

The CWA set Best Practicable Technology (BPT) effluent limitations for industrial sources, and the NPDES system granted a permit for discharging based on compliance with the BPT standard. NPDES permits are valid for five years and must be renewed after that. Currently the majority of the states have the ability to issue or re-issue NPDES permits. EPA defines BPT as "the average of the best existing performance by well-operated plants within each industrial category." Of course, treatment achievable by BPT change over time as the technology progresses and the average of the lowest-polluting plants inevitably improves. EPA is the arbiter of what specifically constitutes BPT. Section 1314 of the CWA states that EPA should take into consideration the costs and benefits of defining BPT requirements, but does not mandate this or provide any guidance. The pollutants for which BPT is applicable are designated as conventional and nonconventional.

2. The 1977 Amendments introduced effluent limitations based on "best available technology economically achievable" (BAT) and "best conventional technology for conventional pollutants" (BCT).

The 1977 CWA Amendments extended the scope of the CWA to include many chemical parameters EPA had designated as "toxic pollutants" to settle a lawsuit brought by environmental groups. The 1977 Amendments also changed the technology-based standards for other pollutants. Toxic pollutants, along with some nonconventional pollutants face Best Available Technology (BAT) standards for effluents. BAT standards were more stringent that BPT standards, and are defined as "a level of technology based on the best existing control and treatment measures that are economically achievable within the given industrial category or subcategory."[11]

The 1977 amendments also redefined the standards for conventional pollutants, defining Best Conventional Technology (BCT) standards. BCT specifically tasks EPA with examining the relationship between the costs of achieving a standard and the benefits of the pollutant discharge reduction.

[11] http://www.epa.gov/npdes/pubs/final99.pdf (Introduction to the National Pretreatment Program)

Any "new" source of water pollution (i.e., a discharger that commenced construction of the pollutant source after effluent guidelines for the relevant industrial sector were established) is subject to New Source Performance Standards (NSPS). NSPS forces the use of best available technology regardless of the type of activity or the pollutants discharged. The result is a bias in favor of existing producers using older technologies, as the cost of building new facilities and employing more stringent technology is often prohibitive.[12]

3. Municipal wastewater treatment works also face effluent standards

Municipal wastewater treatment facilities (publicly owned treatment works or POTWs) face guidelines for water treatment similar to industrial sources that discharge the same pollutants. However, POTWs also face the necessity of achieving "the degree of effluent reduction achievable through secondary treatment." The result is an even stricter standard for POTWs, which are the largest volume dischargers among the various classes. The majority of the pollutants from POTWs are conventional: biochemical oxygen demand, suspended solids, pH, fecal coliform, and grease and oil from runoff. In addition to effluent guidelines for the POTWs, EPA establishes pretreatment guidelines for any point source that empties into a POTW. Pretreatment guidelines for existing sources (PGES) and pretreatment guidelines for new sources (PGNS) seek to limit the number of pollutants that POTWs are not equipped to deal with.

One of the most enduring pillars of the CWA is federal funding for POTWs. Beginning in 1972, the CWA established federally authorized funds for the construction of treatment facilities that meet the rigorous standards of EPA's effluent guidelines. These funds were administered under Title II of the CWA, and from 1972 to 1985 EPA paid up to 75 percent of eligible costs for conventional treatments facilities. From 1985 to 1988, EPA provided 55 percent of eligible capital costs. Beginning in 1988, the program was shifted from Title II grants to Title VI funding of the State Revolving Fund (SRF) program. The plan was to phase out federal funding by 1994, however, funding of the SRF program continues to this day. In 2004, appropriations for Title VI SRF funding was $1.35 billion. Table 3 below shows the history of Title VI funding since the program was scheduled to end in 1994.

[12] For a discussion of this bias, see Peter Huber's classic "Exorcists vs. Gatekeepers in Risk Regulation," *Regulation*, November/December 1983, pp. 23-32. He illustrates the new source bias phenomenon and observes "the paradox of risk regulation is that too much of it makes life more dangerous. Not just more expensive, not just less convenient, but more dangerous."

Table 2. History of Title II & Title VI Funding

(Millions of 2002 $)

Year	Title VI Funds
1995	1240
1996	2070
1997	625
1998	1350
1999	1350
2000	1345
2001	1350
2002	1350
2004	1350

Source: Copeland, "Water Quality: Implementing the Clean Water Act," Congressional Research Service, IB89102. Updated to 2004 from *Budget of the United States Government, Fiscal Year 2005—Appendix*.

The principal of the SRF program is that states would match the federal capitalization of funds at 20 cents on the dollar. EPA predicted that the funds would be self-sufficient by 1994 and federal funding would no longer be needed. This was based on the SRF funds being loans that would be paid back by the municipalities. However, with ever-tightening regulation on treatment and effluent discharge, municipalities have not been able to pay down debts taken to meet ever-increasing standards. In fact, smaller municipalities may not even be able to participate in the program because they lack access to capital markets and sufficient tax bases to raise necessary funds for steep capitalization requirements to meet EPA standards.

C. Recent Clean Water Act Issues

Over the decade of the 1990s and into the 21st century, EPA has both continued to expand some traditional programs and undertaken new regulatory water quality initiatives. The most prominent, due to scope, high costs, or controversial nature, are discussed below.

1. Total Maximum Daily Load (TMDL) Program

Depending on how they are implemented, TMDLs could potentially be the largest and most significant water regulation program since the passage of the CWA.

The CWA requires each state to develop an assessment of each waterway within its borders and determine the maximum daily load of each pollutant the waterbody can handle and still meet designated uses, such as fishing, swimming, and boating. The states then individually decide whether stricter effluent guidelines, or some other control program, should be implemented in order to bring the waterway into compliance with its pollutant-loading limit. Note that this program focuses on the overall quality of a waterway, and requires officials to perform regular analyses of water quality to evaluate the progress of implementation programs. This is in stark contrast to the technology-based effluent guidelines that form the backbone of CWA regulation, which are not connected to any water quality goals or the marginal effect of any pollutant on a specific water body. Additionally, the TMDL program, as originally codified in the CWA, leaves much discretion to the states as to which water pollution problems are worth pursuing.

Over the years, environmental activists have used the federal court system to bring suits against the various states for not implementing TMDLs more actively. In 2000, EPA responded to these concerns by issuing a controversial new TMDL regulatory program that would have shifted the central role from the individual states to EPA (for final rule text, see FR 65 43586). While states would still be required to undertake water quality analyses and implement plans to bring waterways into compliance, the 2000 rule would have given EPA the role of setting standards and timetables. In other words, EPA would dictate what should be done and the states would be responsible for doing it, and more importantly paying for it.[13] Congress placed the final rule on hold to more closely study its economic impact. In March 2003 EPA withdrew the 2000 rule, and is expected to issue a new rule in the future.

In 2001 EPA, at the behest of Congress, published a report analyzing the costs of the proposed TMDL rule.[14] It stated that currently less than one-third of the nation's waterways have ever been assessed for water quality, and that those assessments that had been completed were not done in a systematic way so as to be representative of all waters. The report went on to base a cost of TMDL development and implementation on a sample of only 15 completed TMDLs. This is a small fraction of the 36,000 TMDLs that would have been required for the waters surveyed at the time the report was written, which itself is only one-third of that nation's total waters. Thus, the sample does not include many important pollutants, for which TMDL costs will be large. Nevertheless, despite the use of an inadequate and unrepresentative sample, the EPA report stated that TMDLs would cost between $1 billion and $4.6 billion annually on top of any costs already associated with TMDL programs currently underway.[15] Minor changes to the assumptions used by EPA lead to a higher cost estimate of $2.5 to $5.5 billion per year.[16]

2. Agricultural Runoff

EPA recently (February 2003, 68FR7175) issued a final rule on requirements for Concentrated Animal Feeding Operations (CAFOs). CAFOs are one of the most significant nonpoint sources of water pollution, and the first beyond storm water

[13] For a detailed review and critique of EPA's 2000 rule, see Mercatus Public Interest Comment on "The Environmental Protection Agency's Proposed Changes to the Total Maximum Daily Load (TMDL) Program, the "National Pollution Discharge Elimination System (NPDES), and Water Quality Standards (WQS) Regulation" by Meiners and Yandle, January 20, 2000. Available at (http://www.mercatus.org/regulatorystudies/article.php/104.html)

[14] Environmental Protection Agency, *The National Costs of the Total Maximum Daily Load Program (Draft Report).*

[15] See also the Mercatus Public Interest Comment on EPA's "The National Costs of the Total Maximum Daily Load Program (Draft Report)," by Joseph M. Johnson, December 11, 2001. Available at (http://www.mercatus.org/regulatorystudies/article.php/66.html)

[16] *Ibid.*

discharges to be directly addressed by new regulations since the 1987 Water Quality Act's mandate to shift focus to nonpoint source problems.

The new rule, and CAFO nonpoint source pollution in general, was the centerpiece of the Clinton administration's "Clean Water Initiative." In 1997, the 25th anniversary of the CWA, the Clinton White House announced a plan to address the nation's remaining water quality issues. This plan directed EPA and the U.S. Department of Agriculture (USDA) to work cooperatively to develop regulations that would address agricultural water pollution issues. In addressing CAFO issues, the EPA rule as originally proposed strengthened existing CAFO regulations that had been in place since the 1970s. The early regulations, which required many animal feeding operations, the largest of which are labeled CAFOs, to obtain discharge permits, were criticized by the 1990s primarily due to a lack of enforcement. EPA chose to address this problem by issuing new regulations that significantly expanded the definition of, and extended the regulatory requirements for, CAFOs.[17]

The proposed regulation was heavily criticized because it greatly expanded the number of operations that would be required to obtain discharge permits. Of major concern was the number of smaller animal feeding operations that would be forced into the permitting process. While the costs of obtaining a permit are considerable for large operations, they are prohibitive for small agricultural operators and would have resulted in job displacement and the closing of numerous operations. After a lengthy period of Congressional pressure and public comment, the final regulation issued by EPA reduced the number of covered operators from 26,000 to 39,000 under the proposal to 15,500 in the final rule. According to EPA estimates, the annual costs to operators were consequently reduced from $867 million to $1 billion under the proposal to $360 million under the final rule.

While the CAFO rule is the most significant regulation to address agricultural impacts on water quality, it is not the only federal initiative to do so. USDA administers a number of programs to enforce and enhance conservation efforts by American farmers, most of which are on-budget programs that pay farmers for conservation efforts. The 1985 Food Security Act initiated the most significant program, the Conservation Reserve Program (CRP), which pays farmers to set aside land that is deemed susceptible to erosion. This program and others have expanded in recent years under the farm bills of 1990, 1996 and 2002. The acreage set aside for conservation under the CRP is scheduled to rise by 2.8 million acres, or 7.5 percent, by 2007, raising the over $2 billion annually budgeted to this program. Other programs tie payments to environmental efforts and address nonpoint source water pollution, wetlands preservation, and soil erosion.

3. Storm Water Issues

EPA struggled throughout the 1990s to codify a comprehensive policy on storm water discharges from municipal and industrial sites. Storm water discharges occur when heavy rains cause existing treatment facilities and networks for wastewater to overflow.

[17] See "EPA's National Pollutant Discharge Elimination System Permit Regulations and Effluent Limitation Guidelines and Standards for Concentrated Animal Feeding Operations," by Sean Blacklocke, July 30, 2001. Available at (http://www.mercatus.org/regulatorystudies/article.php/70.html)

Generally speaking, when it rains especially heavily, the existing sewer facilities on city streets or in an industrial facility may not have the flow capacity to handle the higher volumes of water. When this happens, waters contaminated with various wastes from roads, eroded soil, or other sources can flow past treatment points and directly into rivers, streams, or other water bodies.

In 1990 EPA addressed the issue by implementing a permitting system for storm water discharges. However, these so-called Phase I rules applied only to large dischargers—such as municipalities with significant populations—due to the enormous cost burden they would place on small dischargers, such as small municipalities, industrial complexes, and construction programs. It was not until October 1999 that EPA issued the Phase II regulations addressing smaller dischargers (64FR68721).

Although the 1999 Phase II rule was designed to extend the storm water permitting system to small dischargers, critics doubt if it will be possible for small municipalities to meet the requirements. The scheduled date of compliance in the rule was March 2003, and while EPA has yet to publish any assessment of compliance rates, it is unlikely that most small municipalities have been able to meet the standards. EPA estimated the cost of the Phase II rule at $932 million to $1.08 billion annually. Because small municipalities do not have access to debt financing via bond markets to the extent that larger municipalities do, they are left to finance costly unfunded mandates through tax or other revenue collections. However, many states limit the ability of municipalities to levy taxes, putting small cities facing enormous costs in a serious bind that has not been addressed by EPA.[18]

Other new rules related to storm water permitting address combined sewer overflows (CSOs) and separate sanitary sewer overflows (SSOs). Many cities have wastewater treatment systems that combine sanitation, industrial waste, storm water runoff, and groundwater runoff into a single system for treatment. When the system becomes overtaxed and overflows occur, the excess volume of discharges is left untreated. A CSO permitting strategy was implemented in 1994, but by 1998 little progress had been made by the over 700 municipalities that have CSOs. In addition to CSOs, over 18,000 municipalities have overflow issues with separate sanitary sewers. In 2001 the Clinton Administration issued regulations addressing SSOs, but those regulations have not yet been published and are under review by the Bush Administration.[19]

4. Wetlands Conservation

While not necessarily a water pollution issue, wetlands conservation is specifically addressed by the CWA, which delegates authority to EPA as well as other federal agencies. As noted above, a series of farm bills also give USDA authority to address wetlands issues.

[18] For more on municipality size and borrowing see Bill Simonsen, Mark D. Robbins and Lee Helgerson, "The Influence of Jurisdiction Size and Sale Type on Municipal Bond Interest Rates: An Empirical Analysis," *Public Administration Review,* 61(6) : 709-17, 2001; and Mary-Jean Rivers, and Barbara M. Yates "City Size and Geographic Segmentation in the Municipal Bond Market," *Quarterly Review of Economics and Finance,* 37(3) : 633-45, 1997.

[19] See "Water Quality: Implementing the Clean Water Act," by Claudia Copeland, Congressional Research Service, IB89102, February 2003.

The Wetlands Reserve Program (WRP) is one such program that monitors agriculture and prohibits farmers from converting wetlands, or swamps, into arable farmland lest they be denied other federal benefits, but establishes grants to farmers who set aside wetlands under the program. Furthermore, the Natural Resources Conservation Service (NRCS), a USDA agency, is largely responsible for wetlands conservation issues under a memorandum of understanding signed by four competing agencies that all have jurisdiction over certain wetlands issues under Section 404 of the CWA: the NRCS, U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and EPA.

