Online Appendix: Consequences of the Clean Water Act and the Demand for Water Quality

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[1]We thank Olivier Deschenes for providing the weather data and Michael Greenstone for providing the 1972-1977 nonattainment data.

A Expenditure on Water Pollution Abatement

This Appendix reviews available data on expenditures for abating water pollution and air pollution. Measuring such expenditures is difficult. The first attempt by the Bureau of Economic Analysis (BEA) to measure pollution abatement costs describes five challenges (Cremeans and Segel 1975) including determining counterfactual pollution abatement; the problem that many abatement technologies also have valuable byproducts; the proper classification of capital goods used for abatement; the difficulty in recognizing business decisions as environmental or not; and the separation of pollution abatement expenditures from expenditures for industrial safety and related purposes. These are only accounting challenges; an additional challenge is that even correct accounting measures do not equal full economic costs. Our goal is simply to describe available estimates, recognizing these caveats.

We consider three sets of estimates: BEA annual accounts for the period 1972-1994; Census abatement cost surveys for manufacturing combined with EPA expenditure records for government; and EPA reports on the costs of the Clean Water Act and Clean Air Act. All three methods suggest that total expenditure on water pollution abatement since the Clean Water Act has exceeded $1 trillion ($2014), which is over $100 per person-year, or equivalently, annual expenditure just over half a percent of GDP. All three methods also imply that expenditure on water pollution abatement has exceeded expenditure on air pollution abatement.

The first set of estimates comes from the Bureau of Economic Analysis (BEA) for the years 1972-1994 (Vogan 1996).[2] The BEA estimates aggregate expenditure on water pollution abatement in the period 1972-1994 of $1.3 or $1.4 trillion ($2014) when deflated using quantity or price indices, respectively. Private business accounts for two-thirds of these expenditures, and government for the remaining one-third. The BEA data report total air pollution abatement expenditures at $1.0 to $1.4 trillion ($2014) using quantity or price indices, respectively, including expenditures by private households (e.g., for vehicles). This indicates that water pollution abatement expenditures exceed air pollution abatement expenditures by 6 to 27 percent.

The second set of estimates comes from the Census Bureau for private industry and EPA for government sources. The Census conducted the Pollution Abatement Costs and Expenditures survey annually between 1972 and 1994. We sum capital and operating costs from this survey, and linearly interpolate for the year 1987 (which had no survey). These data indicate total 1973-1994 abatement expenditures of $315 billion for water pollution abatement and $338 billion for air pollution abatement ($2014). These numbers include only the manufacturing sector. Our EPA data on the construction grants program indicate that local governments spent about $215 billion in federal grant funds, supplemented by local expenditures, and a federal Revolving Loan fund.[3]

The third set of estimates is from EPA reports on the costs of the Clean Air and Clean Water Acts (USEPA 1997, 2000). In 1990, the compliance cost of the Clean Air Act was about $25 billion ($1990). In 1994, the cost of water pollution abatement was $44.6 billion ($1997), though $32 billion of this would have been spent even without the Clean Water Act. These reports provide no evidence on trends in these numbers. Under the strong assumption that they had been constant over the period 1972-2001, they imply costs of $2.5 trillion

[2]The BEA reports both quantity and price deflators indexed to 1992. We deflate all BEA values to 1992. For comparability with the rest of the paper, which reports figures in 2014 dollars, we then deflate these values to the year 2014 using the 1992 and 2014 Construction Price Index of Engineering News Records.

[3]A study by the U.S. Conference of Mayors (Anderson 2010) estimates that local governments spent $1.4 trillion ($2008) on wastewater treatment between 1956 and 2008. Another estimate of these expenditures is a report by the Congressional Budget Office (CBO 1985) which reports that total annual wastewater spending by federal, state, and local governments was above $7 billion (in 1983 dollars) in each year between 1972 and 1983. Extrapolating to the entire period 1972-2016 implies total expenditure was above $753 billion (2014$).

for water pollution and $1.8 trillion for air pollution ($2014).

B Data Details

For each dataset, this section provides additional details on the data and on tests undertaken to probe their accuracy.

B.1 Deflator

To express investments in wastewater treatment capital in real dollars, we deflate all capital expenditures by the Construction Cost Index of the Engineering News Record (ENR). Published annually since 1908, this index reflects the cost of 200 hours of common labor including wages and fringe benefits, the cost of 2,500 pounds of fabricated structural steel, 1.128 tons of bulk portland cement, and 1,088 board feet of 2x4 lumber. To obtain the index, ENR averages the cost across 20 large cities. The closest series published by the federal government is the Census' construction price index for single-family homes.

To express housing values and rents in real dollars, we deflate these values by the Bureau of Labor Statistics Consumer Price Index for urban consumers.

B.2 National Hydrography Dataset (NHD)

EPA and USGS designed the general attributes of NHD, and a private contractor developed it. The first version of NHD appeared in 2006, while version 2 with more detail was released in 2012.[4] These data include physical features of every surface water in the U.S. including rivers, streams, ditches, canals, lakes, ponds, and others.

NHD includes a variety of identifying variables that the main text describes with more common language. We use the term "watershed" to describe what hydrologists and NHD call an 8-digit hydrologic unit code (HUC). We use the term "river" to describe what NHD calls a "levelpathi." We use the terms "river basin" or just "basin" to describe a 4-digit HUC. NHD classifies 1 million distinct rivers, though most are not conventional rivers (e.g., many "rivers" are seasonal streams less than one mile long), and only 70,000 levelpathis are named. We use the phrase "river segment" to describe what NHD calls a "comid." A comid is a unique identifier code for a specific line segment in NHD. On average a comid is 1.2 miles long. A comid connects a set of points, and we refer to these points as "stream nodes." NHD also includes a more coarse partition of rivers called reach codes which we do not utilize.

We use NHD's "flowline" features to describe upstream and downstream relationships of rivers and streams. In many cases, the "flowline" data include flows through lakes, ponds, and other types of water bodies.

B.3 Water Pollution Data

This section provides additional information on the data then explains how we extract and clean it. About 83 percent of the data come from rivers and the rest from lakes (Appendix Table I). The average monitoring site

[4]Since the 1970s, the EPA has developed increasingly detailed hydrologic data on U.S. water networks. This sequence of data includes Reach File 1 (created in 1975); Reach File 2 (created in 1987); and and Reach File 3 (available in 1993). Technically, the National Hydrography Dataset Plus is an application of the National Hydrography Dataset, which also incorporates information from the 30-meter National Elevation Dataset and the National Watershed Boundary Dataset.

appears in 10 different years and has 25 to 40 total readings per pollutant. About 25 percent of monitoring sites are in metro areas but only 15 percent of the U.S. land area is in metro areas, so they sightly over-represent metro areas. Monitoring is somewhat evenly spread through the 1970s, 1980s, and 1990s, though much less common in the 1960s.

Plotting densities of the raw data helps illustrate some of their properties (Appendix Figure I). Dissolved oxygen deficits follow a roughly normal distribution, while BOD, fecal coliforms, and TSS are more skewed. The dissolved oxygen deficit distribution is smoother than the others because its sample size is bigger. Some reports list pollution only out to two, one, or zero decimal points, which leads to heaping in the raw data and visible pileups at some round numbers.

We download the Storet Legacy data from U.S. EPA's Storet Legacy Data Center and Storet and NWIS data from the Water Quality Portal. Several decisions are required to extract data from the three repositories of water pollution data and to make them comparable. We describe steps for each issue in turn, and then steps taken to make the three repositories comparable.

Ambient Monitoring in Rivers and Lakes. Our analysis includes only rivers and lakes. This excludes estuaries, oceans, wells, pipes, canals, sampling inside industrial plants, and other sites, though these other types are uncommon in the pollution data. In Storet Legacy, we identify streams and lakes using the Storet Legacy station type field provided by the station files. We also remove measurements where the Primary Activity is Effluent Permit Condition, Effluent(Sample), Biological, or Tissue. We also exclude records where the Secondary Activity Category is Dredge, Core, Ground Water, or others that are clearly not river or lake samples, such as Standard Deviation or Sum of Squares. Additionally in all three repositories, we exclude records around dams since they are highly dependent on dam operations and often intended for dam monitoring; these are identified from the word, "Dam," in the station name or description.

In Modern Storet and NWIS, we limit the data to rivers/streams and lakes in a few steps. First, we restrict the sample media to surface water. We also restrict the media subtype to Surface Water, which removes typically less than 1 percent of records that are coded as other media subtype such as Effluent or Groundwater. For Modern Storet, the media subtype field is only populated for approximately 20 to 30 percent of observations. Of those coded, typically less than 1 percent of records are classified as something other than "Surface Water." Thus, for Modern Storet, we keep records where the media subtype is missing to preserve a large amount of data given that nearly all records that are coded are for surface water. Next, we limit the site type to lake, reservoir, impoundment, or stream. We distinguish streams and lakes in the NWIS station data using the provided monitoring location type name field in the station file. Streams are identified as "Stream," "Stream: Canal," "Stream: Ditch," or "Stream: Tidal stream." Lakes are identified as "Lake, Reservoir, Impoundment." For Modern Storet, we also identify streams and lakes using the monitoring location type name field. For Modern Storet, streams are identified as "River/Stream," "River/Stream Ephemeral," "River/Stream Intermittent," "River/Stream Perennial," "Riverine Impoundment," "River/stream Effluent-Dominated," "Canal Drainage," "Canal Irrigation," "Canal Transport," "Channelized Stream," "Floodwater," "Floodwater Urban," or "Floodwater non-Urban." Lakes are identified as "Lake," "Reservoir," "Great Lake," "Pond-Anchialine," or "Pond-Stormwater."