Controversy surrounds the federal government's wetlands conservation efforts in a general sense due to the encroachment many of the programs make on private property rights. These programs give agencies the authority to deny benefits to farmers who choose to cultivate wetlands, many of which have questionable protected status, causing the erosion of private property rights, thus raising the issue of unconstitutional "takings."[20]

III. The Economic Costs of Regulation

Cost is a term economists use to qualify and quantify the market valuation of the next best alternative to the one chosen. Cost and choice are intermingled, and in economics, the presence of one implies the other.[21] Therefore the pursuit of a regulatory agenda necessarily inflicts costs on society because it demands that resources be devoted to uses dictated by the regulation. Even regulations that require no direct expenditure for capital, equipment, training, or paperwork carry costs because they take away options and limit the alternatives open to a decision-maker. Of course, some rules are necessary in society and provide benefits that outweigh their costs. Obvious examples are prohibitions against murder or theft, or traffic regulation, which provide the institutional framework within which civil society can thrive.

This paper does not attempt to estimate the benefits that may be derived from the CWA or the regulations it authorizes.[22] This is not meant to suggest that these regulations do not have benefits, as well as costs, for American citizens. Indeed, the desired benefits of regulation are the force behind legislative initiatives that create them, and the benefits of regulation are often better understood, qualitatively, at least, than the costs.

There are considerable gains from understanding the cost side alone. First, any reasonable estimate of the macro costs to the economy can make a valuable contribution to the education of citizens, taxpayers, businesses, and policy makers. Second, a comparison of

[20] See "Proposal to Issue and Modify Nationwide Permits (Wetlands)," by Susan Dudley, November 30, 1998. Available at (http://www.mercatus.org/regulatorystudies/article.php/121.html) See also, "Comment on the Definition of Navigable Waters in Light of SWANCC," by Daniel Simmons, Public Interest Comment, April 16, 2003. Available at (http://www.mercatus.org/regulatorystudies/article.php/291.html)

[21] For an insightful discussion see James M. Buchanan, *Cost and Choice: An Inquiry in Economic Theory,* Chicago: Rand McNally, 1969.

[22] As Hopkins notes, tracking only the cost side follows the lead of the federal fiscal process, which does not measure benefits. Thomas D. Hopkins, "Regulatory Costs in Profile," Policy Study No. 132, Center for the Study of American Business, August 1996; and Murray Weidenbaum and Robert DeFina, "The Cost of Federal Regulation of Economic Activity," American Enterprise Institute, May 1978.

the cost of regulations that address diverse needs can provide policy makers and voters with an understanding of the relative burdens imposed on the limited resources of the economy in tackling economic and social problems. As in the realm of the fiscal budget, such comparative data will be useful in allocating these limited resources. This is especially true where some qualitative if not quantitative sense of the benefits of various regulatory initiatives already exists, so cost information would further help policy makers in choosing how resources should be allocated. Third, a better understanding of the costs of specific types of regulatory procedures will assist in the evaluation of one regulatory approach against another, which in itself may lead to a more efficient regulatory process. All three of these goals benefit from a process that provides a systematic approach to estimating costs.

Over the past quarter century, regulatory cost assessments have become more common, due in part to the availability of data through government agency-produced regulatory impact analyses for newly issued rules. Through legislative and executive branch action, most notably the Regulatory Flexibility Act (RFA), Small Business Regulatory Enforcement Fairness Act (SBREFA), and Executive Orders 12291 and 12866 (EO 12866), regulatory agencies must justify proposed regulations based on an examination of alternatives and their estimated costs and benefits. The Office of Management and Budget, Office of Information and Regulatory Affairs reviews regulatory impact analyses and issues standards for how analyses must be conducted. Thus, the assessments prepared by disparate agencies have become more comparable over time, and therefore more amenable to aggregation.

One often cited study that attempts to measure regulatory costs was performed by Thomas Hopkins (1995) and later updated by Crain and Hopkins (2001).[23] Crain and Hopkins estimate that the total cost of federal government regulation was $877 billion in 2000, with $205 billion of that attributable to environmental regulation. Their study builds on past studies that estimated regulatory costs, such as Weidenbaum and DeFina (1978), one of the earliest, which estimated the cost of regulation at $208.9 billion in 1976.[24] Litan and Nordhaus (1983) is another early estimate that placed the costs of regulation in 1977 at between $103 and $269 billion.[25]

Later studies became more refined as data grew more plentiful. Hahn and Hird (1990) authored an authoritative study that reviewed and critiqued nearly every regulatory cost and benefit analysis that had been conducted prior to 1990. While they did not employ new data to derive their estimates of regulatory costs, they provided a useful touchstone for researchers studying regulatory issues. Their discussion of the various methods of cost estimation helps to frame the debate. They discuss the pros and cons of studies using statistical economic analyses, expenditure surveys, and macroeconomic simulations, among others.

[23] Thomas Hopkins *Profiles of Regulatory Costs* report to the U.S. Small Business Administration, U.S. Department of Commerce, National Technical Information Service #PB96 128038, November 1995 and Crain and Hopkins, 2001.
[24] Murray Weidenbaum and Robert DeFina, *The Cost of Federal Regulation of Economic Activity,* American Enterprise Institute Reprint No. 88, 1978. (Cost of $66.1 billion in 1976 dollars.)
[25] R. Litan and W. Nordhaus, *Reforming Federal Regulation*, New Haven: Yale University Press, 1983. (Cost of $34.7 to $90.6 billion in 1977 dollars.)

The latter type of analysis, macroeconomic modeling, is used by Hazilla and Kopp (1990) and Jorgensen and Wilcoxen (1990) with great effect to estimate the social costs of environmental regulation, including water pollution regulation.[26] Hazilla and Kopp employ general equilibrium analysis to estimate the total cost of environmental regulations at $117.9 billion in 1985. They also find a large disparity between their estimate and EPA's cost estimates of $93.5 billion that used expenditure data. Jorgensen and Wilcoxen used a growth accounting methodology to estimate that environmental regulations reduce GDP by 2.59% at the level of regulation in 1986. These types of estimates include a greater range of costs than perhaps any other methodology. However, they also tend to be very sensitive to the assumptions and parameters used to estimate the models. Thus, the results are often open to critique and are sometimes less convincing because of this.

The most precise and straightforward estimates of water pollution regulatory costs are those based on expenditure surveys. The U.S. Census Bureau collected data on Pollution Abatement and Control Expenditures (PACE) from 1972 to 1994. This long time series of data allowed users to calculate capitalized annual costs from the annual expenditures series and analyze trends in spending across a number of expenditure categories. Nevertheless, there are shortcomings associated with expenditure-based cost estimates. Expenditure analyses of costs miss many potential impacts: the shrinking of the market for a product, the elimination of firms, the loss of consumer welfare from higher prices, the possibility that raising cost barriers changed market structures and entrenched monopoly power for existing firms.

On the other hand, expenditure studies also have much to recommend them. They are very straightforward and easily understood because the expenditures were actually recorded on balance sheets and income statements. They are not sensitive to any outside parameters used to calculate costs, such as market elasticities used in the calculation of lost consumer or producer surplus. Finally, they offer an estimate of costs with a consistent bias: they always underestimate the real costs because they exclude certain cost categories, most notably deadweight losses induced by distortions in market incentives from the regulatory tax.

An early report on water pollution costs using expenditure data came from the U.S. Council on Environmental Quality (CEQ), which estimated that the costs of water quality regulation totaled $28.2 billion in 1978.[27] Denison (1979) using economic growth accounting methods, estimated that in 1975 all environmental regulations cost $31.7 billion, which was about three times the total cost of regulations as estimated employing the 1972 PACE survey data. Clearly the expenditure survey method underestimates costs

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[26]Michael Hazilla and R. Kopp, "Social Cost of Environmental Quality Regulations: A General Equilibrium Analysis," *Journal of Political Economy* 98(4) : 853-73, 1990. (Total cost of $70.6 billion in 1985 dollars.) D. Jorgensen and P. J. Wilcoxen, "Environmental Regulation and U.S. Economic Growth," *RAND Journal of Economics* 21(2) : 314-40, 1990. In a similar vein to Jorgensen and Wilcoxen, Wayne Gray found that the productivity slowdown that began in the 1970s was due largely to environmental and safety regulation issued by the EPA and OSHA (Gray 1987) "The Cost of Regulation: OSHA, EPA and the Productivity Slowdown," *American Economic Review* 77, p. 14.

[27] U.S. Council on Environmental Quality, *Environmental Quality-1979: The Tenth Annual Report of the CEQ,,* 1979. (Costs of $10.2 billion in 1978 dollars.)

since nearly all other methods of analysis find higher costs.[28] Subsequently Freeman (1990) updated the CEQ water pollution regulation estimates to between $43.6 and $53.3 billion in 1985.[29] Both the CEQ study and Freeman's analysis include the costs of the Safe Drinking Water Act as well as the Clean Water Act in their estimates, somewhat inflating them over a pure analysis of CWA costs.

In 1990 EPA released a comprehensive analysis of environmental regulatory costs using the PACE survey data entitled *Environmental Investments: The Cost of a Clean Environment*. This report included detailed analyses of all facets of water pollution regulation along with a detailed narrative of the cost accounting methodology employed. The *Cost of Clean* estimated the costs of regulations emanating from the CWA at $44.6 billion per year in 1987.[30]

In the following estimation of water pollution control costs for 2001, I employ a methodology broadly similar to that used by EPA in the *Cost of Clean*. I do so for the reasons listed above enumerating the positive qualities of expenditure estimates. I believe the advantages of this approach outweigh the disadvantages,[31] provided the results are qualified. Indeed, the estimate of regulatory costs performed by EPA in the *Cost of Clean* remains one of the most widely cited estimates 12 years after its publication. Another reason for performing an expenditure-based cost estimate is that the results are comparable with the earlier results from the *Cost of Clean*, allowing for a comparison of the changes in costs across time.

IV. Cost Estimates for Water Pollution Control Regulations

When the Clean Water Act was passed in 1972, the U.S. government also began an ambitious data collection project through the auspices of the U.S. Census Bureau. The Pollution Abatement and Control Expenditures (PACE) survey collected data on expenditures for equipment installed and operated to meet the regulatory standards of new environmental laws. The Census Bureau combined the data from the PACE survey with information on government pollution abatement expenditures from other sources. The final product, the *Survey of Current Business* (*SCB*), featured aggregate estimates for

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[28] E. Denison, *Accounting for Slower Economic Growth: The United States in the 1970,* 1979. (Costs of $9.5 billion in 1975.)

[29] Freeman, "Water Pollution Policy" in *Public Policies for Environmental Protection* (P. Portney ed), 1990. (Costs of between $25.2 and $30.8 billion in 1984 dollars.)

[30] A 1997 report on the costs of the CWA upon the 25th anniversary of the passage of the act updated the *Cost of Clean* estimate. However, the methodology employed was somewhat different, and despite the passage of 10 years reported lower total costs. The report posited an unrealistic counterfactual argument of what water pollution expenditures would be in a world without the CWA. For instance, over the 1972 to 1994 period there are instances in the report when the difference between the with-CWA and without-CWA estimates reported is significantly less than that year's federal construction grant level. Additionally the author's base their entire estimated data series of private without CWA capital expenditures on a single, unsupported anecdotal data point.

[31] As noted above, the main advantage of an expenditure-based approach is that the data are transparent and replicable. The disadvantages are that expenditures will underestimate the cost of foregone opportunities (products, innovations, etc.).

private and government expenditures that were constantly refined and updated until the program ended in 1994.[32]

I utilize the government and private PACE data from the final *SCB* update from 1996 to form the basis for estimating current annual costs for water pollution control. In section A, below, I estimate the costs of water pollution regulation to government, primarily state and local governments that fund wastewater treatment. Section B examines costs to the private sector. I utilize the 1972-1994 PACE data to form predictions for expenditures from 1995, the date when PACE was suspended, to 2001. In section C, I sum the costs from sections A and B to form a total cost estimate. In section D, I discuss changes in water pollution regulations enacted by EPA since 1994 when the PACE survey ended. Because government regulatory agencies are required to perform a cost-benefit analysis for significant regulations, it is relatively simple to obtain annualized estimates of the cost of these newer regulations. Finally, I aggregate the annualized cost estimates and the estimated costs of the post-1994 regulations to form an estimate of the total annual costs of water pollution regulation in 2001.

A. The Costs of Water Pollution Control to Government

The costs borne by governments for water pollution control fall into five categories. The largest is capital and operating expenditures by state and local governments for public wastewater treatment facilities. The expenditures reported in the *SCB* are total state and local expenditures, including federal grants from EPA under Title II and Title VI of the CWA, and more recently the State Revolving Fund loan program.[33] The second category is the portion of state and local capital and operating expenditures on natural resources that are for water programs. I follow the methodology used by EPA in its 2000 *Cost of a Clean Environment* Report[34] and allocate 20% of total natural resources costs to water. The third cost category covers regulation and monitoring costs. In the fourth category are costs for research and development of new technologies and methodologies. Finally, I include all other costs in a miscellaneous category called simply “Other Government Costs,” which includes costs for highway erosion abatement and some other nonpoint source programs. In Part 1, below, I discuss capital expenditures, in Part 2 operating expenditures, and Part 3 regulation and monitoring, R & D, and miscellaneous expenses. In Part 4, I aggregate and capitalize expenditures to form annualized costs for the government share of water pollution regulation costs.

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[32] Note that the PACE survey program was conducted in 1999 for the first time in 5 years. However, because the capitalization of expenditures to form annualized cost estimates requires a time series of expenditure data, the single data point from 1999 is not useful by itself. Furthermore, the 1999 data are not necessarily comparable to earlier data, and indeed an initial inspection of the 1999 data reveals many of the totals to be difficult to reconcile with the point estimates and trends from earlier data.

[33] I chose to include capital and operating expenditures for publicly owned electric utilities with private business expenditures rather than government expenditures. Because privately owned electric utilities are included in private business expenditures, publicly owned electric utilities would seem to fit best in that category.

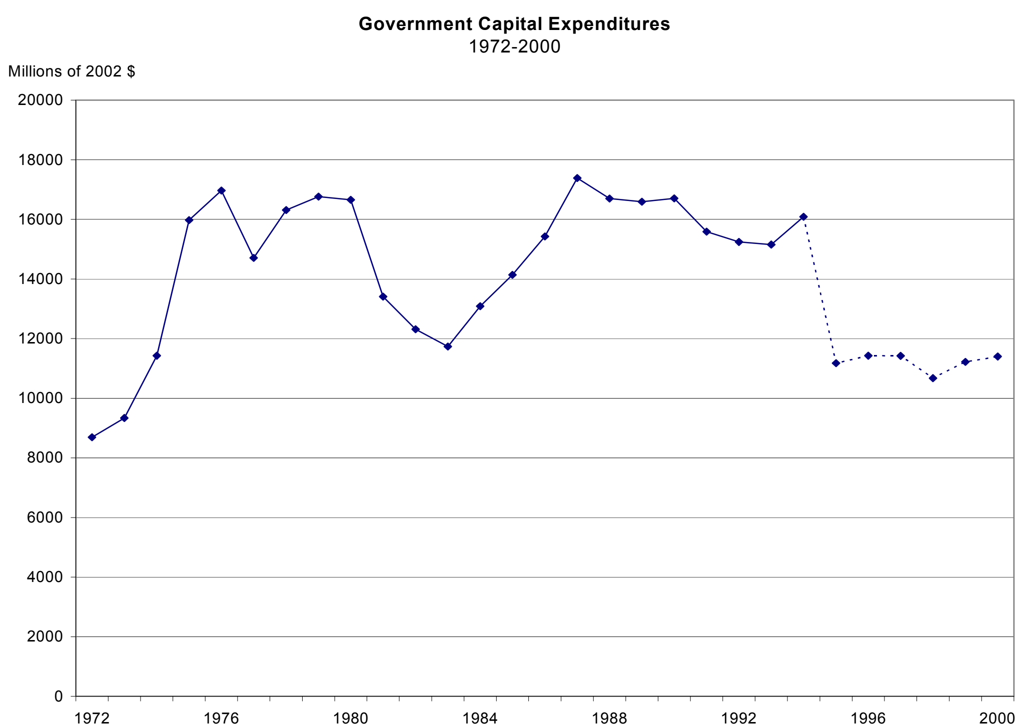
[34] *Environmental Investments: The Cost of a Clean Environment*, EPA, 2000.

1. Capital Expenditures for Wastewater Treatment and Natural Resources

Local governments bear the majority of the capital expenditures for public wastewater treatment. Since the passage of the 1972 Clean Water Act, the federal government has provided grant money to help offset the cost burden on local governments for meeting the Act's more stringent treatment and pre-treatment guidelines. Conversely, the states overwhelmingly bear the costs of other natural resource control and conservation efforts, many of which are required by the CWA.

Figure 1 shows capital expenditures at all levels of government from 1972 to 2000, the last year for which data are available. The data come from two sources, the PACE summary data from the *SCB* and state and local government expenditures from the *Government Finance* series of the U.S. Census Bureau. The totals from 1972 to 1994 include capital expenditures for publicly owned wastewater treatment facilities from the *SCB* and capital expenditures on natural resources from the *Government Finance* series. From 1995 to 2000 all expenditure totals are from the *Government Finance* series, as 1994 was the last year for which *SCB* data were available. Note that while the *SCB* government expenditure totals are based on data from the *Government Finance* series, they include additional data and are calculated using a different statistical procedure. Consequently the *Government Finance* figures are significantly lower than the *SCB* PACE totals, evident in Figure 1 and indicated by designating the 1995 to 2000 totals with a broken line. Importantly, the difference between the two measures is not constant across the years 1972 to 1994, and I make no attempt to adjust the 1995 through 2000 totals for consistency. This introduces a serious downward bias in my expenditure, and ultimately cost, estimates for government entities.

Figure 1.



As Shown in Figure 2 in the next section, operating expenditures exhibit the opposite trend and are somewhat greater in the *Government Finance* series than in the *SCB* PACE data. Again, I make no attempt to adjust the data and simply use the available expenditure totals to form my cost estimates. However, I treat the *SCB* PACE totals as my primary source and rely upon them whenever they are available since they contain private expenditure estimates in addition to government spending and were compiled with the specific purpose of estimating pollution control expenditures.

Figure 1 shows that real government capital expenditures do not exhibit any clear upward or downward trend over the observed time period. It is likely that the level of expenditures can be expected to continue into the foreseeable future. EPA continues to generate regulations that expand treatment or pre-treatment requirements. The federal grant program for capital investment in wastewater treatment under Title VI of the CWA continues, and despite the fact that the budgetary authorization for this program ended in 1994, recent trends indicate that around $1.35 billion annually is still allocated to it from federal funds. Finally, in its most recent assessment of the state of wastewater treatment EPA estimated that $140 billion in additional spending over the next 20 years is required to meet current standards.[35] Contrasted with the fact that the federal government had spent $73 billion over the 24 years since 1972 when that report was published, it would appear that EPA feels that increased levels of annual expenditures are necessary.

The lowest level of government capital expenditures occurred in 1972, the first year of the CWA, when $8.7 billion was spent.[36] By 1974 expenditures exceeded $10 billion annually and have held above that level ever since. The highest expenditure level occurred in 1987 when $17.4 billion was spent. The last observed expenditure in 2000 was $11.4 billion. The average annual expenditure over the period 1972 to 2000 was $13.9 billion. Again, it is clear from Figure 1 that no upward or downward trend exists in the expenditure data, but rather that expenditures appear to have reached a plateau by the mid-1970s about which large cyclical fluctuations occur. This is not surprising, as the ability of state and local governments to fund capital expenditures varies with the business cycle as the tax base waxes and wanes. More telling is the underlying plateau of expenditures, which may be related to the efforts of states and localities to meet regulatory requirements as laid down by EPA. In part 4 of this section I capitalize the annual expenditures shown here to form real capital costs.

While annual expenditures on water pollution capital have increased dramatically since 1972, state and local governments were clearly spending resources for water pollution and sewage control over many years prior to the passage of the 1972 CWA. This raises the question of how to account for these expenditures. In a 1997 paper, EPA concluded, through questionable statistical procedures, that by 1994, the final year of the PACE survey, water pollution control capital expenditures by state and local governments would

[35] *1996 Clean Water Needs Survey Report to Congress*, EPA832/R-97-003, Washington, D.C., 1997.

[36] Note that all expenditures in this report are expressed in 2002 dollars as determined by the Consumer Price Index. While a chain-type price index would be more appropriate, the proper chain-type deflators were only calculated for the years 1972-1994 in the *SCB* PACE summary.

actually have been *greater* without the 1972 CWA than with it.[37] This allows the authors of that paper to make the claim that the actual costs of the 1972 CWA were rather marginal.

How then did we reach the level of annual expenditures that has prevailed over the last two decades? An examination of the historical data on sewage capital expenditures prior to 1972 proves fruitful. While the PACE survey was only conducted between 1972 and 1994, the data on state and local capital expenditures from the Census Bureau's *Government Finance* time series reaches back to 1958. The Census Bureau's *Historical Statistics of the United States, Colonial Times to 1970* provides data prior to 1958. As shown in Table 1, the history of Clean Water legislation and regulation in the U.S. dates back to 1948, with six major pieces of legislation from 1948 through 1970. Importantly, the focus of the 1948 Act, and subsequent legislation, was treatment of wastewater in municipal sewage systems. Over the 24 year from 1924 to 1948, the average annual growth rate of sewage capital expenditures was 2.8%. Through the next 24 years after the passage of the 1948 Act, the average annual growth rate of expenditure was 8.7%. Clearly the early water pollution control legislation had a significant impact.

Despite the clear impact of water pollution control measures, it is nearly impossible to ascertain what the underlying level of expenditure would be without regulation. Clearly pollution control is a luxury good, with demand levels increasing with incomes, but the actual demand function is hard to estimate. One reason is that federal regulation has been a reality for over a half century, making it difficult to postulate a non-regulatory world. How would the market handle pollution control, for instance? Would we currently have more or less, better or worse, water pollution control? Most importantly, how much would it cost? Because the point of this paper is to estimate the costs of water pollution control, not simply those costs attributed to the 1972 CWA, the most defensible methodology is to simply accept the annual expenditure estimates from the *SCB*.

2. Operating Expenditures for Wastewater Treatment and Natural Resources

I calculate operating expenditures on the same basis as capital expenditures; that is I utilize *SCB* data for wastewater operating costs from 1972 to 1994 and *Government Finance* data from 1995 to 2000. For natural resources operating costs, *Government Finance* data is again used throughout. Figure 2 shows total operating expenditures for wastewater treatment and natural resources programs.

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[37] *Supra* note 4.

Figure 2.

Note that unlike capital expenditures, there is a clear and obvious upward trend in operating expenditures. This is due to the fact that given the high and continued levels of capital expenditures observed in Figure 1, the level of capital stock is steadily increasing. Given that the expected life of capital used in wastewater treatment, for instance, is roughly 30 years, 2002 marked the first year that capital acquired due to the passage of the 1972 CWA was retired. If capital expenditures maintain their current trend of remaining nearly steady year-to-year, operating expenditures should peak in the near future and remain constant thenceforth. However, if EPA continues to issue new regulatory requirements that require greater capital expenditures, operating expenditures could continue their upward trend for some time to come.

Due to the upward trend in operating expenditures, the minimum observed value of $6.8 billion was in 1972 while the most recent observation, $22 billion in 2000, was the maximum. The average over the period is $14.3 billion, but with real annual expenditures still growing, the average is also increasing each year. From Figure 2 it is clear that real operating expenditures increased at a steady, nearly constant rate, with an average annual growth rate of 4.3% from 1972 to 2000.[38] Annual operating expenditures are clearly the

[38] Average growth rate calculated by simple annual growth formula: $X=P[(1+r)^t]$, where X is the final period amount, P is the first period amount, r is the interest rate, and t is the number of time periods.

largest component of government water pollution control expenditures, dwarfing capital expenditures by nearly two to one in 2000.

3. Regulation & Monitoring, Research & Development, and Other Miscellaneous Expenditures

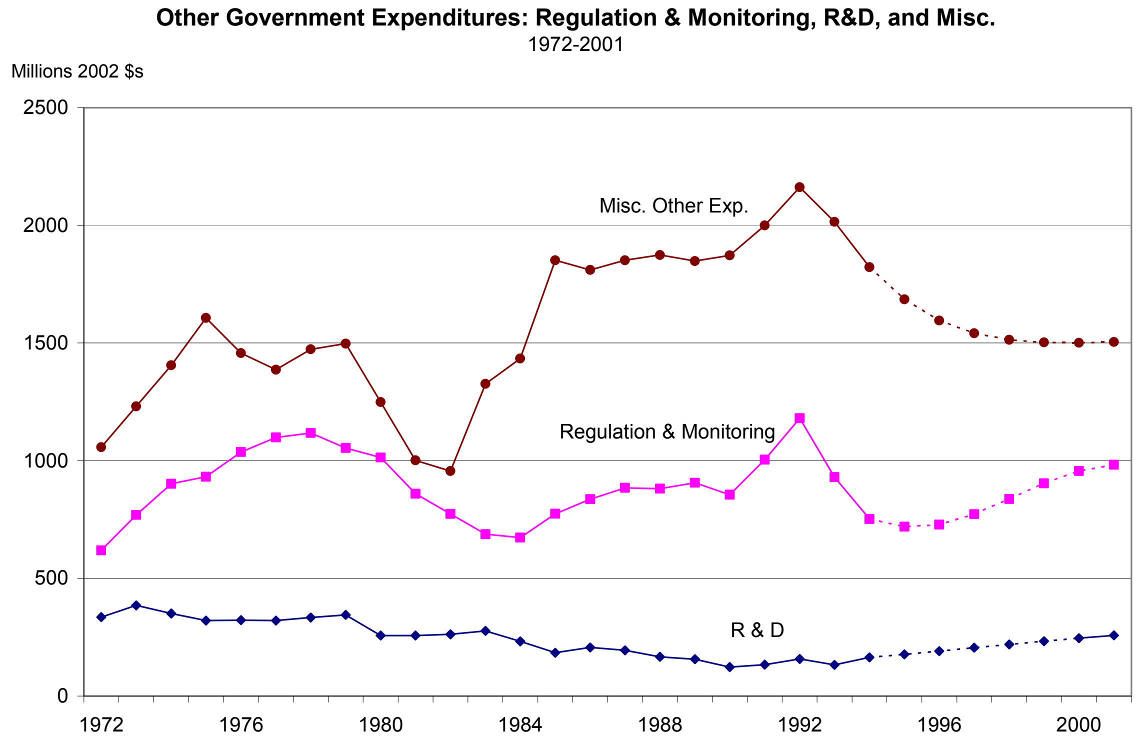
In addition to investments in new capital and expenditures to operate programs related to wastewater treatment and natural resources, there are myriad other government programs that require funding at the federal, state, and local level. Some of these expenditures are categorized in the *SCB* PACE summary data; among them are the costs associated with developing and implementing regulations, monitoring compliance, developing new pollution control technologies and methods, and implementing nonpoint source pollution control programs for erosion control and soil conservation.

Figure 3 shows observed expenditures in three categories as tracked by the *SCB* data. The largest of the three is designated Miscellaneous Other Government Expenditures, which largely reflects expenditures for nonpoint source prevention linked to erosion control. There is a slight upward trend in these expenditures from 1972 to 1994, but with a great deal of volatility. Expenditures increase sharply in the late-1980s due to increased regulatory requirements for nonpoint source pollution arising from the Water Quality Act of 1987. The lowest expenditure level of $956 million occurred in 1982, while the highest level of $2.2 billion occurred in 1992. The average expenditure level over the time period of observations was $1.6 billion. The single largest nonpoint source category is highway soil erosion prevention, ranging from more than half of total expenditures at the start of the period to about one-third by the end in 1994. Nearly all highway erosion prevention expenditures occur at the state level, and all state and local expenditures focus on highway erosion prevention. Most of the expenditure growth over the period was in federal non-highway expenditures, increasing by 1300% between 1972 and 1994. Unfortunately, the summary data in the *SCB* does not make clear exactly what is included in federal non-highway expenditures.

The second largest expenditure category covers regulation and monitoring. The costs are split roughly equally between federal and state governments over the entire 1972 to 1994 period, with most of the regulation cost accruing at the federal level and most of the monitoring cost at the state level. This is due to the structure of the CWA, under which EPA is responsible for developing regulations while the states are largely responsible for implementing them and monitoring the results. Real expenditures for regulation and monitoring surprisingly show little in the way of a trend over the period. However, there is a rather large cyclical component. The minimum observation is again in 1972 at the beginning of the program when expenditures totaled only $619 million. The maximum observed level was $1.2 billion in 1992, after which levels fell to $753 million in 1994. The average level over the entire time period was $893 million.

The third and final expenditure category shown in Figure 3 is government research and development, R&D, expenditures. R&D expenditures are significantly lower than the

Figure 3.



other two categories, and while remaining relatively stable over the period, do indicate a slight downward trend. Indeed, the highest observed value for real R&D expenditure was in 1973, the first year after passage of the CWA, totaling just $385 million. By 1994 the total annual expenditures had fallen to $165 million, with the lowest recorded level of $123 million occurring in 1990. The average expenditure level over 1972-1994 was $244 million. It is somewhat discouraging to see so little expenditure on developing new water pollution control methodologies or implementation plans. However, given the centralized command and control structure of national water pollution policy, it is not surprising. With EPA officials responsible for dictating technology requirements, there is little impetus on research and development. EPA also has little to gain from developing new technology since it faces little in the way of competitive pressure to do so. One could easily argue that this lack of competitive force is the Achilles heel of command and control regulation, as there is no pressure to develop cost effective technologies and no pressure for technological advancement over time.