Measures of Water Pollution. Storet Legacy and NWIS classify each measure of water pollution according to a single parameter code. These parameter codes classify water quality parameters according to a broadly defined characteristic (e.g., biochemical oxygen demand) and the method for measuring the pollutant (e.g., the temperature at which the measurement is taken and the incubation time period). For example, the parameter code 00310 describes biochemical oxygen demand, measured at a temperature of twenty degrees Celsius, over a five day incubation period. The parameter code 00306 describes biochemical oxygen demand, also measured at twenty degrees Celsius, but only over a four day incubation period. For each measure of water pollution that we use, we start by choosing the parameter code which has the most observations in STORET Legacy. In nearly all cases, this parameter code corresponds to the parameter code given in the EPA's first major water pollution report after the Clean Water Act (USEPA 1974c). We also include parameter codes which are comparable to this main code(s) (e.g., measured in different units or a different device) if they have at least 10,000 observations in Storet Legacy. We use this rule because Storet Legacy has the largest number of observations among the three repositories used in the study, and the largest share of observations concentrated around the early 1970s when the Clean Water Act began. For NWIS data, we use the same parameter codes as Storet Legacy to extract corresponding measures of water quality from the Water Quality Portal.

Modern Storet does not use a parameter code, but rather identifies water quality parameters according to characteristic names. We take several steps to match these characteristics in Storet to those pollutants in Storet Legacy and NWIS repositories. We utilize concordance tables provided by EPA and the Water Quality Portal that map Storet Legacy and NWIS parameter codes to Modern Storet "search names."[5]

A single characteristic name often corresponds to multiple parameter codes. The EPA concordance provides the meaning of parameter codes, including information on sample preparation (e.g., details regarding filter size), whether the measurement was in the field or laboratory, measurement units, result sample fraction (e.g., total versus dissolved), result temperature basis, result statistical basis (e.g., mean, median), additional comments, and additional measurement method details. We supplement this information with a similar table from the Water Quality Portal website that provides a few additional details for each parameter code including result time basis, result weight basis and result particle size basis.

Between these two files, we note which aspects distinguish certain parameter codes from others and use these to restrict and subsequently match Modern Storet pollution records to Storet Legacy and NWIS records by pollutant. In addition to the characteristic name, the main distinguishing aspect of a measure of water pollution is the result sample fraction field that often identifies total versus dissolved measurements. For biochemical oxygen demand and fecal coliforms, we also restrict based on the result temperature basis (20 degrees Celsius or missing and 45 degrees Celsius or missing respectively) and result time basis (5 day or missing and 24 hours or missing respectively). For dissolved oxygen, we convert dissolved oxygen in mg/L to dissolved oxygen saturation (%) using a standard formula (Lung 2001).[6]

Sample Exclusions. We impose several sample exclusions. We keep observations with non-missing observation date, latitude, and longitude, within the continental U.S. We limit to latitude and longitude observations which are located within a U.S. county, as defined by the 2010 edition of the year 2000 Census Topologically Integrated Geographic Encoding and Referencing (TIGER) shapefiles. We also limit to observations within a U.S. hydrologic unit code (HUC), according to the 1994 1:250,000-scale HUC shapefile of the U.S. Geological Survey. We define each monitoring site's county and HUC based on its latitude and longitude as of the year 2000 (for counties) and 1994 (for HUCs), which implicitly addresses the potential

[5]The U.S. EPA provides several crosswalks to identify measurements in Storet that are comparable to those in the Storet Legacy and NWIS repositories (ftp://ftp.epa.gov/storet/modern/reference_tables/Characteristic_Parameter_Code_Map/). In particular, we use the crosswalk STORET_Modern_vs_NWIS.xls. The water quality portal table links a parameter code to characteristic name, measurement unit code, result sample fraction, result temperature basis, result statistical basis, result time basis, result weight basis, result particle size basis, and medium. (http://waterqualitydata.us/public_srsnames/)

[6]The formula is $DO_{perc} = \frac{DO_{mgl}}{468/(31.5+T)}$ where T is the water temperature in Celsius. We only apply this conversion for observations which record both dissolved oxygen in mg/L and water temperature, and for station-days which do not already have dissolved oxygen saturation (%) defined. When applied to stations which do have dissolved oxygen saturation defined, regressing the reported level of dissolved oxygen saturation on the value obtained from this conversion obtains a coefficient of 0.996 with a standard error of 0.001.

issues of changing boundary definitions for counties and HUCs over time. We also limit analysis to ambient monitoring. To limit the influence of outliers, for each reading above the 99th percentile of the distribution of readings, separately by pollutant, we recode the result to equal the 99th percentile. To ease interpretation, we define all pollution outcomes so that lower levels of the outcome represent cleaner water.

For NWIS, we exclude records of Spills, Hurricanes, and Storms by limiting to routine hydrologic events. Modern Storet and Storet Legacy, unlike NWIS, provide no information on hydrologic events. We convert all temperature readings to degrees Fahrenheit. For other pollutants, we keep all records with unit data that are easily converted to standard units. For Storet Legacy and NWIS, we keep observations with missing units since parameter codes are already assigned to specific units. For Modern Storet, we keep observations with missing units except for dissolved oxygen and temperature. We exclude observations with missing units for dissolved oxygen and temperature since we are unable to distinguish between mg/l and percent saturation in the dissolved oxygen data and degrees C and degrees F in the temperature data.

Definitions of Geographic Variables. We use a few steps to define geographic variables. Storet Legacy has separate files describing stations and describing actual pollution readings. Geographic identifiers like latitude, and longitude appear in both. We prioritize values of these variables from station files. When those are missing, we supplement them with values from the results files.

Types of Water Pollution. We use a few criteria to choose additional measures of pollution for sensitivity analysis in Appendix Table IV. This is important—one of our repositories alone, Storet Legacy, includes 16,000 different measures of water pollution. We partly take this list of additional pollutants from the EPA's (1974a) first major assessment of water pollution after the Clean Water Act was passed. These additional pollutants include water temperature, ammonia-nitrogen (total as N), nitrates (total as N), total nitrite plus nitrate, orthophosphate (dissolved as P),[7] total phosphorus, total and dissolved chlorides, color, total phenols, total dissolved solids, dissolved sulfate, total coliforms, and turbidity.[8] Finally, we add total nitrogen as a key measure of nutrient pollution, and lead and mercury as important heavy metals. Standard water quality monitoring programs collect data on the main pollutants we study (BOD, dissolved oxygen, fecal coliforms, and TSS). We interpret estimates for the pollutants in Appendix Table IV somewhat more cautiously since fewer monitoring programs collect data on many of these pollutants, which makes estimates with these other pollutants both potentially less precise and less representative.

Specific Monitor Networks. For NWIS, we identify stations that are a part of several networks specifically designed by USGS to examine long-term trends in water quality. These networks are NASQAN, NAWQA, and HBN. Station identifiers were obtained from USGS. We obtained NASQAN and HBN station identifiers through a request from USGS. NAWQA site identifiers were downloaded from a USGS website using filters on "stream" and "lake" for site types (http://cida.usgs.gov/nawqa_queries_public/jsp/sitemaster.jsp). Our NASQAN and HBN samples include only the original NASQAN and HBN networks, which spanned the years 1974-1995. Our NAWQA sample includes both the NAWQA networks focused on streams/rivers and on lakes. We add "USGS-" to the stationid field and match these station files to monitoring files provided by the Water Quality portal. In several cases, monitoring was performed at these stations even when they were not officially part of their designated networks. We include all monitoring results during the years 1962-2001.

Station Definitions. Some stations change name slightly—for example, the same station may have

[7]The 1974 report includes total soluble phosphate to determine reference levels. We choose to use orthophosphate (dissolved as P) instead. The number of records in Storet Legacy corresponding to total soluble phosphate (38,000) is far fewer than the 870,000 monitoring results for orthophosphate (dissolved as P).

[8]We add dissolved chlorides and dissolved sulfate to this list since the unique pollutant parameter codes listed in the NWQI Report for chlorides and sulfate refer to total chlorides and total sulfate in Storet Legacy, but dissolved chlorides and dissolved sulfate in the NWIS.

similar names in Modern Storet and in Storet Legacy. In regressions that include station fixed effects or allow station-level autocorrelation, we define a station as a unique latitude and longitude pair. For these reasons, the main text generally refers to stations as "monitoring sites."

In our data, the tuple of a station's name, the name of the agency that manages it, and the repository (Storet Legacy, Modern Storet, or NWIS) uniquely identifies a station. When we pool the three repositories, 5-10 percent of "stations" that appear unique by this definition have the same longitude and latitude as another "station." This is typically because a single station appears in both Storet Legacy and Modern Storet but with slightly different station codes. This motivates our use of longitude and latitude to define monitoring sites.