There is no analog for the above three expenditure categories in the *Government Finance* series that would allow inclusion of observed values for the 1995-2001 period. Therefore, I estimate each of the three expenditure categories for that period using autoregressive moving average (ARMA) estimation. Attempts at forming structural estimations using available exogenous predictor variables proved not to be fruitful. In the case of government R&D, one might expect private R&D to be a reliable predictor, but this was not the case, and indeed a casual examination of the data shows government R&D to be relatively invariant over the 1972-1994 period. Regulation and monitoring might be expected to be increasing in the number of regulations, which have continued to grow over the sample period. However, again this is clearly not the case from an examination of the data, which appear to exhibit some cyclicality. The "other" category is understandably difficult to predict with a structural estimation because it is a miscellaneous category whose members and their relative importance have changed over time.

Therefore, ARMA was chosen as an estimation procedure because the three data series exhibit significant autocorrelation. Inclusion of AR(1) and AR(2) terms along with a one-period moving average term drastically improved the regression fit over simple regression on a trend.[39] Note that each data series was estimated simply by regressing the dependent variable on a constant and the autoregressive and moving average terms.[40] Thus, each estimated data point is essentially represented by an expected value and autocorrelated deviations from the expected value. While certainly an oversimplification of the true underlying process, this method has the virtue of providing simple short-term forecasts that quickly devolve to the long run expected value. Indeed, as previously noted, a visual inspection of the admittedly short time series for each variable reveals little in the way of trending or other growth phenomena, save for the Government R&D series which exhibits a subtle downward trend. Clearly the Government R&M and Other series exhibit cyclicality about a mean, such that the expected value approach yields reasonable if not overly accurate results. The bottom line is that because in this case it was not possible to form a fruitful structural model using exogenous predictor variables, a reasonable approach to long run forecasting is to use the simple expected value, or mean, of the data series; while at the same time estimated autocorrelation parameters inform the short run forecasts.

4. Annualized Costs of Government Water Pollution Control

Table 3 displays each series of expenditures outlined in the previous three sections: real government capital expenditures, real government operating expenditures, real government regulation and monitoring expenditures, real government research and development expenditures, and other miscellaneous government expenditures. Along with the total expenditures in each category in year 2002 dollars, the annual expenditure total for each year is shown in the final column.

[39] The baseline regression of each data series on a trend had a Durbin-Watson statistic less than 1, indicating significant autocorrelation. The ARIMA regressions including the autoregressive and moving average corrections had the following D-W statistics: Government R&D 1.70; Government R&M 1.80; and Government Other 1.90.

[40] Clearly the fact that important explanatory variables that might exhibit an autoregressive structure are omitted from the model is one reason why the Durbin-Watson test statistic was so low, and why the estimated autocorrelation terms have such high significance levels. However, while this implies a model misspecification due to omitted variables, it does not invalidate forecasts produced with the model as specified.

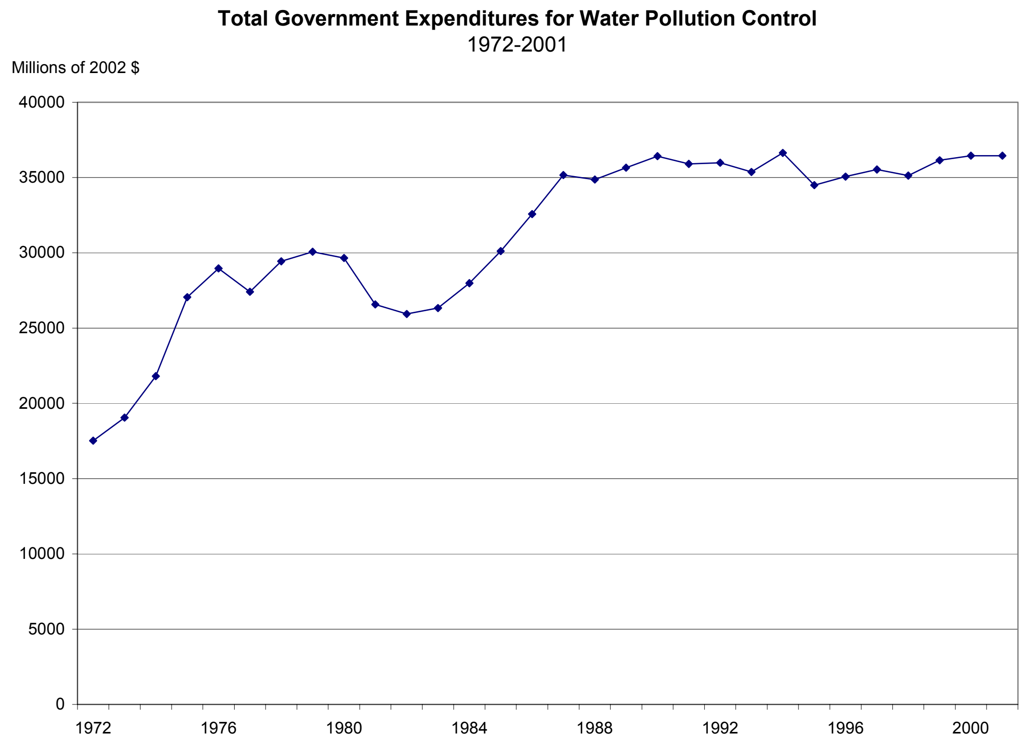
Table 3. Government Expenditures for Water Pollution Control

(Millions of 2002 $)

Year	Gov. Capital Exp.	Gov. Operating Exp.	Regulation & Monitoring	Research & Development	Misc. Other Exp.	Total
1972	8694.6	6811.2	619.2	335.4	1057.8	17518.2
1973	9334.4	7325.6	769.5	384.8	1231.2	19045.5
1974	11428.9	7719.8	901.6	350.4	1405.3	21805.8
1975	15973.9	8216.4	931.9	320.6	1606.5	27049.3
1976	16970.5	9179.8	1036.5	322.3	1456.8	28965.8
1977	14703.9	9902.0	1098.9	320.8	1387.0	27412.5
1978	16316.6	10190.5	1117.8	334.0	1473.8	29432.6
1979	16765.3	10406.1	1054.0	344.7	1497.9	30068.0
1980	16656.3	10477.5	1013.7	257.2	1249.1	29654.1
1981	13407.8	11045.6	859.3	257.4	1001.9	26572.0
1982	12314.7	11622.8	773.8	262.3	956.0	25929.5
1983	11736.4	12301.1	687.8	276.9	1326.7	26329.0
1984	13086.8	12555.6	673.0	231.8	1434.2	27981.4
1985	14138.6	13154.9	774.9	183.7	1852.0	30104.1
1986	15425.2	14284.7	836.4	206.6	1810.6	32563.5
1987	17388.2	14841.6	884.8	194.3	1851.8	35160.7
1988	16698.4	15246.8	881.6	167.2	1874.2	34868.2
1989	16590.9	16150.1	906.3	156.6	1848.8	35652.6
1990	16704.9	16862.2	855.6	122.8	1872.7	36418.2
1991	15587.6	17180.1	1004.5	133.3	1999.8	35905.3
1992	15242.5	17237.2	1180.2	157.4	2161.9	35979.3
1993	15158.3	17131.6	930	132.7	2015.0	35367.5
1994	16086.7	17813.1	752.6	164.6	1822.3	36639.3
1995	11177.2	20250.0	719.2	177.4	1685.8	34488.3
1996	11424.6	20578.6	728.4	191.1	1595.3	35064.2
1997	11420.9	21043.2	772.8	205.2	1541.5	35525.2
1998	10672.4	21387.5	837.3	219.4	1513.8	35121.0
1999	11221.0	21855.5	903.7	233.2	1502.8	36137.6
2000	11401.0	21982.1	955.7	246.2	1501.3	36444.0
2001	*11401.0*	*21982.1*	982.4	258.3	1504.3	36444.0

All figures shown in italics in Table 3 are extrapolations from the data and not observed values. Figure 4 below shows total annual government expenditures for each year from 1972 to 2001.

Figure 4.



Note that because data for 2001 government finances are not yet available, I assume that 2001 expenditures will equal 2000 expenditures for wastewater and natural resources capital and operations. This assumption allows government expenditures to coincide with the projections for private expenditures in the next section and to make the final estimates of costs as timely as is allowed by the data.

Now, in order to express the real economic costs borne by federal, state, and local governments it is necessary to capitalize annual capital expenditures. Capitalization accounts for the fact that an investment in plant and equipment is not used up in one year, but typically takes many years before it must be replaced. Depreciation of capital, or the portion used up in a given year, is part of the capitalization calculation. The other portion is based on the economic principle of opportunity cost. If one were to avoid making the capital investment and instead placed the funds in a market investment instrument and earn a market rate of return, or interest, on the investment. Thus the market interest rate is also reflected in the capitalization process.

I utilize the same capitalization parameters as EPA does in the *Cost of a Clean Environment* report. The assumed life of capital is 30 years. The discount rate is 7%, based on the procedural recommendations of the Office o Management and Budget.[41] Capitalized costs are calculated with the following formula:

(Eq. 1) $$C = K \cdot \left[d/(1-(1+d)^{-t})\right];$$

where C is the annual cost, K is the total stock of capital, d is the discount rate, and t is the capital life.

Table 4 shows the annual cost of capital, as calculated from the annual capital expenditures in Table 3, along with non-capital expenditures and total annual costs from1972 to 2001.

Table 4. Annual Capital Costs and Total Government Water Pollution Costs
(Millions of 2002 $)

Year	Capital Cost	All Other Costs*	Total Annual Cost
1972	700.7	8823.6	9524.3
1973	1452.9	9711.1	11164.0
1974	2373.9	10377.0	12750.9
1975	3661.2	11075.4	14736.6
1976	5028.8	11995.4	17024.1
1977	6213.7	12708.6	18922.3
1978	7528.6	13116.1	20644.7
1979	8879.7	13302.7	22182.4
1980	10221.9	12997.6	23219.5
1981	11302.4	13164.2	24466.7
1982	12294.8	13614.8	25909.7
1983	13240.6	14592.6	27833.2
1984	14295.2	14894.6	29189.8
1985	15434.6	15965.5	31400.1
1986	16677.7	17138.3	33816.0
1987	18078.9	17772.5	35851.4
1988	19424.6	18169.8	37594.4
1989	20761.6	19061.7	39823.3
1990	22107.8	19713.3	41821.1
1991	23363.9	20317.7	43681.6
1992	24592.3	20736.8	45329.0
1993	25813.8	20209.3	46023.1
1994	27110.2	20552.6	47662.8
1995	28010.9	23311.1	51322.0
1996	28931.6	23639.6	52571.2
1997	29851.9	24104.3	53956.2
1998	30712.0	24448.6	55160.6
1999	31616.3	24916.6	56532.9
2000	32535.0	25043.1	57578.1
2001	33453.8	25043.1	58496.9

*Includes expenditures for operations, regulation and monitoring, and research and development.

[41] The OMB recommends that agencies use a 7% discount rate as well as a 3% rate. While many agencies advocate the use of a 3% rate, which serves to deflate capital costs, it is unrealistic. The 7% rate much more closely reflects a realistic rate of return that businesses could earn on alternate investment projects.

In 2001 the total cost to federal, state, and local governments for water pollution regulation was $58.5 billion. As Table 4 shows, annual costs have been increasing throughout the entire 1972 to 2001 period, and this is due mostly to the fact that capital stock has been steadily increasing over that 30 year period, and so have operating costs. Beginning in 2002, the 1972 capital will be officially retired and no longer contributing to annualized costs. However, capital costs, and therefore total costs, will continue to climb, perhaps at a higher rate since retired capital must be replaced even as new capital investments continue. I make no attempt to model the rate of capital accumulation after the assumed capital life of 30 years expires. One reason is that the capital investment decision process of public facilities managers is not clear. They are generally budget-constrained, and may therefore choose to extend capital life, increasing maintenance costs, to avoid capital replacement, or substitute capital replacement for new capital investment. However, given EPA's assessment of capital expenditure needs to meet current wastewater treatment and pre-treatment standards,[42] it is a conservative assumption that capital expenditures should remain *at least* as high as their current level, and with all likelihood will increase significantly.

B. The Costs of Water Pollution Regulation to the Private Sector

The private sector bears significant costs from federal water pollution regulation. While governments bear the cost of wastewater treatment, natural resources management, such as wetlands conservation, nonpoint source runoff management and erosion control,[43] and of developing, implementing, and enforcing regulations, private businesses are faced with the costs of the NPDES. The NPDES permit system is, next to the wastewater treatment regulation and grant program, one of the keystones of the CWA. Indeed, as discussed earlier, permitting under the NPDES ensures that it is not legal to dump anything listed as a conventional, nonconventional, or toxic pollutant into a body of water without having a permit to do so and first following the prescribed treatment program. Decisions to approve or disapprove permits to release effluents affect the number of establishments in heavily regulated industries as well as the level of business activity in those sectors. Unfortunately those costs, which are likely large, cannot be estimated here.[44] I estimate costs in a manner similar to that employed above for government costs; that is using the reported expenditures from the PACE survey as a basis for calculating costs. While it misses some opportunity costs of regulation, this methodology carries the advantage of being straightforward and easy to understand and interpret: businesses are forced to spend funds on pollution control that would otherwise be invested in projects or distributed to

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[42] *Supra* note 10.

[43] It is not entirely accurate to say that government bears all of the costs of wetlands and nonpoint source management. The private sector bears the costs of restrictions to wetlands development, which is difficult to quantify but may be quite burdensome. Additionally, many private agricultural enterprises face costs from nonpoint source management, as do many forestry and mining industries. Some of these costs are reflected in the above estimates of private enterprise costs, but certainly not all. For instance, the discussion later of newly enacted Concentrated Animal Feeding Operations (CAFO) regulations on nonpoint source runoff dwarf all of the annual reported costs to agriculture in the *SCB* PACE summary data.

[44] See the cost estimates of Hazilla and Kopp (1990) for a general equilibrium estimate of lost GDP from water pollution regulation. Unfortunately the estimate of Hazilla and Kopp is becoming dated and does not reflect the large economic losses experienced during the era of high productivity growth in the latter half of the last decade.

stockholders, and in turn find their way back into the capital markets to be used productively.