In a few cases, individual pollution readings (i.e., records) appear in both Storet Legacy and Modern Storet. We identify and remove such duplicates based on station latitude and longitude, reading date and time, and reading value.

Monitoring Depth. We do not account for reading depth since many depth values have missing units and our inspection suggests different monitors use different depth units.

Measurement Limits We capture special cases where the pollutant could not be measured or the measurement was outside of standard detection limits. For NWIS and Storet, we flag records with non-missing information in the detection type field. For example, this includes records coded with "Historical Lower Reporting Limit," "Upper Reporting Limit," or "Estimated Detection Level." For flagged records, we then let the result value equal the detection limit if the result value is missing and the detection limit is not missing. We also restrict the detection limit to be greater than zero except for temperature. For Storet Legacy, we use the "remarks" field to flag similar records. This includes remarks coded as "B," "C," "I," "J," "K," "L," "M," "N," "O," "P," "T," "U," "W," "Z," and "$," where the key is provided by the U.S. EPA (http://www.epa.gov/storet/legacy_remark.pdf). We make no changes to the reported measurement since the remarks suggest that the reported measurement equals the result value. In one sensitivity analysis, we take readings with the "Below Detection Limit" (BDL) field coded as "Lower Limit" or "Other," and replace them as half the listed value.

Measurement Time. For observations with missing information on the measurement time, we create a missing hour indicator and include it alongside controls for a cubic polynomial in hour. For Storet Legacy and Modern Storet, we also code this indicator for hour equal to 0 since there is a pileup of observations at this hour.

Test of Dissolved Oxygen Data Quality. Standard hydrology textbooks predict that dissolved oxygen deficits should increase with temperature, in summer (when flows are lower and temperatures higher), and in morning. The time-of-day patterns of dissolved oxygen are due to photosynthesis adding oxygen during the day and respiration removing oxygen at night. Appendix Figure II plots regressions of dissolved oxygen deficits on binned indicators for each of these physical factors, while including monitor fixed effects. The patterns closely follow standard chemistry predictions. We interpret this as one additional piece of evidence that these data provide good quality measures of water pollution.

B.4 Grants

The average government manages multiple plants, and the average plant receives multiple grants. Governments include cities, towns, sewage or water districts, and environmental agencies. After 1987, small grants to a few areas, mainly islands and Washington DC, continued through the year 2000. Two-thirds of U.S. wastewater treatment plants in the analysis sample received at least one grant (Appendix Table II).

The $650 billion total cost mentioned in the main text includes only grants given in years 1972 or later with non-missing award date. An additional approximately $135 billion in expenditure occurred due to grants given in years before 1972.

A local government could receive at least three grants for a single project. The first grant was for creating a facility plan, the second was for detailed engineering plans, and the third was for construction. Money was disbursed as it was spent and EPA reviewed projects after completion. The grants data used for analysis exclude the very few grants in the raw data that list either the federal or total (federal+local) cost as zero.

The microdata we obtain on grants are up to 50 years old, from an era when computers were rare, so we sought to corroborate the accuracy of the data.

In order to test the accuracy of the microdata on 35,000 grants, we compare the grants against several published reports describing this program. A USEPA (2000b) report and associated book (Stoddard et al. 2002) were based on detailed data describing these grants. Andy Stoddard and Jon Harcum generously shared the microdata underlying these reports. The grants data they analyze exactly mirror ours, with two exceptions. First, the aggregate nominal figure they report for grants ($61 billion) reflects both federal and associated municipal capital spending. Second, they only obtained records of 10,000 grants. This appears to be because their data apply several exclusion criteria.

We also compared individual grants in the microdata we received against published reports we found that list individual grants given in early years (USEPA 1974a,b). The grants in our microdata also appear in these printed volumes, with the same plant and government authority listed. Grant dates are similar in the microdata and 1970s reports, though some differ by several months. The dollar amounts of individual grants have the same order of magnitude but the exact amounts differ. This may be because funds requested, approved, and disbursed can differ, and can take over a decade to finalize.

One sensitivity analysis in our paper looks only at grants given for construction rather than engineering plans. Following Stoddard et al. (2002), we define a grant as for construction if the grants microdata list the grant "Step" as equal to three or four, and if the grant also lists the facility number of the plant receiving the grant.

Operating and Maintenance Costs. Clean Water Act grants involve three types of costs: federal grants for capital, local matching expenditures for capital, and expenditures for operating and maintenance (O&M). Our grants microdata report only the first two costs, so we estimate the third from other sources.

National data are consistent with the idea that the ratio of lifetime O&M costs to upfront capital costs increased almost linearly from 130 percent in 1972 to 259 percent in 1996. We linearly extrapolate these values to years before and after 1972-1996. These values reflect several sources. Two independent sources provide identical reports that concrete structures of treatment plants have a useful life of 50 years but mechanical and electrical components have a useful life of 15-25 years (USEPA 2002; American Society of Civil Engineers 2011). We assume grants require O&M expenditures for 30 years.

We combine this 30 year statistic with the estimated ratio of O&M costs to capital stock in a typical year. This ratio grew almost linearly from 3.7 percent in 1972 to 7.4 percent in 1996 (USEPA 2002). These values reflect historic census records on O&M expenditures and perpetual inventory estimates of capital stocks (U.S. Army Corps of Engineers 1994), both for sewerage infrastructure.

These values represent the most accurate estimates of O&M costs that we can discern. Nonetheless, it is informative to compare these values against other estimates of these costs. One survey of 226 Clean Water Act projects found a ratio of annual O&M costs to upfront capital costs of 3.76% to 3.96% (Lake, Hanneman and Oster 1979).[9] The ratio was similar across different community sizes and government types.

[9] This study reports the ratio as 3.96% on p. 42 and 3.76% on p. 110. The reason for the discrepancy is unclear.

These values are similar to the aforementioned numbers that we use, which report a ratio of 3.7% in 1972. A second source reports the prediction that for a typical city of 25,000 people, the total cost of building a treatment plant is about $4.6 million, and the expected real annual O&M cost is about $200,000 (USEPA 1979). The ratio of annual O&M costs to upfront capital costs in this second source is 4.3%, which is the value for the year 1976 implied by the data we use. A third source is an ex ante engineering prediction that lifetime O&M costs are 93 percent of upfront capital costs (Hitchcock and Giggey 1975).[10] The reason why the engineering predictions in this third study are smaller than the ex post realized costs we use is unclear, though engineering predictions have underestimated the costs of energy and environmental investments in other settings also. A fourth source indicates that nominal operations and maintenance cost per unit volume treated increased perhaps more rapidly than these numbers suggest, by nearly 5 percent per year during the period 1982-1988, which is large particularly since unit volumes treated if anything likely increased in this period (U.S. Army Corps of Engineers 1994). Other studies report aggregate national trends in real total operations and maintenance costs over parts of this period, which were fairly flat between 1977 and 1987 then increasing, and in the real total value of the capital stock over this period, which increased steadily after 1977 (U.S. Army Corps of Engineers 1994; USEPA 2002).

The preceding paragraph describes several snapshots of operating and maintenance costs. They are in the ballpark of the main estimates we use, which cover the period 1972-1996, though some numbers in the previous paragraph would imply higher or lower operations and maintenance costs than our main estimates. Linearly interpolating the values from the previous paragraph to form a complete time-series of these costs would require strong assumptions on how to extrapolate data points for one or a few years out to several decades. Section VII.C of the main text describes a more conservative and simple calculation, which is to ask how cost estimates would change under the assumption that no operations and maintence costs are included in the benefit-cost calculation.

B.5 Census Data from Geolytics

For each census tract, the Geolytics Neighborhood Change database reports mean or total values for the relevant housing and population variables we use. We measure the mean home value in a tract as the total value of specified owner-occupied housing divided by the total number of specified owner-occupied housing units. In years 1970 and 1980, these data cover non-condominium housing units only. The housing data comes from the census "long form," which is given to 1 in 6 households. The actual census questionnaire has homeowners estimate the value of their property as falling into one of several bins.

We use a version of these data in which Geolytics has concorded all tract boundaries to the year 2010 boundaries. We use information on resident demographics, total population, physical features of housing (e.g., the number of rooms), home values, and rents. Some regressions control for housing structure characteristics. Because each observation is a census tract (which is subsequently aggregated to buffer a given distance from a river), we measure these structural characteristics as the share of homes with a given characteristic. The rental data for 1970 are "contract rents," which report the amount paid from renter to owner; the rental data for 1980-2000 are "gross rents," which include the contract rent plus utilities and fuels, if these are paid by the renter. As with home values, the actual census questionnaire has renters enter their contract rent as falling into one of several bins.

[10] This study reports O&M predicted costs for different categories of water pollution abatement expenditures. We obtain a national number by combining the category-specific O&M predictions from this study with category-specific capital expenditures under the Clean Water Act from Stoddard et al. (2002).

The census home values data reflect self-reported home values, rather than actual transaction values. The census data are also top-coded. Many studies find high correlation between self-reported home values and sales price indices, either in the cross-section or time-series (Follain, Jr. and Malpezzi 1981; Ihlanfeldt and Martinez-Vazquez 1986; Goodman, Jr. and Ittner 1992; DiPasquale and Somerville 1995; Kiel and Zabel 1999; Banzhaf and Farooque 2013; Benítez-Silva et al. 2015), suggesting that self-reports provide some important information about true market values. Because home values are the dependent variable in hedonic regressions, using self-reported home values in the presence of classical measurement error may decrease the precision of estimates but not create attenuation bias (Griliches and Hausman 1986; Bound and Krueger 1991).

These studies, however, also find some inaccuracies of self-reported home values. One issue is bias—in most studies, homeowners overestimate the market value of their property by 5-10 percent. Another concern is inertia—owner-occupants who have not purchased a home recently may be slow to update their beliefs about a home's value (Kuzmenko and Timmins 2011; Henriques 2013). This inertia appears to be consistent with a simple Bayesian updating model, specifically, a Kalman filter (Davis and Quintin 2017). But this means that homeowners may be slow to reflect changes in local amenities due to investments in surface water quality. Longstanding rental tenants often receive tenure discounts, though we are not aware of direct evidence on the speed with which such discounts adjust to changes in amenities. As one way to address these concerns, in analyzing home values and rents, we report specifications which allow homeowners and renters up to 10 years to reflect changes in water quality.

In regressions involving home values, the controls for structure characteristics are allowed to have different coefficients in each year, and include the following: number of bedrooms, number of housing units in building, number of stories in building, heating fuel, cooking fuel, hot water fuel, heating equipment type, sewer type, plumbing type, year built, air conditioning, kitchen, number of bathrooms, and water access. All variables are expressed as share of housing units with the indicated characteristic. All categorical variables (e.g., number of bedrooms) are expressed as the share of housing units with each possible category. The 1970 characteristics are the following: distance to central business district; share of population that is black; share of population over age 65; share of population under age 6; share with a college degree; share on public assistance; income per family; and all the 1970 structure characteristics.

We define city centers for all Standard Metropolitan Statistical Areas (SMSAs) as follows. The definition of central business district locations used in most research comes from the 1982 Census of Retail Trade. This definition has two downsides in our setting—it is potentially endogenous to the Clean Water Act, since the definition was constructed ten years after the Act and since cleaning up rivers might shift the location of businesses; and it includes a limited number of cities. Instead, for each Standard Metropolitan Statistical Area (SMSA), we use the 1970 Population Census to construct an original definition of the city center as the latitude and longitude of the census block centroid which has the greatest population density. In cities with a central business district defined from the 1982 Census of Retail Trade, this typically ends up defining close but not identical definitions of city centers. For census tracts within an SMSA, we then define distance to the city center as distance to the city center of that SMSA. For census tracts outside an SMSA, we define the distance to the closest city center overall.

B.6 Municipal Expenditure Data

We impose a few sample restrictions to ensure that we accurately measure the response of municipal spending to federal grants. We restrict the sample to governments appearing in all years 1970-2001.[11] This is important since the data report capital expenditures but not capital stocks, and missing some years of municipal expenditures data could underestimate the response of municipal spending to federal grants. We also restrict the sample to municipalities and townships, which we collectively refer to as cities. This restriction excludes state governments, county governments, special districts, school districts, and the federal government. Finally, we exclude cities which have other governments with similar names in the same state, and cities that have sewer districts, counties, or other nearby related governments that may receive or spend grants. We make these exclusions because they help accurately measure sewerage capital and grant receipt. We identify such cities both using listings of sewer districts and local counties in the survey and census of governments, and using grants which list the authority receiving the grant as a sewer board, county agency, or other local government that is not a city. Many grants go to water boards, sewer districts, county agencies, or other local governments which have separate financial management from a city. Such grants would not appear in the city's financial records, but the grants data do not always distinguish which local government administered the grant. These restrictions leave a balanced panel of 198 cities. As noted in the main text, because this sample is relatively small, we report one specification using inverse propensity score reweighting to match the characteristics of a broader sample of cities.[12]

B.7 Additional Environmental Data[13]

We measure county-year-day air temperature and precipitation using data from the National Climate Data Center Summary of the Day files (file TD-3200). We use information on the daily maximum temperature, daily minimum temperature, and daily total precipitation. We use only weather stations reporting valid readings for every day in a year. To obtain county-level values, we take an inverse-distance weighted mean of data from stations within a 300 kilometer radius of the county centroid. Weights equal a monitoring site's squared distance to the county centroid, so more distant monitoring sites receive less weight.

As mentioned in the main text, we report one specification controlling for two separate counts of polluting industrial plants. The 1972 Census of Manufactures asked every U.S. manufacturing plant whether it used more than 20 million gallons of water per year, and the roughly 10,000 plants indicating that they used this much water appeared in the 1973 SWUM. For each wastewater treatment plant in our data, we count the

[11]The census has these data for the year 1967 and then annually beginning in 1970; our sample begins in 1970 since we need a balanced panel. All governments report data in years ending in 2 and 7 (1972, 1977, etc.). Other years contain a probabilistic sample of governments. In most years, the largest cities measured by population, total revenue, or expenditure are sampled with certainty. Among smaller cities, sampling probabilities vary by region, type of government, and size. The balanced panel is the main limiting factor in our data extract, since less than 1,000 cities appear in all years of the data 1970-2001.The "year" in these data refers to each local government's fiscal year. We convert the data to calendar years using data from these surveys on the month when each government's fiscal year ends, assuming that government expenditure is evenly distributed across months. For the few governments that don't report when their fiscal year ends, we assume they report by calendar year.

[12]We estimate the propensity score from a probit using all cities. The estimated propensity score is a function of the city's log mean total expenditure across all years 1970-2001 when it appears in the census or survey of governments, the city's log mean population, an indicator for being a municipality (rather than township), and census division fixed effects. Cities with lower expenditure and in the West and South are significantly more likely to appear in the sample; conditional on the other variables, population does not significantly predict appearance in the sample.

[13]We thank Olivier Deschenes for providing the weather data and Michael Greenstone for providing the 1972-1977 nonattainment data.

number of manufacturing plants in the same county which use at least 20 million gallons of water in 1972. We control for these counts, interacted with a downstream indicator and interacted with year fixed effects. Although these data only directly measure total water use and not total water pollution emissions, the SWUM survey questions and resulting report both focus on water pollution,[14] and plants with extensive water use also emit large amounts of water pollution. For example, the industries that consume the most water in the 1978 version of these data (Becker 2016) – blast furnaces and steel mills, industrial organic chemicals, petroleum refining, and paper mills – are also the industries that emit the most water pollution.

The current EPA PCS data list the first year a plant received a water pollution emissions permit. These data suffer from incomplete reporting, since not all states and plants uploaded data to the EPA's centralized database. They also suffer from sample selection, since plants which closed may not appear in the data. In counting the number of industrial pollution emitters from PCS, we exclude wastewater treatment plants (Standard Industrial Classification 4952).

Some sensitivity analyses control for county×year×pollutant nonattainment designations. For years after 1977, these data come from the EPA Green Book. Data for years 1972-1977 are constructed from raw monitors based on the reported nonattainment rule. We define ozone nonattainment to include all ozone or nitrogen oxides designations, and we define particulate matter nonattainment to include Total Suspended Particulates (TSPs), particulates smaller than 10 micrometers (PM_{10}), and particulates smaller than 2.5 micrometers ($PM_{2.5}$). Our binary measures of nonattainment include all partial, whole-county, and other types of nonattainment.

Farms, confined animal feeding operations (CAFOs), and other agricultural or "non-point" sources are not likely to be a major source of confounding variation during this time period since they were not regulated under the first few decades of the Clean Water Act. The Safe Drinking Water Act was passed in 1974, just after the Clean Water Act. It is not a likely source of confounding variation since its goal is to improve the quality of tap water, not ambient river water. It also focused on establishing water standards and overseeing local authorities that enforce those standards, rather than on providing grant funds to improve infrastructure.

B.8 Data for Analyzing Heterogeneous Effects

Appendix Table VII analyzes how the effects of grants on water pollution and housing values differs for certain subsets of grants. This subsection describes how we define these subsets.

Row 1 of Appendix Table VII distinguishes grant projects which have a total cost (including federal and local contributions) above $1.2 million, measured in $2014. This is the median cost.

Row 2 of Appendix Table VII describes grants to plants that have secondary or tertiary baseline abatement technology. These plant-level abatement technology data come from the Clean Watershed Needs Survey. Only available data for the 1978, 1984, and 1986 years of this survey cover all plants and include accurate plant identifier codes.[15]

These abatement technology data have several limitations. Only about 40 percent of grants or real grant dollars were given after 1978. Additionally, only having reports for 1976, 1984, and 1986 implies that without some kind of interpolation, abatement technologies are only directly reported for three years which together account for about 15 percent of grants or grant dollars. The CWNS data contain two possible measures of a plant's abatement technology: one is a field where the respondent writes in the level of treatment stringency

[14] The SWUM microdata were recently recovered from a historic Census Univac system. Unfortunately the water pollution data in that survey were not available. We thank Randy Becker for helping access and interpret the SWUM data.

[15] The available microdata from the 1976 survey exclude over half the plants. The 1980 and 1982 surveys have incorrect plant identifier codes that can only be linked with substantial classification error to other years of the survey.