1. Private Sector Capital Expenditures: 1972-1994

The *SCB* PACE summary reported business capital, operating, and research and development expenditures on pollution abatement from 1972 to 1994. Figure 5 below shows business expenditures on capital equipment used to meet water pollution regulatory requirements. Note that I include publicly owned electric utility (POEU) capital investment with private expenditures since those expenditures are most like

Figure 5.

private expenditures, which include expenditures by privately owned electric utilities facing the same constraints.[45]

Figure 5 shows that, unlike government capital expenditures, private capital expenditures rose immediately upon passage of the CWA and consequent effluent permitting. In fact, there is a sharp distinction between the level of expenditures over the first eight years under the CWA and the final fourteen years for which data are available. It appears that industries, given until July 1977 to meet "best practicable control technology," were more able to react to guidelines than were state and especially local governments, even with

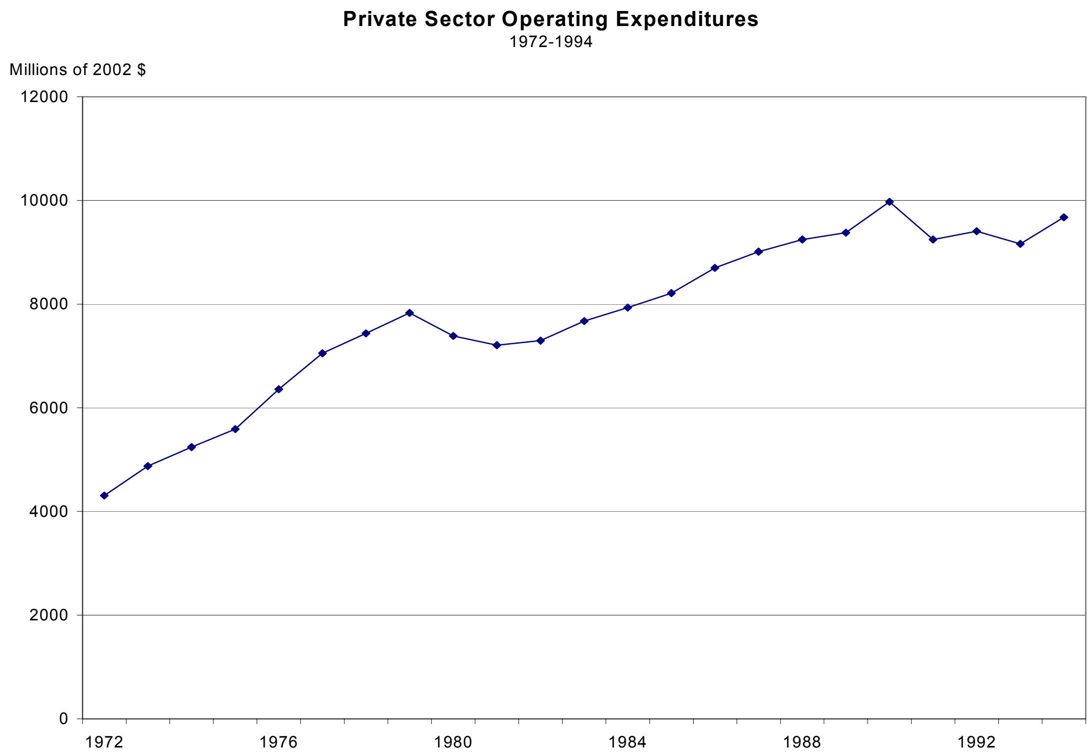
[45] The highest level of POEU capital expenditure was $160 million in 1982, which was 2% of total capital expenditure that year. In nearly every other year POEU expenditure was less than 1% of total expenditure.

federal grant monies. Indeed the highest recorded private sector real capital expenditure level occurred in 1977, totaling $12.7 billion. Expenditure levels fell after 1980 and remained at a roughly constant level thereafter displaying only minor cyclicality. From 1981 to 1994 the average expenditure level was $7.7 billion, with a standard deviation of only $567 million.

2. Private Sector Operating Expenditures: 1972-1994

Private sector businesses also incur expenditures to operate water pollution control capital. Figure 6 shows the private sector operating expenditures from 1972 to 1994.

Figure 6.

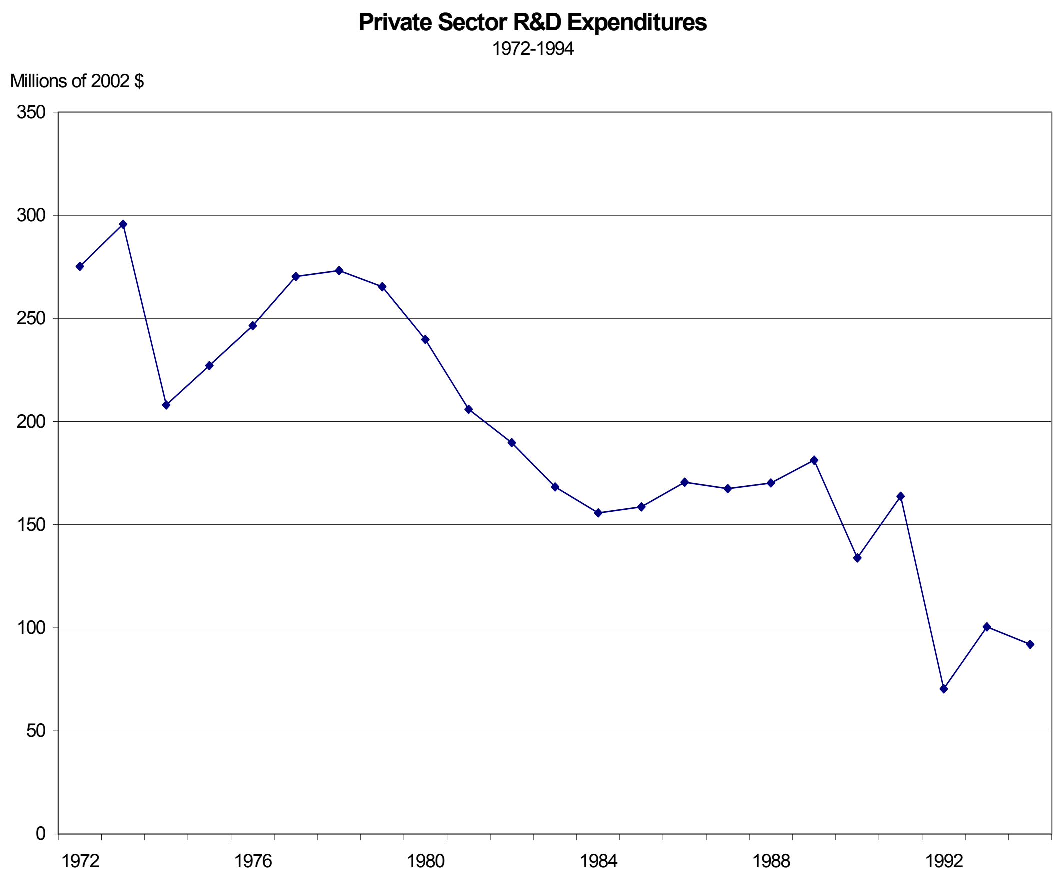


As with government sector operating expenditures, private sector operating expenditures climb steadily over the period as the capital stock increases. The minimum observed value is $4.3 billion in 1972, while the maximum is $9.9 billion in 1990. The average level over the period is $7.7 billion. There is nothing surprising about the operating expenditures series given the observed capital expenditures levels, save for the slight but significant flattening of expenditure growth after 1990.

3. Private Sector Research & Development Expenditures: 1972-1994

Unlike operating expenditures, which generally grew from year to year over the period of the PACE survey, R&D expenditures display an obvious downward trend. Except for some significant fluctuations at the beginning and end of the period, the downward trend is relatively steady, as shown in Figure 7.

Figure 7.



The highest level of private R&D was $295 million, occurring in 1973. The lowest level was $70 million in 1992. The average expenditure level over the period was $193 million. As noted earlier in the discussion of government R&D expenditures, with a centralized technology directive under the auspices of EPA, there is little incentive for even profit maximizers in the private sector to innovate. After all, even the development of a new technology would have to be approved by the regulatory forces before it could be implemented. Indeed, all firms emitting a given specified pollutant are required to use the Best Practicable or Available Technology for pollution control. Firms have an incentive to try to free ride off of the technology development of others since only one regulatorauthorized BAT or BPT will be sanctioned anyway. Therefore it is unlikely that any private sector firms, save for those that produce water pollution control technology and already enjoy a close relationship with EPA regulators, would invest in new technologies under the current regulatory regime.

4. Estimating Private Sector Expenditures for the 1995 to 2001 Period

After reviewing the *SCB* PACE summary data for the private sector for 1972 to 1994, the obvious question arises: how to estimate expenditures since that time to derive current costs of water pollution regulation. Using the *SCB* summary data, I employ ordinary least squares regression analysis to first estimate the 1972 to 1994 expenditures with exogenous variables, then to form predictions for the 1995 to 2001 period.

a) Capital Expenditures Estimation

As noted earlier, private sector capital expenditures appear to remain at a high annual level for the first few years after passage of the CWA then drop to a lower level. Within these two sub-periods there appears to be no significant or simple upward or downward trend, but given the small number of observations it is difficult to draw conclusions. After experimenting with a number of candidate regressor variables that could theoretically be correlated with capital spending, including real GDP, population, and manufacturing employment, real private water pollution capital expenditures seem to be poorly correlated with all of them. Furthermore, it is not practical to employ an estimation technique with a large number of explanatory variables due to the small sample size, only 23 observations, so a robust yet limited set of regressor variables is required.

Theoretically, since private businesses are constrained in their production procedures by the use of approved water treatment or effluent reduction technology, the use of that pollution reduction capital must be related to the use of productive capital. I estimated the following relationship:

$$\text{(Eq. 2)}\ \ln(WPK/K) = \underset{(2.40)}{9.253} - \underset{(3.53)}{0.807} \cdot \ln KStock - \underset{(3.37)}{0.296} \cdot \ln AAABond + \underset{(2.09)}{0.259} \cdot Early\,;$$

where *WPK/K* is the natural ratio of water pollution capital expenditures to total capital expenditures in a given year, *KStock* is the total U.S. industrial capital stock, *AAABond* is the interest rate on corporate bonds rated AAA by Moody's Investor Service, and *Early* is a dummy for the first seven years of CWA enforcement.[46] The continuous variables on both sides of Eq. 2 are entered in natural log form. The coefficients in Eq. 2 are estimated via ARMA with AR(1) and AR(2) terms and a first order moving average term to control for serial correlation of the error terms.[47] Z-statistics are shown in parentheses under each

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[46] Data for annual capital expenditures and total industrial capital stock are from the NIPA series Private Gross Nonresidential Fixed Investment. Available from the Bureau of Economic Analysis at (http://www.bea.gov)

[47] Visual inspection of the residuals from the OLS estimation of Eq.2 showed no obvious signs of heteroscedasticity, and indeed the results of a Cook-Weisberg test for heteroscedasticity failed to reject the null hypothesis of constant variance at any significance level.

estimated coefficient. The coefficients on the autoregressive terms were as follows (z-statistics in parentheses): AR(1): 1.19 (6.39) and AR(2): -0.69 (2.64). Eq. 2 was first estimated using Ordinary Least Squares and the Durbin-Watson test statistic of 1.03, indicating first order autocorrelation in the error terms. The ARMA regression returned a Durbin-Watson statistic of 1.90, which rejects the null hypothesis of correlated error terms at the 5% confidence level. Note that the percentage of water pollution capital to total capital, *WPK/K*, varied from 0.7% to 2.1%, with a mean of 1.2%, over the sample period.

The empirical results show that the ratio of water pollution capital expenditures to total industrial capital expenditures is decreasing in the level of total industrial capital stock. Thus the water pollution capital stock is growing at a lower rate than the total capital stock. This is an interesting result in and of itself, because it means that given the EPA regulatory regime wherein pollution permits are granted on the basis of meeting technological control requirements, pollution control investment does not match total industrial investment one-to-one. This result could arise from a shift over the sample period to greater investment in less regulated industries, while in regulated industries the ratio of water pollution capital to total capital remained constant. This in turn would mean that more regulated industries are growing less quickly than less regulated industries, at least from a capital investment standpoint. Another explanation is simply that there are economies of scale in water pollution capital, and therefore investment in productive capital has outstripped that in water pollution capital. This possibility has interesting implications for industry concentration in heavily regulated industries. Further exploration of this interesting topic would require more detailed data by closely defined industry than is currently available.

The interest rate on AAA corporate bonds also has a negative effect on the capital expenditures ratio. The AAA corporate bond rate is included as a proxy for the price of capital, and is expected to be negatively correlated with capital expenditures. It is interesting that the bond rate is negatively correlated with the ratio of water pollution to total industrial capital expenditure, as this indicates that water pollution control capital is more price elastic than total capital. Put another way, in the face of cheap prices for capital, firms will spend proportionally more on water pollution capital, but when capital prices are relatively expensive they will spend proportionally less.

After estimating Eq. 2, I used it to predict out-of-sample values for the ratio of water pollution capital expenditures to total capital expenditures. I then converted those figures into real water pollution capital expenditures using observed values of industrial capital expenditures. The predicted values were formed using only the structural coefficients of the ARMA regression, those on the selected predictor variables. Figure 8 below shows the observed values of water pollution capital expenditures for 1972 to 1994 from Figure 5 (solid line) alongside the fitted values from the model in Eq. 2 for 1972 to 2001 (broken line).

Figure 8.