(primary, advanced primary, secondary, advanced secondary, or tertiary). The other is a list of all the different abatement technologies the plant uses. The 1984 plant codebook classifies lists of abatement technologies into primary, secondary, and tertiary. Between these two reports, only 45 percent of plant-year observations have the same level of treatment (primary, secondary, or tertiary). In the self-reported level of treatment, a third of plants that report a change in the treatment level report a decrease in the level. In the lists of abatement technologies, large shares of plants that report changes in an abatement technology reports its disappearance–for example, plants are almost as likely to report losing a trickling filter or activated sludge process (which are the two most common types of secondary treatment) as to report gaining one. We use secondary and tertiary classifications based on listed abatement technologies, which appear to have a lower level of gross reporting errors than the handwritten secondary or tertiary entries.

Row 3 of Appendix Table VII describes grants to plants with baseline pollution above the median. We measure baseline pollution as the mean pollution level for each watershed as measured in the years 1962-1971. Baseline pollution levels are calculated separately for dissolved oxygen and for the fishable standard.

Row 4 of Appendix Table VII considers states that have decentralized authority to implement the Clean Water Act NPDES program.[16] This measure indicates whether a state holds authority to administer NPDES permits.

Row 5 of Appendix Table VII considers counties that have above-median shares of people who report outdoor fishing or swimming in the previous year. We obtain these data from the confidential version of the National Survey on Recreation and the Environment (NSRE) years 1999-2009. Fishing is defined as coldwater or warmwater fishing in rivers, lakes, or streams. Swimming includes swimming in streams, lakes, ponds, or the ocean. (A separate question that we don't use asks about swimming in swimming pools.) Our sample includes approximately 85,000 households. Earlier versions of the survey have been conducted intermittently since 1960; however, county and state participation shares are unavailable from earlier years. The NSRE is a partnership between the USDA Forest Service Southern Research Station, The National Oceanic and Atmospheric Administration, the University of Georgia, the University of Tennessee and other federal, state or private sponsors. The survey is a randomized telephone survey of households across the U.S. Unfortunately, state- or county-level rates of fishing participation for the entire U.S. are not available from years before the Clean Water Act.

Row 6 of Appendix Table VII uses data on environmental views from the "Total Green Index" of Hall and Kerr (1991). States with Pro-Environmental Views are defined as those with above-median values of the total green index.

Row 7 of Appendix Table VII uses data on city growth and amenities. To identify declining urban areas, we follow Glaeser and Gyourko (2005) by taking 1970-2000 city population growth rate as reported in the 1972 and 2000 city data books (Haines and ICPSR 2010). We define declining urban areas as cities with population above 25,000 in the year 1970 which had a population decline of five percent or more by the year 2000. High amenity areas are defined as counties in an SMSA with above-median total amenity value, as reported in Albouy (2016), Appendix Table A1.

Row 8 of Appendix Table VII uses each monitoring site's location to identify its census region.

C Spatial and Other Matching Across Datasets

Conducting the analysis of this paper requires linking several datasets. To link monitors and treatment plants to rivers, we use the fact that rivers in NHD are internally defined as 70 million distinct longitude and latitude

[16] These data are obtained from https://www.epa.gov/npdes/npdes-state-program-information (accessed August 31, 2016).

points connected by straight lines. We refer to these points as stream nodes. We identify the location where each treatment plant discharges waste using longitude and latitude values from the 1984-1996 CWNS. For each monitor and treatment plant, we then find the nearest stream node. All treatment plants in the analysis sample are within 0.6 miles of a stream node.

To measure distances upstream and downstream along rivers, we use files in NHD which list, for each stream node, the node(s) that are immediately upstream and/or downstream. We recursively construct a network tree that defines, for each treatment plant, all stream nodes that are upstream or downstream. We construct this algorithm to follow these flow relationships when one river flows into another, when rivers cross watersheds, or when the flow network passes through lakes, estuaries, and other types of water. Finally, we calculate distances between stream nodes and sum them to measure the distance along a river between a treatment plant and pollution monitor.

We also link treatment plants to upstream and downstream census tracts. For each treatment plant, we construct buffers of a given radius around river segments upstream and downstream of the plant. We define one buffer to include all homes within 1 mile of those rivers, and another buffer to include homes 0 to 25 miles from those rivers. Many census tracts span multiple buffers. For each tract, we calculate the share of the tract's area which is in each buffer. For each tract, we measure population and housing characteristics within a buffer by multiplying the total within the tract by the share of the tract's area within the buffer.

Finally, we link each grant to the exact wastewater treatment plant receiving the grant. The Freedom of Information Act (FOIA) data we received list an identifier code for the facility receiving the grant. These same identifier codes appear in the Clean Watershed Needs Survey (CWNS), so they let us precisely identify the wastewater treatment plant receiving the grant. In some cases where the facility identifier code is missing, CWNS itself lists the grant code which a plant used, and this grant code matches the grant codes used in the FOIA data. These two links unique identify the facility receiving a grant for about 76 percent of grants and 87 percent of grant dollars.

D Cross-Sectional Water Pollution Around Wastewater Treatment Plants

We use the following equation to estimate how water pollution changes as a river flows past a wastewater treatment plant:

$$Q_{pdy} = \beta d_d + \mu_{py} + X'_{pdy}\gamma + \epsilon_{pdy}$$

Each observation in these data represents a plant-downstream-year tuple. Here Q_{pdy} measures pollution at plant p in year y and downstream location d. Location $d = 1$ includes areas downstream of the treatment plant, and location $d = 0$ includes areas upstream of the treatment plant. The plant×year fixed effects μ_{py} imply that these comparisons are made within a river×year, so they measure how water pollution changes as the river flows past the wastewater treatment plant. The coefficient β represents the mean difference in pollution between downstream and upstream waters near a treatment plant. We include temperature and precipitation controls X_{pdy}.

These comparisons are cross-sectional and do not analyze changes in a river over time. Because wastewater treatment plants may locate near other pollution sources, such as urban runoff and industrial plants, these regressions do not identify the effect of wastewater treatment plants on water pollution. Area characteristics may also differ in the cross-section between upstream and downstream areas. Indeed, the average upstream and downstream monitoring sites are 20 miles apart. Compared to upstream areas, downstream areas have similar population density and share of families on welfare, though slightly lower share of adults with a college degree and slightly greater share population black.[17] These cross-sectional differences are another reason that our research design exploits the timing of grants across treatment plants.

As a river passes a wastewater treatment plant, data show large and statistically significant increases in pollution (Appendix Table V). Dissolved oxygen deficits rise by 1.2 percent saturation, which is an increase of ten percent relative to the upstream pollution level. Fecal coliforms increase the most as a river passes a treatment plant, by about 40 percent. Other pollutants increase by smaller amounts. The probability that a river is not fishable rises by about 4 percentage points as a river passes a wastewater treatment plant.

E Sensitivity Analyses

E.1 Pollution Trends

This subsection reports sensitivity analyses for pollution trends; most are qualitatively and quantitatively similar to the main results.

Rows 2-6 of Appendix Table III consider important subsamples. Row 2 only uses long-term stations, which begin operating by the year 1971 and report data through at least the year 1988, since the grants program largely converted into a subsidized loans program in 1987. Row 3 restricts the sample to the largely metro counties that had some home values data in all four decennial censuses 1970-2000; as mentioned earlier, the 1970-80 censuses excluded many non-metro areas. Rows 4-6 separately estimate results for the three pollution data repositories – NWIS, Storet Legacy, and Modern Storet – since each has different coverage and affiliated organizations which collect the data.

Rows 7-11 of Appendix Table III report sensitivity analyses prompted in part from discussing this analysis with hydrologists. Row 7 limits the sample to include only stations which have at least 25 readings, since these may have higher-quality data. Row 8 controls for the level of instantaneous stream flow, as measured at the same station and time as pollution, and so is limited to to "stream gauge" observations recording both streamflow and pollution. Row 9 uses data from only the months of July and August, since this is when streamflows are lowest, temperatures are greatest, and pollution concentrations are highest. Row 10 takes readings which indicate that they are below a monitor's detection limit ("BDL"), and replaces them with half the recorded value. (The main analysis uses the reported value for these BDL readings.) Row 11 specifies the pollutants with skewed distributions (BOD, fecal coliforms, and TSS) in logs rather than levels.

Rows 12-13 of Appendix Table III reports an alternative water pollution index. Row 12 reports results where each observation describes mean values for a river-year. In this specification, a "river" is defined as a unique combination of a watershed and river code.[18] Row 13 defines the dependent variable as an indicator for whether more than 50 percent of pollution readings in the river-year are below the fishable or swimmable standard.

Rows 14-16 of Appendix Table III report results separately for three small and well-documented networks of high-quality monitoring sites, all managed by USGS. Row 14 shows estimates for the National Stream Quality Accounting Network (NASQAN). Row 15 shows estimates for the National Water-Quality Assessment

[17] The census tracts of downstream monitoring sites have population density of 835 persons per square mile; upstream areas have density of 862. Downstream areas have 4.88 percent of families on welfare, while upstream areas have 4.81 percent of families on welfare; downstream areas have 9.2 percent of adults with a college degree while upstream areas have 9.9 percent of adults with a college degree, and downstream areas have 8.5 percent of population black while upstream areas have 7.7 percent of population black. These values use 1970 census data.

[18] A river here is defined as a "levelpathi" from NHD.

(NAWQA) (Smith, Alexander and Wolman 1987; Alexander et al. 1998; Rosen and Lapham 2008). Row 16 shows estimates for the Hydrologic Benchmark Network (HBN), which includes a small number of watersheds expected to have "minimal" effects from human activity (Alexander et al. 1998). HBN shows smaller trends than the main sample for BOD, fecal coliforms, and TSS, which is consistent with anthropogenic causes of these pollutants in the national data.

Rows 17-25 of Appendix Table III report other important sensitivity analyses. Row 17 allows arbitrary autocorrelation within both watersheds and years. Row 18 limits the sample to lakes. An important paper finds that dissolved oxygen in lakes has not changed since the Clean Water Act (Smith and Wolloh 2012), and Row 18 corroborates that finding. But the lake point estimate for dissolved oxygen deficits is negative, all other pollutants in lakes show downward trends, and nearly all of the other sensitivity analyses in Appendix Table III also show statistically significant downward trends. These results suggest that broader trends in water pollution differ from patterns evident in dissolved oxygen in lakes. Row 19 adds controls for temperature and precipitation. These are relevant since climate change is increasing air temperatures, but hotter temperatures can increase dissolved oxygen deficits. In row 20 each observation is the mean value in the county-year, and regressions are generalized least squares weighted by the population in the county-year. This may better reflect the trends experienced by the average person. Row 21 interacts the time-of-day and day-of-year controls with river basin region fixed effects, to capture the idea that seasonality and time patterns may differ across space. Rows 22-25 report estimates separately for each of the four census regions; all pollutants are declining in all regions, though declines were more rapid in the Northeast.

E.2 Effects of Clean Water Act Grants on Pollution: Sensitivity and Heterogeneity

This subsection reports sensitivity analyses for effects of Clean Water Act grants on pollution. Rows 1-13 of Appendix Table VI report the sensitivity analyses used for analyzing trends. Most of these give broadly similar results to the main specification. The alternative definitions of the "fishable" and "swimmable" standards do give more variable results—for example, defining fishable and swimmable as an indicator for whether 50% of readings are below the standard shows that each grant decreases the probability that waters violate the fishable standard by 2.4 percentage points, but does not significantly change the probability that waters are swimmable.

We also estimate sensitivity analyses which we do not report for trends regressions, and most also give similar results. Row 14 includes dummies for the range of distances from 0-25 miles, 25-50, 50-75, and 75-100 miles. These analyses show that the effect of grants on water pollution is concentrated within 25 miles. For BOD and dissolved oxygen, small and statistically insignificant effects may appear at further distances. Row 15 considers the subsample of plants with pollution monitoring sites at least 10 miles upstream and downstream.

Rows 16-20 of Appendix Table VI describe other ways of measuring grants. Row 16 includes only grants that are for physical construction, and excludes grants for architectural or engineering plans. Row 17 includes separate indicators for each possible cumulative grant that a plant received. All grants appear to decrease pollution, though later grants may have had larger effects, and most pollutants show a positive dose-response function. Row 18 controls for both the cumulative number of grants to any plants within 25 miles upstream and also (separately) for grants to plants within 25 miles downstream, which hardly changes estimates. This control is designed to address the possible concern that facilities may be located near each other in rivers, and nearby plants may receive grants at similar times.[19] Row 19 includes controls for the number of grant projects of three different magnitudes (roughly terciles of the grant size distribution). The smallest grant projects have no clear effects on pollution, moderate-size projects lead to statistically insignificant decreases in pollution, and the largest projects produce the clearest decreases in pollution. Row 20 replaces the cumulative number of grants with a measure of the log of the cumulative real grant dollars provided, and indicates that a one percent increases in grant size increases the probability that downstream rivers are fishable by about 1 percent. To avoid excluding all the many plant×downstream ×year observations with zero cumulative grants, we specify row 20 as $ln(cumulativeDollars + 0.01)$.

Rows 21-26 of Appendix Table VI present several other important sensitivity analyses. Row 21 shows a differences-in-differences specification using data only from downstream waters. This specification includes plant fixed effects and water basin×year fixed effects, and reports the coefficient on a variable measuring the cumulative number of grants a plant has received. Row 22 allows arbitrary autocorrelation of confidence regions within year and within watershed. Row 23 includes monitoring sites on other rivers than the river where the wastewater treatment plant is directly located. Row 24 excludes small wastewater treatment plants that never received a grant. Row 25 shows unweighted OLS estimates. Row 26 adds several potentially important control variables, each interacted with a downstream indicator: whether the county of the wastewater treatment plant was in nonattainment under the Clean Air Act, separately for each air pollutant; the total population in the county-year of the wastewater treatment plant; and two indicators for the number of polluting industrial plants in the county-year of the wastewater treatment plant, extracted from the databases SWUM and PCS as described earlier.[20]

Finally, we estimate the effect of these grants on other pollutants (Appendix Table IV, column 2). We find no effect of a grant on any of the industrial pollutants (lead, mercury, or phenols), and perverse signs for two of the three. It is not impossible for a grant to affect these industrial pollutants, since some industrial waste can flow through treatment plants, but the lack of substantive effects on any of these three and incorrect signs are consistent with the idea that these grants are not correlated with unobserved variables like industrial activity or industrial water pollution regulations. We also detect no effects of grants on most measures of nutrients or more general water quality measures such as chlorides, stream flow, or temperature.

The main text uses these regressions to calculate the cost-effectiveness of grants. It is also useful to consider how our cost-effectiveness estimates would change under different assumptions about crowd out. Table III shows that it costs \$0.53 million annually to increase dissolved oxygen saturation in a river-mile by 10 percent, and \$1.5 million annually to make a river-mile fishable. Our real pass-through point estimate of 0.89 from column (4) of Table IV implies cost-effectiveness numbers of \$0.47 million for oxygen and \$1.34 million for the fishable standard. The 95 percent confidence region for our real pass-through estimate ranges from 0.44 to 1.34, which implies a range of cost-effectiveness values between \$0.23 million and \$0.71 million for oxygen, and between \$0.66 million and \$2.01 million for fishable. All these estimates represent the cost per year to make a river mile fishable or to increase dissolved oxygen saturation by 10 percent for a year.

[19]Around half of the plants we analyze have at least one other plant within 25 miles upstream or 25 miles downstream, and the mean plant in our data has 1.7 other plants within 25 miles upstream or 25 miles downstream.

[20]Because the SWUM data are only observed in 1972, they are interacted with a full set of year indicators, in addition to the interaction with downstream indicators.

Heterogeneity

For several attributes of grants, we estimate regressions like equation (3), but include an additional interaction of the main downstream×grants term with a given binary characteristic of grants.[21] Appendix B.8 describes measurement of these characteristics.

Columns (1)-(2) of Appendix Table VII report these estimates, and columns (5)-(6) use these regressions along with data on grant costs to estimate cost-effectiveness. We compare these cost-effectiveness values against the numbers in Table III, rows 7-8, column 3, to see how they compare to the average grant. Row 1 finds that grant projects above the median size ($1.2 million) cause larger decreases in pollution. Because these larger grants cost more, however, columns (5)-(6) suggest they are slightly less cost effective than the mean grant. Row 2 analyzes grants for plants that initially had more advanced (secondary or tertiary) abatement technology. If plants face increasing marginal abatement costs, then grants given to plants with better initial technology might be less cost-effective.[22] Row 2 does not provide evidence to support this hypothesis, and the point estimates actually suggest that grants to plants with tertiary technology are more cost-effective. These estimates are imprecise, however, and we interpret them cautiously given the poor quality of the data on abatement technologies (see Appendix B.8). Row 3 suggests that grants to more polluted areas decrease pollution more and are slightly less cost-effective. Row 4 suggests that grants to state-years with decentralization authority to manage NPDES permits are more effective, and have similar cost-effectiveness.

Rows 5-7 of Appendix Table VII study three additional dimensions of heterogeneity which are more relevant to housing markets. We discuss them briefly here. Row 5 finds that grants to counties with a large share of people who do outdoor fishing or swimming are significantly more cost-effective.[23] These counties may be more rural, so may face lower wage and construction costs. Row 6 finds that states with pro-environmental views have slightly more cost-effective grants. Row 7 considers two sets of cities highlighted in the urban economics literature—declining older cities (Glaeser and Gyourko 2005), and high amenity cities (Albouy 2016). Both groups of cities have low cost effectiveness. High amenity areas may face high wages and construction costs, while declining urban areas may have governments which are less effective at managing grants. Row 8 compares across the four census regions; only the Northeast has significantly lower cost-effectiveness, which occurs in part because grants there are estimated to decrease pollution less.

E.3 Hedonic Estimates: Sensitivity and Heterogeneity

Appendix Table VIII reports sensitivity analyses for the effect of grants on home values. Columns (1)-(3) report effects of grants on log mean home values for different radii. Columns (4)-(6) analyze rental values. Columns (7)-(12) report estimates for residential characteristics like income, education, race, and age. If residents value characteristics of neighbors and grants change those characteristics, then looking only at price or quantity effects could poorly measure willingness to pay (Bayer, Ferreira and McMillan 2007; Greenstone and Gallagher 2008).