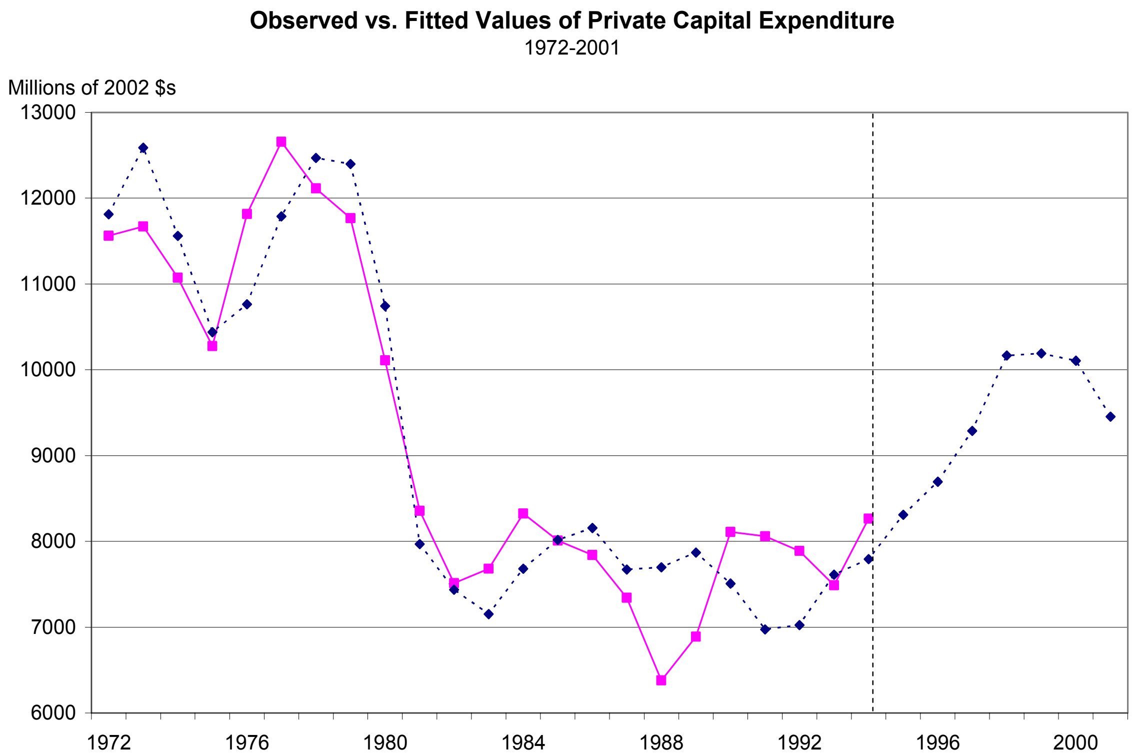


Figure 8 shows, the fitted values follow the observed values quite closely within the sample period. The fitted values do, however, appear to follow the observed values with a lag when the data reverse a local trend, and this seems to increase somewhat towards the end of the period. Due to the small sample size, the extensive use of lagged variables was not an option. Using a simple one period lag did not improve the results, likely because of the dropped degree of freedom. Thus, longer lag structures are out of the question.

Overall the model appears to predict the annual level of water pollution capital expenditures quite well. Furthermore, the out-of-sample predicted values seem reasonable in light of the prevailing trend in expenditures at the end of the sample period. Therefore the predicted values provide a useable approximation of private capital expenditures for constructing annualized cost estimates.

b) Operating Expenditures Estimation

As shown in Figure 6, private operating expenditures follow a strong upward trend similar to government sector operating expenditures. The obvious explanation for this is that expenditures for operating and maintaining capital increase as the capital stock increases. Therefore the most obvious explanatory variable for operating expenditures is the gross stock of pollution control capital.

The following model was estimated using the stock of pollution control capital:

(Eq. 3) $$\ln OE = \underset{(20.58)}{5.814} + \underset{(10.98)}{0.271} \cdot \ln WPKStock \;;$$

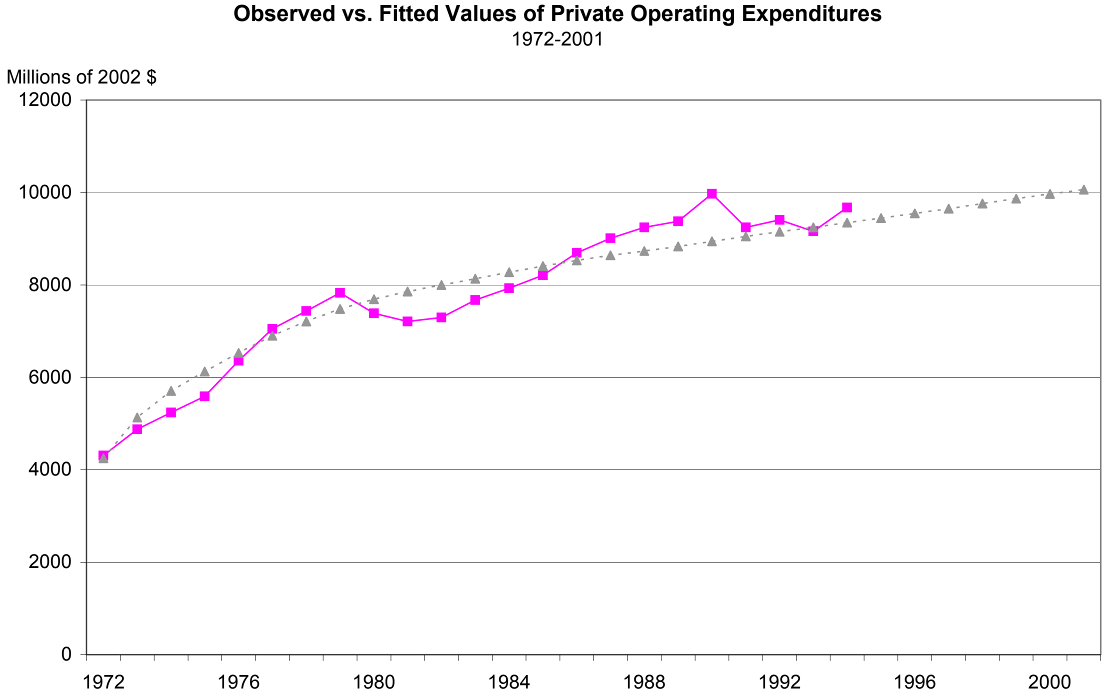
where ln*OE* is the natural log of private operating expenditure in a given year and ln*WPKStock* is the natural log of gross water pollution control capital stock in that year. T-statistics are shown in parentheses. As above, Eq.3 was estimated using the Prais-Winsten procedure to correct for serial correlation in the error terms. Interestingly, while in Eq.2 the adjusted R^2 statistic improved from 0.94 to 0.95, the adjusted R^2 value for the estimated model in Eq.3 improved from 0.95 to 0.99. Note that while operating expenditures are likely influenced by the price of inputs such as labor, I utilized only the capital stock variable in the model estimation due to the immense explanatory value of the simple model as evidenced by the high R^2.

Eq. 3 was used to produce fitted values for water pollution operating expenditures. For the in-sample fitted values, observed water pollution capital expenditures were used in the calculation, while for the out-of-sample fitted values the predicted values of capital expenditures from Eq. 2 were employed. As with government water pollution capital, a 30-year capital life was used for private capital in calculating the capital stock.

Figure 9 shows observed values of private water pollution operating expenditures for 1972 to 1994 from Figure 6 (solid line), and the fitted values for 1972 to 2001 (broken line). The fitted values indicate how well the model predicts operating expenditures. The estimated model has only one predictor variable, so the fitted values vary only if the predictor variable does. In this case, capital expenditures vary from year to year, so the annual change in water pollution capital stock is not linear, but is close to linear. Despite the smooth upward trend of the fitted variables, the only sub-periods when the observed values diverge are two short periods in the late 1970s and early 1990s when observed expenditures deviate from trend and the fitted values remain on trend.[48] The out-of-sample fitted values also appear to be relatively conservative predictions since the upward trend appears robust, as it should given a constantly growing capital stock.

[48] This indicates that the model may have an omitted variable that is responsible for the deviations. A Ramsey RESET test for omitted variable bias in the estimators was run, and the null hypothesis that there are no omitted variables could not be rejected at any standard confidence level. This does not indicate that there are no omitted variables that could better explain the data, but simply that the omission of said variable does not introduce bias in the estimators.

Figure 9.



c) Research and Development Expenditures Estimation

Private sector water pollution Research and Development (R&D) expenditures are rather small in magnitude when compared to capital and operating expenditures, particularly by the end of the sample period after decreasing for over twenty years. Nevertheless, they are an important component of total water pollution costs, if for no other reason than to highlight the perverse incentives codified in the federal command and control regulatory structure, where technology forcing induces massive investment and expenditure while spending on innovation is crowded out.

The following model is used to predict values for private water pollution R&D expenditures after the end of the sample period in 1994:

(Eq. 4) $$\underset{}{R\,\&\,D} = \underset{(7.57)}{342.07} + \underset{(2.24)}{0.0002249} \cdot IKE - \underset{(7.01)}{0.0000271} \cdot KStock\,;$$

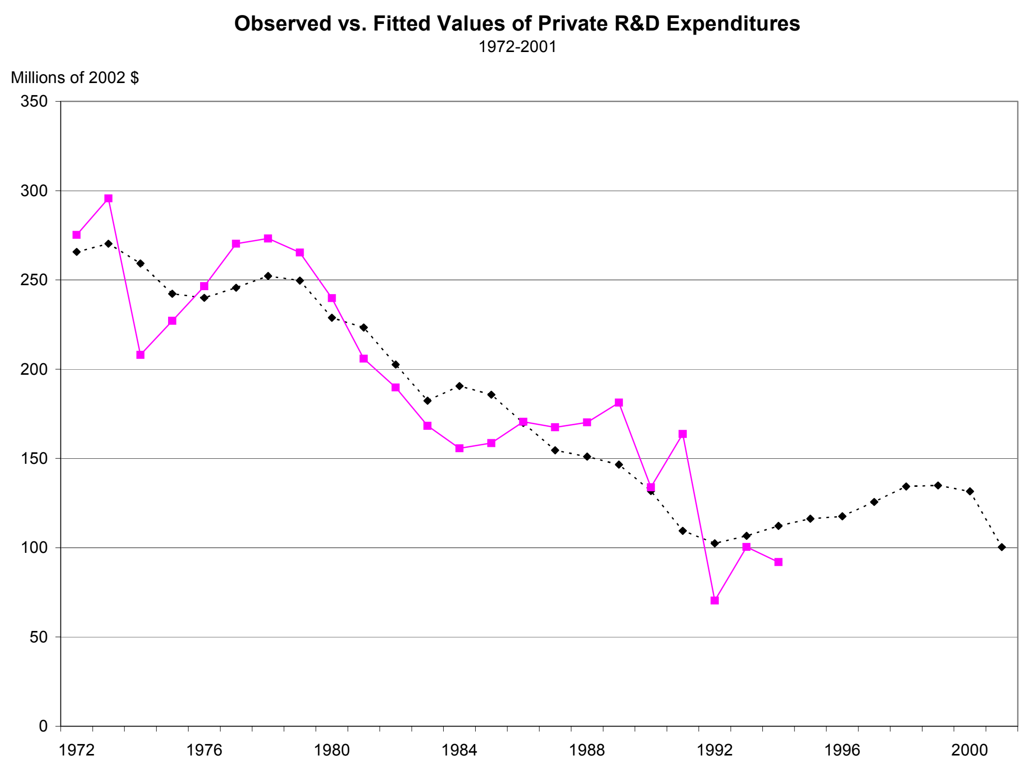
where *R&D* is private water pollution R&D expenditures, *IKE* is gross industrial capital investment, and *KStock* is the level of industrial capital stock. Again t-statistics are given in parentheses below each estimated coefficient. For Eq. 4, unlike the previous two cases, standard tests showed no serial correlation or heteroscedasticity in the residuals. The adjusted R^2 for this specification is 0.84. Note that Eq. 4 is linear and not a double log model as in Eq. 2 and Eq. 3. Unlike the previous cases the linear model specification yielded the best fit by a wide margin.

The interpretation of the coefficients in this case is straightforward. Water pollution R&D spending increases with capital expenditures at a rate of 0.02 cents per dollar. At the same time water pollution R&D expenditure decreases with the level of total industrial stock at a rate of 0.003 cents per dollar. This relationship dictates that water pollution R&D expenditure is initially increasing in capital expenditures then begins decreasing after the industrial stock reaches a high enough level to more than counteract the capital expenditure induced increase.

The observed relationship may indeed be merely spurious. Theoretically, standard R&D expenditures should be increasing in capital expenditures and capital stock. First, a larger capital stock denotes a larger economy, which is generally accompanied by more advanced technologies and higher value added production that relies on R&D. Second, as the capital stock increases over time and an economy matures, greater levels of R&D may be required for each new technology. The results here seem to indicate that water pollution R&D decreases in the total U.S. capital stock, which may be caused by a crowding out of water pollution R&D, since innovation brings little return on investment in the current regulatory regime.

Figure 10 shows the relationship of the fitted values for private water pollution R&D expenditures (broken line) against the observed values (solid line) carried over from Figure 7.

Figure 10.



Note that the fitted values follow the observed values relatively closely during the in-sample period, save for the years when large oscillations seem to occur near the beginning and end of the sample. Additionally, the out-of-sample predicted values seem relatively conservative and make intuitive sense.[49] It is unlikely that water pollution R&D expenditure would bottom out at zero as long as annual expenditures on water pollution capital continue and firms are producing this capital, so the observed downward trend must have a boundary. The predicted values place that boundary somewhere near the $100 million a year mark.

5. Annualized Costs of Private Water Pollution Control

Table 5 below shows real private capital, operating, and R&D expenditures from 1972 to 2001. The values for 1972 to 1994 come from the PACE survey series, while the figures for 1995 to 2001 come from the three series of predicted values above.

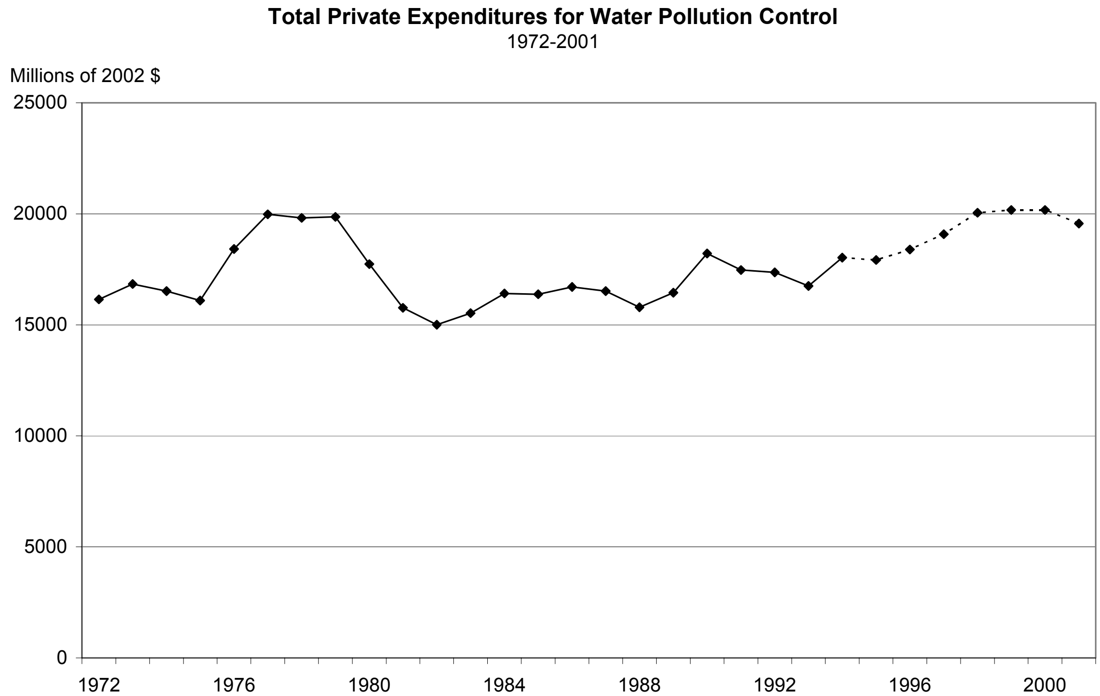
[49] Other specifications with higher R^2 values were estimated using private water pollution capital and operating expenditures as predictors. In all cases the out-of-sample fitted values quickly dropped into negative territory, which is impossible and makes little sense as noted in the discussion in the body of the text.

Table 6. Private Capital, Operating, and R&D Expenditures
(1972-2001)

Year	Capital	Operating	R&D	Total
1972	11562.7	4308.6	275.2	16146.5
1973	11672.1	4876.2	295.7	16844.0
1974	11074.1	5241.4	208.1	16523.6
1975	10277.2	5587.8	227.1	16092.1
1976	11815.2	6357.9	246.5	18419.6
1977	12658.1	7050.8	270.3	19979.2
1978	12113.6	7435.4	273.2	19822.3
1979	11767.6	7829.4	265.4	19862.3
1980	10110.8	7385.8	239.8	17736.5
1981	8355.6	7209.2	205.9	15770.7
1982	7514.4	7296.8	189.7	15000.9
1983	7681.6	7674.4	168.3	15524.4
1984	8326.5	7932.1	155.7	16414.2
1985	8011.0	8213.1	158.7	16382.7
1986	7840.8	8698.6	170.6	16710.0
1987	7342.3	9012.3	167.5	16522.1
1988	6381.0	9247.7	170.2	15798.9
1989	6890.4	9378.6	181.3	16450.5
1990	8111.6	9973.3	133.9	18218.8
1991	8061.2	9246.6	163.7	17471.5
1992	7888.6	9406.7	70.4	17365.8
1993	7489.6	9162.4	100.4	16752.4
1994	8264.3	9675.2	92.0	18031.4
1995	*8310.4*	*9446.1*	*116.2*	*17872.7*
1996	*8695.6*	*9546.6*	*117.6*	*18359.8*
1997	*9288.0*	*9650.7*	*125.7*	*19064.4*
1998	*10166.1*	*9761.0*	*134.3*	*20061.4*
1999	*10191.0*	*9868.2*	*134.8*	*20094.0*
2000	*10107.3*	*9971.4*	*131.5*	*20210.2*
2001	*9455.0*	*10065.1*	*100.3*	*19620.4*

The figures shown in italics, all of those from 1995 to 2001, are estimated using the models in Eqs. 2 through 4. Total expenditures are shown in Figure 11 below.

Figure 11.



Total private expenditures are rising in the post-1994 period, mostly due to predicted rises in operating expenses required as the capital stock grows. Capital expenditure remains largely unchanged from the in-sample period. Importantly total expenditures range between $15 and $20 billion annually over the entire 30 year period. Only in the late 1990s do expenditures reach the level of the late 1970s when capital expenditures peaked before dropping precipitously in the early 1980s. In 2001 I estimate expenditures at $19.6 billion, and it is not unreasonable to believe that expenditures will remain at least at this level into the foreseeable future on the conservative end, or more likely increase. Assuming a capital life of 30 years as with government capital, replacement of early period capital purchases began in 2002, which should raise total capital expenditures as both new and replacement capital must be purchased.

To transform expenditures to annualized costs, I again employ Eq. 1 to capitalize annual capital expenditures, which I then sum with other annual expenditures to form estimates of annual costs. Table 6 shows capitalized expenditures, other expenditures, and the sum, total private sector costs.

Table 7. Annual Capital Costs and Total Private Water Pollution Costs
(Millions of 2002 $)

Year	Capital Cost	All Other Costs*	Total Annual Cost
1972	931.8	4583.8	5515.6
1973	1872.4	5171.9	7044.3
1974	2764.8	5449.5	8214.3
1975	3593.0	5814.9	9408.0
1976	4545.2	6604.4	11149.6
1977	5565.3	7321.1	12886.3
1978	6541.4	7708.7	14250.1
1979	7489.8	8094.7	15584.5
1980	8304.6	7625.6	15930.2
1981	8977.9	7415.1	16393.0
1982	9583.5	7486.5	17070.0
1983	10202.5	7842.7	18045.2
1984	10873.5	8087.8	18961.2
1985	11519.1	8371.7	19890.8
1986	12150.9	8869.1	21020.1
1987	12742.6	9179.8	21922.4
1988	13256.8	9417.9	22674.8
1989	13812.1	9559.9	23372.0
1990	14465.8	10107.1	24572.9
1991	15115.4	9410.3	24525.7
1992	15751.1	9477.1	25228.3
1993	16354.7	9262.8	25617.5
1994	17020.7	9767.1	26787.8
1995	17690.4	9562.3	27252.7
1996	18391.2	9664.2	28055.4
1997	19139.6	9776.4	28916.0
1998	19958.9	9895.3	29854.2
1999	20780.1	10003.0	30783.1
2000	21594.7	10102.9	31697.6
2001	22356.6	10165.4	32522.0

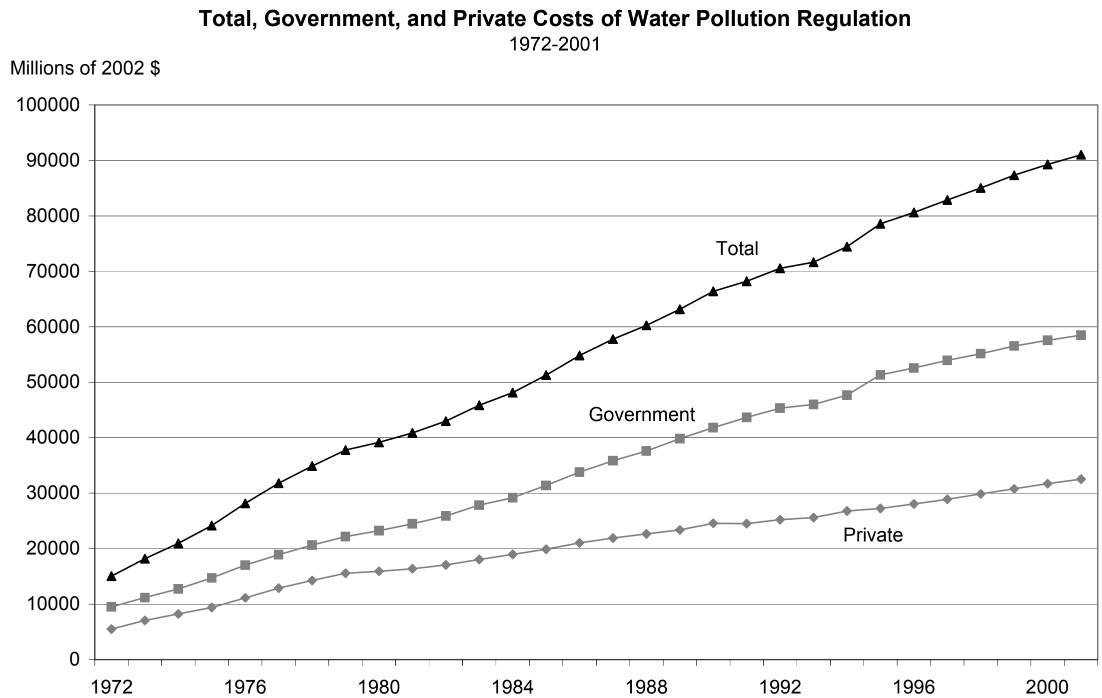
*Includes Operating and R&D expenditures.

Total costs for private water pollution control as estimated using the PACE expenditures survey data were $32.5 billion in 2001.

C. Government and Private Sector Annual Costs

Figure 12 shows government sector annual costs, private sector annual costs, and total costs, the sum of the two, as estimated from the PACE survey data from 1972-2001.

Figure 12.



As shown above, total costs as calculated via the PACE survey expenditure data increase steadily over the thirty years from 1972 to 2001. Real total costs were $15 billion in 1972 and had grown to $91 billion by 2001. The average annual rate of growth in total costs was 6.2%. In comparison, real GDP grew by an average annual rate of 2.9% over the same period.

As noted previously, the water pollution capital stock, and therefore the annualized cost of capital, was growing throughout the period and contributed much of the growth in costs. Operating costs, the second largest cost component, grew throughout the period as well since the primary determinant of operating costs is the level of water pollution capital stock. Total costs may begin rising in the near future as old capital begins to wear out and need replacement. However, this is not certain as capital budget constraints may simply force firms and governments to forego new capital investments in favor of replacing old capital. Future trends in capital expenditure are almost the sole determinant of future costs and the growth or decline in costs. At present it is difficult to imagine a scenario in which costs decline due to a reduction in annual capital expenditure levels. Indeed, EPA issued a report that indicates a need for increased government capital expenditure according to their criteria.[50]

As indicated above, the real costs of water pollution control grew at an average rate almost twice that of the growth in real GDP. This implies that water pollution control is a luxury good, with demand rising more than proportionately with income. Given that real GDP and real *per capita* incomes are likely to continue growing at a respectable rate into the foreseeable future, as long as the observed trend of high income elasticity of demand for water pollution control continues, costs will also continue to grow. Of course, referring to the observed levels of water pollution control investment as "income elastic" implies that the quantity of this good is market-determined. This is clearly not the case, at least not in a pure sense. The level of water pollution control is largely determined by government regulation, which distorts market-based incentives. Nevertheless, it is unlikely that the trend in government environmental regulation will reverse in the near future, especially in light of the influence that environmental interests have on regulatory outcomes.

Perhaps the most important reason to believe that water pollution costs will continue increasing into the future is the level of regulatory activity in EPA. In Section II, I discussed the history of the CWA and the regulations promulgated under its auspices. Regulatory activity steadily increased over the 1972 to 2002 period. The 1972 CWA had an increasingly tight set of technological requirements for the private sector and government sector. The 1977 amendments increased the number of toxic contaminants covered, and the 1987 amendments expanded federal regulation of nonpoint sources of water pollution. New issues such as TMDLs, a potential source of massive costs for state and local governments as well as the private enterprises, are currently being discussed.

All of the new regulatory edicts that went into effect prior to 1994 are included in the PACE survey data, in as far as they were included in the expenditure survey instrument. However, significant new regulations and programs since 1994 are not reflected in the PACE data or the projections I made using that data. The following section reviews these recent regulations.

D. The Costs of Water Pollution Regulation post-1994

EPA has issued a number of significant water pollution regulations under the CWA since 1994. None of the costs emanating from these regulations are included in the cost estimates above because they are not reflected in the PACE expenditure survey instrument. In order to form a more complete picture of total costs it is important to include as much available cost information as possible.

Due to the lack of an expenditure data series, such as the PACE data that incorporates these newer regulations, an alternative cost estimate must be employed. Increasing pressure for regulatory scrutiny has led to a number of executive and legislative branch mandates requiring economic impact studies by regulatory agencies. While the economic impact analyses performed by agencies to justify new regulation include a wider range of

[50] *Supra* note 10.

costs than expenditure surveys, the quality of individual impact analyses varies.[51] For post-1994 regulatory costs, I use the Regulatory Impact Analyses (RIAs) prepared by EPA, reviewed by OMB, and published, at least in summary, in the Federal Register upon promulgation of a final rule.

The following major regulatory programs extended the scope and reach of EPA water regulation between 1994 and 2002.

1. Water Quality Standards: Great Lakes & Bay and Delta

In 1995 EPA issued two sets of "guidance" standards dealing with water pollution issues in certain specific water bodies. These programs establish water quality management and monitoring requirements. The Office of Management and Budget (OMB) recently revised the cost estimates of these and other major regulations issued from 1992 to 2002 in its 2003 *Report to Congress on the Costs and Benefits of Regulations and Unfunded Mandates on State, Local and Tribal Entities*[52]. The most significant of these was for the Great Lakes water system (60FR15365). OMB estimated the costs of the Great Lakes program at between $74 and $420 million annually. The Bay/Delta Water Quality Standards program was similar, and carried an annual cost of between $38 and $253 million (60FR4663). Combined, these two water quality standards programs cost between $112 and $673 million each year. Because these costs are related to water quality standards programs, they fall on individual states that are responsible under the CWA for establishing, monitoring, and enforcing these standards.

2. Pulp and Paper Effluent Guidelines

EPA revised its effluent guidelines for the pulp and paper industry in 1998, and in the same rule re-established air quality standards for the same industry (63FR18503). The marginal cost increase to the pulp and paper industry over the existing guidelines was estimated by EPA at $310 million annually. Naturally these costs fall primarily on the pulp and paper industry and ultimately on the users and consumers of their products.

3. Storm Water Discharges

As discussed above in Part II, Section C, Sub-section 3, EPA issued Phase II Storm Water Discharge permitting standards in late 1999 (64FR68721). It estimates that this extension of the storm water discharge permit system to small municipalities and designated industries imposes an annual cost burden of $932 million to $1.08 billion. These costs fall

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[51] For more discussions of the quality of different regulatory analyses, see Mercatus comments on individual regulatory impact analyses and on OMB's annual reports to Congress utilizing agency estimates, such as: Susan Dudley and Brian Mannix comment on "The Office of Management and Budget's Draft Guidelines for the Conduct of Regulatory Analysis and the Format of Accounting Statements, May 5, 2003. Available at (http://www.mercatus.org/regulatorystudies/article.php/314.html). See also, Dudley and Mannix comment on "The Office of Management and Budget's Draft 2003 Report to Congress on the Costs and Benefits of Federal Regulation," April 29, 2003. Available at (http://www.mercatus.org/regulatorystudies/article.php/309.html)

[52] http://www.whitehouse.gov/omb/inforeg/2003_cost-ben_final_rpt.pdf

on the regulated entities, the majority of which are smaller municipalities with populations under 100,000 persons.

4. CAFO

The particulars of the CAFO regulations recently issued by EPA in 2003 (68FR7175) are outlined in Part II, Section C, Sub-section 2 above. These regulations replace existing regulations that EPA believed were not aggressive enough in limiting CAFO discharges that are a primary contributor to nonpoint source water pollution from the agricultural sector. EPA estimates the annualized cost of these new permitting requirements at $360 million. These costs fall primarily on the CAFO operators, large and small, who will now be required to obtain permits. These costs began accruing in 2003, and so are not reflected in the cost estimates through 2002 shown in this report, but do figure in the cost projections in the conclusion.

5. TMDLs

One of the most controversial, and potentially costly, water pollution issues is the Total Maximum Daily Load program, as discussed in Section II.C.1, above. The TMDL rule that EPA released in 2000 was withdrawn in 2003, and EPA is expected to propose a new rule or revert to the existing TMDL rule. The rule proposed in 2000 would have cost the states at least $1 to $4.6 billion annually, and possibly significantly more. Because the future of the TMDL program is unclear, I do not include any TMDL costs in the cost estimates shown.