Each row describes different analyses. Row 2 excludes all housing units within a 1-mile radius in any direction of the treatment plant, to address the possibility that grants change local disamenities from a

[21]If Z_{py} is a characteristic of plant p in year y, we add the controls $G_{py}d_dZ_{py}$ and $Z_{py}\eta_{dwy}$ to equation (3). The term $Z_{py}\eta_{dwy}$ allows the downstream×basin×year fixed effects to vary with the binary characteristic Z_{py}.

[22]Advanced abatement technologies can target pollutants which more basic abatement technologies do not target. So it is plausible that the marginal abatement cost curve for an individual emitted pollutant is increasing, but the curve for ambient levels of an omnibus measure of water pollution like dissolved oxygen or fishability is not substantially increasing over the range of technologies we observe.

[23]As described in Appendix B.8, the measure of swimming includes only natural water bodies and excludes swimming pools.

plant like noise or odor. Row 3 allows two-way clustering of standard errors by watershed and also by year. The richest specifications of Table V include baseline controls interacted with year fixed effects; row 4 removes these baseline controls. Row 5 reports a differences-in-differences-in-differences regression comparing upstream versus downstream home values.[24] Row 6 reports unweighted OLS estimates. Row 7 replaces downstream×basin×year fixed effects with downstream×year fixed effects and basin linear time trends. Row 8 reports estimates only for grants given in the year 1972. If communities in later years knew in advance a plant would receive a grant, then estimates for later years could be confounded by homeowner expectations. Row 9 reports the change in housing values around 1987 for plants that never received a grant. If homeowners had accurate expectations about future grants, these plants may have experienced a decrease in home values once the grants largely ceased. Row 10 allows grants to affect outcomes after 10 years, which may be important if local public goods are only gradually incorporated into self-reported housing values.

Appendix Table VIII suggests little evidence that grants changed the composition of local residents (columns 7-12). All these point estimates are small, and most are statistically indistinguishable from zero. More broadly, these estimates do not change our qualitative conclusions about how grants affect housing values (columns 1-6), though point estimates do vary. There is modest evidence that home values (though not rents) increase within 0.25 or 1.0 miles of affected waters, though point estimates within 25 miles are uniformly small and indistinguishable from zero. The unweighted estimates for housing (though not rents) are more positive, which may suggest larger effects for less densely populated areas, where outdoor fishing and swimming may be more common.

It is also useful to consider how alternative pass-through numbers would change the interpretation of our results. The point estimate in column (4) of Table IV implies that each dollar of federal grants leads to 89 cents of additional municipal capital spending. In terms of Table VI, this point estimate of pass-through would imply that the ratio of the change in housing values to costs is 0.27. The 95 percent confidence interval of our pass-through estimate ranges from 0.44 to 1.34; in terms of Table VI, this implies the ratio of the change in housing values to costs ranges between 0.18 and 0.55. Alternatively, one way to assess the importance of crowdout is to ask: what value of pass-through would be needed to make the change in housing values exceed costs? Table VI implies that for any pass-through rate above 0.24, costs exceed the change in housing values.

Heterogeneity

We now analyze variation across groups of grants in the ratio of a grant's measured benefits to its costs. This is useful to determine what types and levels of investment may be particularly valuable. For several attributes of grants, we therefore estimate regressions like equation (6), but include an additional interaction of the main grants term with a given binary characteristic of grants.[25]

Columns (3) and (4) of Appendix Table VII show regression estimates which allow the hedonic price function to differ across census regions and other divisions of the data. Column 7 shows the ratio of measured benefits to costs. Rows 1-4 consider heterogeneity most relevant for grants' effects on pollution. The ratio of measured benefits to costs is not significantly different from that of the average grant for any of these rows. Row 5 considers grants to areas where a large share of people go fishing or swimming. The ratio of measured benefits to costs here is double the ratio for the mean grant. Row 6 finds that grants to states with pro-environmental views also have a greater ratio than that of the mean grant. Row 7 finds that grants to

[24]In this sensitivity analysis, we draw a straight line through the treatment plant which is perpendicular to the river as it flows through the treatment plant. We put homes upstream of this line in the upstream group, and similarly for downstream homes.

[25]Formally, if Z_{py} is a characteristic of plant p in year y, we add the controls $G_{py}Z_{py}$ and $Z_{py}\eta_{wy}$ to equation (6). The term $Z_{py}\eta_{wy}$ allows basin×year fixed effects to vary with the binary characteristic Z_{py}.

declining urban areas (Glaeser and Gyourko 2005) have actually negative (but statistically indistinguishable from zero) ratios, while the ratio for high amenity areas (Albouy 2016) is greater. Finally, row 8 tests for differences in the housing market response by census region. This specification finds that grants to the West and Northeast have smaller ratios, while grants to the South have larger ratios around 0.84. None of these ratios in rows 5-8 are significantly different than that of the mean grant.

F Interpreting Hedonic Estimates

Section VII.C in the main text describes several reasons for why the hedonic model might provide a lower bound on willingness to pay for Clean Water Act grants. This section describes several additional possible reasons which we believe have weaker empirical support.

First, the effects of these grants could have been reflected in changes in housing supply or in the characteristics of local residents (Greenstone and Gallagher 2008). As discussed earlier, Table V and Appendix Table VIII show little evidence of changes in either.

Second, people might not fully consider recreational demand or aesthetics when buying a home. Applications of the hedonic model generally assume that homeowners have complete information about the attributes of the home they are buying, not least because a home is typically a person's largest purchase. This common assumption seems plausible in this setting.

Third, if homeowners already expected a grant in a given year, then that grant might affect home prices before it was received. Qualitative evidence on such expectations is ambiguous. As Section II.A explains, states were supposed to discuss priority lists in public hearings, which could provide public knowledge about plants that might soon receive grants. The extent of such public knowledge is unclear, however, and both priority lists and the national budget of the grants program changed substantially between years. Available quantitative evidence does not show clear support for this idea. Homeowner expectations formed in the year(s) before a grant would create a positive pretrend in home values, but Figure IV shows a flat pre-trend in the ten years before a grant. If expectations played a large role overall, then grants given in the first year of the program (1972) might have larger effects since these were largely unexpected. Row 8 of Appendix Table VIII estimates only the effect of grants given in the year 1972, and finds similar effects to the overall estimates of Row 1. Finally, we test for a change in home values in 1987, the year the grants largely concluded, for plants that failed to receive a grant. The point estimates for this are negative but not statistically distinguishable from either zero or the main estimates (Row 9).

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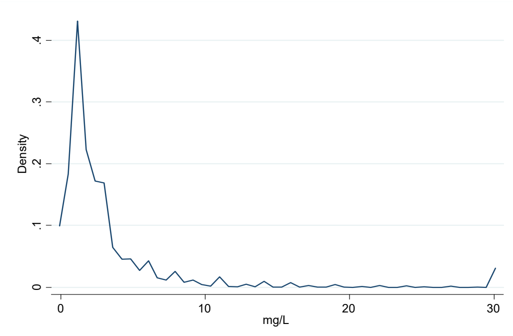
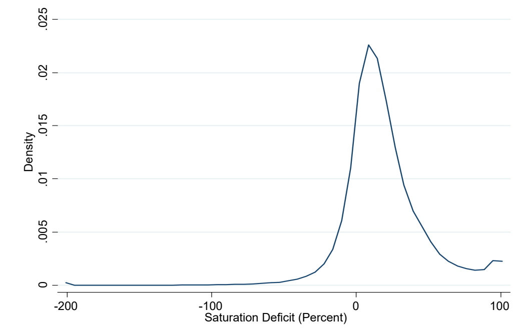
APPENDIX FIGURE I