E. The Total Costs of Water Pollution Regulation: 1972-2001

In Table 8 below, I add the costs of regulations issued after 1994 to the costs to the government and private sector of water pollution regulation from Tables 4 and 7:

Table 8: The Total Costs of Water Pollution Regulation: 1972-2001
(Millions of 2002 $)

Year	Government and Private Costs from Tables 4 and 7	Additional 1994-2001 Costs*	Total Cost
1972	15040.9	--	15040.9
1973	18208.2	--	18208.2
1974	20965.1	--	20965.1
1975	24144.6	--	24144.6
1976	28173.7	--	28173.7
1977	31808.6	--	31808.6
1978	34894.8	--	34894.8
1979	37766.9	--	37766.9
1980	39149.7	--	39149.7
1981	40859.7	--	40859.7
1982	42979.6	--	42979.6
1983	45878.4	--	45878.4
1984	48151.1	--	48151.1
1985	51290.9	--	51290.9
1986	54836.1	--	54836.1
1987	57773.8	--	57773.8
1988	60269.1	--	60269.1
1989	63195.3	--	63195.3
1990	66394.0	--	66394.0
1991	68207.3	--	68207.3
1992	70557.3	--	70557.3
1993	71640.6	--	71640.6
1994	74450.6	--	74450.6
1995	78579.0	673	79252.0
1996	80633.3	673	81306.3
1997	82880.7	673	83553.7
1998	85022.5	983	86005.5
1999	87322.1	983	88305.1
2000	89279.1	2063	91342.1
2001	91018.0	2063	93081.0

*I use the upper bound of EPA estimates as my point estimate of costs.

V. Conclusion

The costs of water pollution control regulations to American businesses, state and local governments, and ultimately consumers and taxpayers under the Clean Water Act are considerable. In 2001, expenditures on capital equipment, operations and maintenance, and other items totaled $56 billion, with 65 percent of that borne by state and local governments and the remaining 35 percent by businesses. Because a significant portion of yearly expenditures are on capital equipment with a significant useful life of operations, it is appropriate to annualize expenditures to reflect both current cash outlays and the portion of capital used up during the year (depreciation) as well as the opportunity cost of capital expenditure. Annualization yields a cost of $93.1 billion in 2001.

The annual cost of water pollution control is growing at a substantial rate. The annualized costs based on PACE expenditure data grew at an average rate of 6.2% per year over the 1972 to 2001 period. As Figure 12 depicts, costs have been increasing at a steady, nearly linear, rate, whereas a constant growth rate would appear as an upward-turning curve. This indicates that the rate of growth is slowing over time. If we concentrate on the 1992 to 2001 period, the average annual growth rate is only 2.6%. Applying this lower annual growth rate, and adding the annualized cost of newer regulations to the PACE-based projections, the cost of water pollution regulation in 2002 was approximately $95.5 billion. By 2005 costs will reach nearly $104 billion, and by 2010 will increase to $118 billion.

Furthermore, there is reason to believe that cost projections based on PACE data in Table 8 and recently enacted regulations understate the true costs of water pollution control. First, capital expenditures will have to increase as the existing capital stock, particularly for public water treatment facilities, will start to be retired. Much of the capital specifically dedicated to meeting CWA requirements is nearing the end of its useful life. Second, new regulatory requirements that carry significant expenditures are increasing. In fact, it is likely that the average compliance cost of individual regulations might be increasing over time. In the early period it usual for regulations to target "low-hanging fruit," those pollution issues that yield the highest visible benefits for the lowest costs. Over time, the flow of regulations does not decline, and often increases, while regulatory issues become more complex and require significantly higher costs to yield ever-smaller benefits. It is not clear that EPA has yet reached that point with respect to water regulation. However, if EPA implements the TMDL program announced in 2000, it alone will add nearly $5 billion annually in costs. This one regulatory program would have constituted a 5 percent increase in water pollution regulatory costs in 2001.

Water pollution control through federal regulation carries enormous costs for Americans. These costs, while nominally paid by state and local governments and businesses, are ultimately a tax on the American economy and consumer. Literally, the need for state and particularly local governments to meet ever tightening regulations for water and sewage treatment means that revenues must be raised through higher taxes. Whether these tax revenues are assessed locally or nationally through grant programs is irrelevant, they still place a burden on the American economy. The costs faced by the business sector are also taxes, though more hidden. They raise the price of goods and services, reduce employment in affected industries, and displace smaller businesses that cannot compete in an environment of elevated costs. It is important to note that the cost calculated above, $93.1 billion in 2001, represents only the direct, expenditure-based portion of the true costs. When the economic costs of lost jobs, lost GDP, and inefficient allocations of resources are included, the costs could be staggering.

References

Academy of Natural Sciences "The Clean Water Act: Thirty Years Later." http://www.acnatsci.org/research/kye/articles.html.

Arnold, F. *Economic Analysis of Environmental Policy and Regulation.* New York: John Wiley and Sons, 1995.

Blacklocke, Sean. "EPA's National Pollutant Discharge Elimination System Permit Regulations and Effluent Limitation Guidelines and Standards for Concentrated Animal Feeding Operations." Mercatus Center, Public Interest Comment RSP 2001-11. Available from the World Wide Web: (http://www.mercatus.org/regulatorystudies/article.php/70.html)

Buchanan, James M. *Cost and Choice: An Inquiry in Economic Theory*. Chicago: Rand McNally, 1969.

Carriker, Roy R. "Wetlands and Environmental Legislation Issues." *Journal of Agriculture and Applied Economics* 26 (1994) : 80-9.

Crain, W. Mark and Thomas D. Hopkins. "The Impact of Regulatory Costs on Small Firms." Washington: Small Business Administration, SBAHQ-00-R-0027, 2001.

Copeland, Claudia. "Clean Water Act: A Summary of the Law." Washington: Congressional Research Service, IB89102, 1999.

______. "Water Quality: Implementing the Clean Water Act." Washington: Congressional Research Service Report, No. RL 30030, 2002.

Denison, E. F. *Accounting for Slower Economic Growth: The United States in the 1970s*. Washington: The Brookings Institution, 1979.

Dudley, Susan E. Comment on "Proposal to Issue and Modify Nationwide Permits (Wetlands)." Mercatus Center, Public Interest Comment RSP 1998-03, November 30, 1998. Available from the World Wide Web: (http://www.mercatus.org/regulatorystudies/article.php/121.html)

Dudley, Susan E. and Brian F. Mannix. Comment "The Office of Management and Budget's Draft Guidelines for the Conduct of Regulatory Analysis and the Format of Accounting Statements. Mercatus Center Public Interest Comment RSP 2003-13, May 5, 2003. Available from the World Wide Web: (http://www.mercatus.org/regulatorystudies/article.php/314.html)

_____. Comment on "The Office of Management and Budget's Draft 2003 Report to Congress on the Costs and Benefits of Federal Regulation." Mercatus Center Public Interest Comment RSP 2003-11, April 29, 2003. Available from the World Wide Web: (http://www.mercatus.org/regulatorystudies/article.php/309.html)

Executive Order 12866. Regulatory Planning and Review. Washington: Federal Register, 58 FR 51735 (1993). Available from the World Wide Web: (http://www.epa.gov/fedrgstr/eo/eo12866.htm)

Fraas, Arthur G. and Vincent G. Munley. "Economic Objectives within a Bureaucratic Decision Process: Setting Pollution Control Requirements Under the Clean Water Act." *Journal of Environmental Economics and Management* 17 (1989) : 35-53.

Freeman, A. Myrick. "Water Pollution Policy" in *Public Policies for Environmental Protection,* P. Portney and R. N. Stavins, editors. Washington, D.C.: Resources for the Future, 1990.

Gray, Wayne. "The Cost of Regulation: OSHA, EPA and the Productivity Slowdown." *American Economic Review* 77 (1987) : 998-1006.

Hahn, Robert W. "Regulatory Reform: What Do the Government's Numbers Tell Us?" in *Risks, Costs, and Lives Saved: Getting Better Results from Regulation*, edited by Rowert W. Hahn. New York: Oxford University Press and AEI Press, 1996, 208-53.

______ and John A. Hird. "The Costs and Benefits of Regulation: Review and Synthesis." *Yale Journal on Regulation* 8 (1990) : 233-78.

Hall, J. V. "The Theoretical and Empirical Basis for Assessing Economic Impacts of Environmental Regulation," in *Advances in the Economics of Environmental Resource*s, edited by D. C. Hall. New York: JAI Press, Inc., 2 (1997) : 13-37.

Harrington, Winston, Richard D. Morgenstern, and Peter Nelson. "On the Accuracy of Regulatory Costs Estimates." *Journal of Policy Analysis and Management*, Vol. 19, 2 (2000) : 297-322.

Hazilla, Michael and R. Kopp. "The Social Cost of Environmental Quality Restrictions: A General Equilibrium Analysis." *Journal of Political Economy* 98,4 (1990) : 853-73.

Hopkins, Thomas D. "Regulatory Costs in Profile," Policy Study No. 132. Center for the Study of American Business, August 1996.

______. *Profiles of Regulatory Costs. Report to the US Small Business Administration*. Washington: U.S. Department of Commerce, National Technical Information Service #PB96 128038, November 1995.

Huber, Peter. "Exorcists vs. Gatekeepers in Risk Regulation." *Regulation*, November/December (1983) : 23-32.

Jaffe, Adam B., S. Peterson, P. Portney, and R. Stavins. "Environmental Regulation and the Competitiveness of U.S. Manufacturing." *Journal of Economic Literature*, Vol. 33, 1 (1995) : 132-163.

Johnson, Joseph M. Comment on "The National Costs of the Total Maximum Daily Load Program (Draft Report)." Mercatus Center, Public Interest Comment RSP 2001-7, December 11, 2001. Available from the World Wide Web: (http://www.mercatus.org/regulatorystudies/article.php/66.html)

Jorgensen, Dale W. *Growth, Vol. 2: Energy, the Environment, and Economic Growth*. Cambridge and London: MIT Press, 1998.

Jorgensen, Dale W. and Peter J. Wilcoxen. "Environmental Regulation and U.S. Economic Growth." *Rand Journal of Economics* 21, 2 (1990) : 314-40.

Kohn, R. E. "Efficient Scale of the Pollution-abating Firm." *Land Economics* 64, 1 (1988) : 53-61.

Litan, R. and W. Nordhaus. *Reforming Federal Regulation*. New Haven: Yale University Press, 1983.

Luken, Ralph A., F. Reed Johnson, and Virginia Kibler. "Benefits and Costs of Pulp and Paper Effluent Controls Under the Clean Water Act." *Water Resources Research* 28 (1992) : 665-74.

Lyon, Randolph M. and Scott Farrow. "An Economic Analysis of Clean Water Act Issues." *Water Resources Research* 31 (1995) : 213-23.

Meiners, Roger and Bruce Yandle. "Constitutional Choice for the Control of Water Pollution." *Constitutional Political Economy* 3 (1992) : 359-80.

_____. Comment on "The Environmental Protection Agency's Proposed Changes to the Total Maximum Daily Load (TMDL) Program, to the National Pollution Discharge Elimination System (NPDES), and Water Quality Standards (WQS)" January 20, 2000, RSP 2000-1. Available from the World Wide Web: (http://www.mercatus.org/regulatorystudies/article.php/104.html)

Peltzman, Sam. "Toward a More General Theory of Regulation." *Journal of Law and Economics* 19, 2 (1993) : 211-40.

Regulatory Flexibility Act, United States Code, Title 5, Section 605, Washington, D.C., 1980.

Rivers, Mary-Jean and Barbara M. Yates. "City Size and Geographic Segmentation in the Municipal Bond Market." *Quarterly Review of Economics and Finance* 37, 3 (1997) : 633-45.

Rothfelder, Marty. "Reducing the Cost of Water Pollution Control under the Clean Water Act." *Natural Resources Journal* 22 (1982) : 407-21.

Schmalensee, Richard. "The Costs of Environmental Protection" in *Balancing Economic Growth & Environmental Goals*. Washington, D.C.: American Council for Capital Formation, 1994, 57-61.

Simmons, Daniel. "Comment on the Definition of Navigable Waters in Light of SWANCC," Mercatus Center Public Interest Comment, RSP 2003-15, April 16, 2003. Available from the World Wide Web: (http://www.mercatus.org/regulatorystudies/article.php/291.html)

Simonsen, Bill, Mark D. Robbins, and Lee Helgerson. "The Influence of Jurisdiction Size and Sale Type on Municipal Bond Interest Rates: An Empirical Analysis." *Public Administration Review* 61, 6 (2001) : 709-17.

Stigler, George. "The Economic Theory of Regulation." *Bell Journal of Economic and Management Sciences* 2, 1 (1971) : 3-21. Available from the World Wide Web: (http://www.ipcreators.org/pdf-files/Stigler%20on%20regulation.pdf)

U.S. Bureau of the Census, Bureau of Economic Analysis. "Pollution Abatement and Control Expenditures, 1972–94." *Survey of Current Business*, Vol. 76, Washington, D.C., 1996.

U.S. Bureau of the Census. *Government Finance*. Washington, D.C., various years.

U.S. Council on Environmental Quality. *Environmental Quality-1979: The Tenth Annual Report of the CEQ*. Washington, D.C., 1979

U.S. Environmental Protection Agency. "Environmental Investments: The Cost of a Clean Environment." EPA, 230-11-90-083, Washington, D.C., 1990.

U.S. Environmental Protection Agency. *1996 Clean Water Needs Survey Report to Congress*. EPA832/R-97-003, Washington, D.C., 2001.

U.S. Environmental Protection Agency. *The National Costs of the Total Maximum Daily Load Program (Draft Report)*. EPA 841-D-01-003, Washington, D.C., 2001.

U.S. Environmental Protection Agency. "A Retrospective Assessment of the Costs of the Clean Water Act: 1972 to 1997." EPA Contract No. 67-W7-0018, Washington, D.C., 2000.

U.S. Environmental Protection Agency. "A Benefits Assessment of Water Pollution Control Programs Since 1972: Part 1, The Benefits of Point Source Controls for Conventional Pollutants in Rivers and Streams." EPA Document No. 68-C6-0021, Washington, D.C., 2000.

U.S. Office of Management and Budget, Office of Information and Regulatory Affairs. *Report to Congress on the Costs and Benefits of Federal Regulations,* Washington, D.C., various years 1996-2003.

Weidenbaum, Murray and Robert DeFina. "The Cost of Federal Regulation of Economic Activity." Washington, D.C.: American Enterprise Institute, May 1978.

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