Densities of Raw Pollution Readings

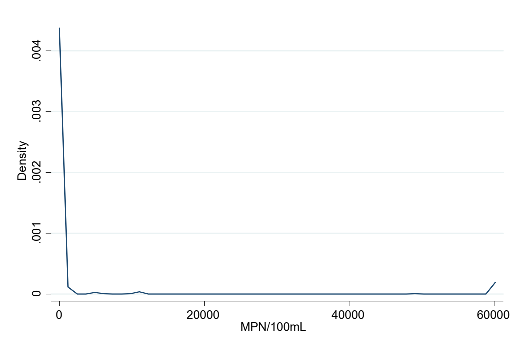
Panel A. Biochemical Oxygen Demand



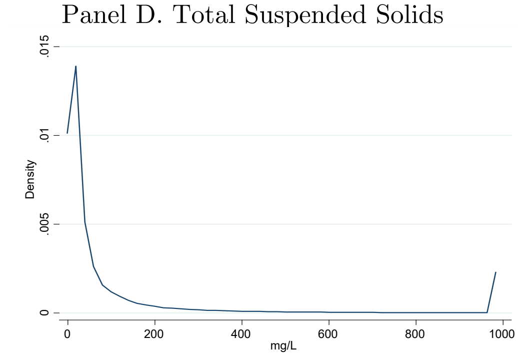
Panel B. Dissolved Oxygen Deficit



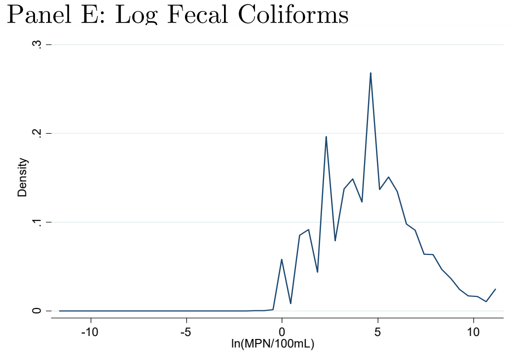
Panel C. Fecal Coliforms



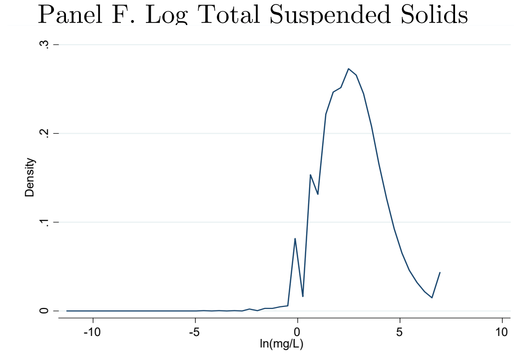
Panel D. Total Suspended Solids



Panel E: Log Fecal Coliforms



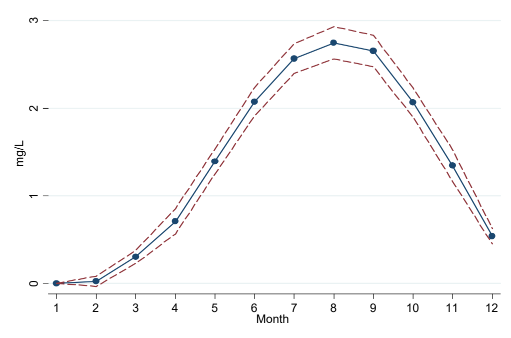
Panel F. Log Total Suspended Solids



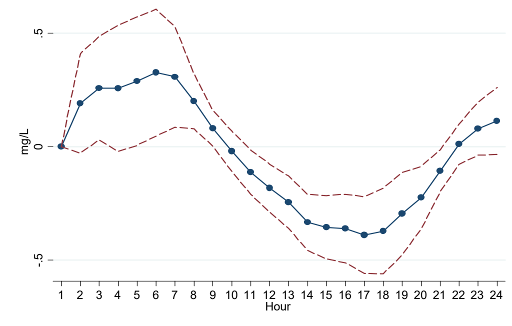
Notes: Data include years 1962-2001.

APPENDIX FIGURE II
Patterns in Dissolved Oxygen Deficits

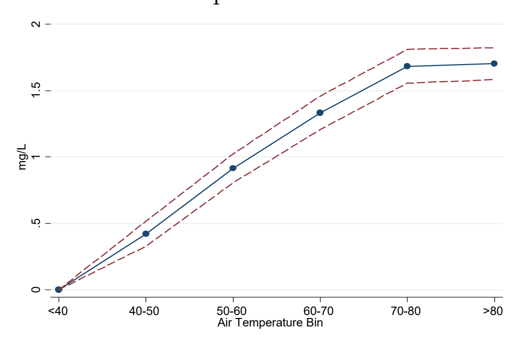
Panel A. Month



Panel B. Hour



Panel C. Air Temperature

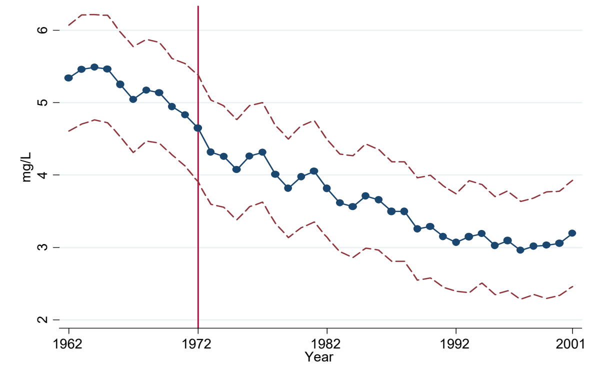


Notes: Figures show coefficients from a regression of dissolved oxygen deficit on monitoring station fixed effects and on dummy variables for the indicated controls. Data use only dissolved oxygen measured in mg/L. Dissolved oxygen deficit is measured as 15 minus the reported level of dissolved oxygen in mg/L. Data cover years 1962-2001.

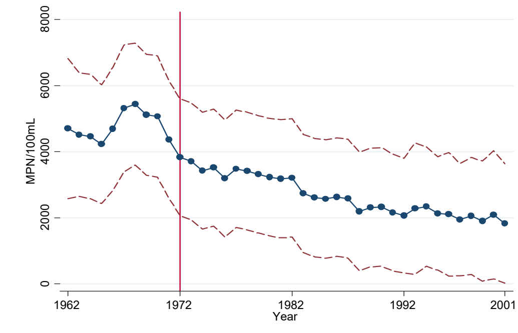
APPENDIX FIGURE III

Water Pollution Trends, Other Pollution Measures, 1962-2001

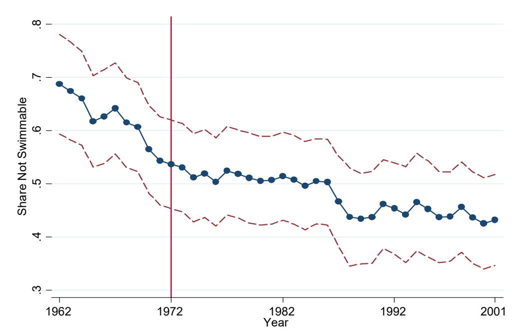
Panel A. Biochemical Oxygen Demand



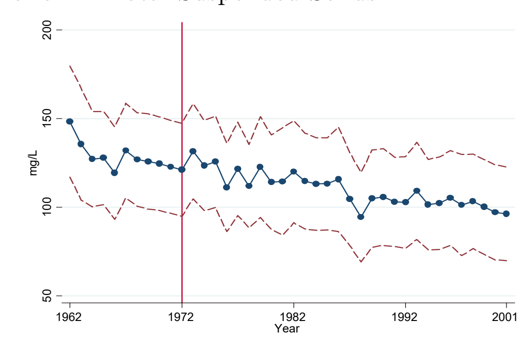
Panel B. Fecal Coliforms



Panel C. Not Swimmable



Panel D. Total Suspended Solids

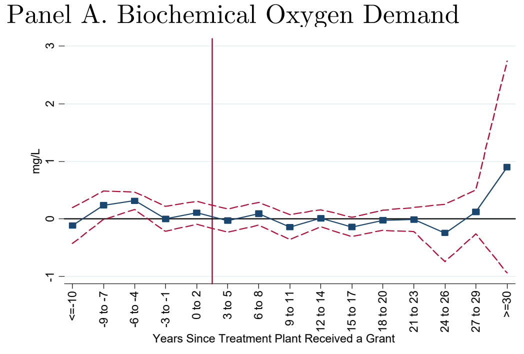


Notes: These graphs show year fixed effects plus the constant from regressions which control for monitoring site fixed effects, year fixed effects, day-of-year cubic polynomial, and hour-of-day cubic polynomial, corresponding to equation (1) in the text. Connected dots show yearly values, dashed lines show 95% confidence interval, and 1962 is reference category. Standard errors are clustered by watershed.

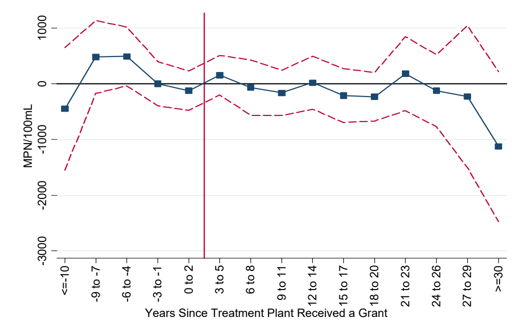
APPENDIX FIGURE IV

Effects of Clean Water Act Grants on Water Pollution, Event Study,
Other Pollution Measures

Panel A. Biochemical Oxygen Demand

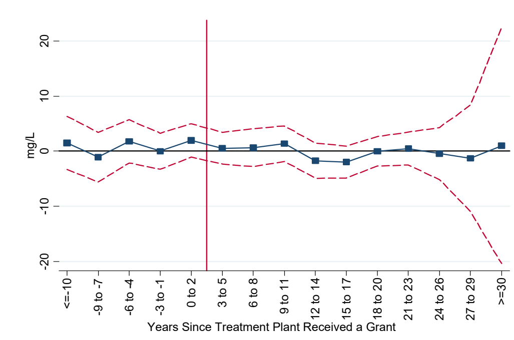


Panel B. Fecal Coliforms



Panel C. Share Not Swimmable

Panel D. Total Suspended Solids

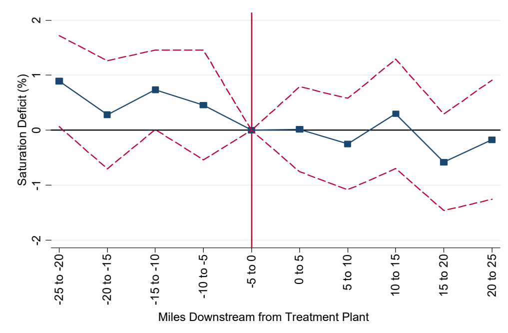


Notes: Graphs show coefficients on downstream times year-since-grant indicators from regressions which correspond to the specification of Table II. These regressions are described in equation (4) from the main text. Connected dots show yearly values, dashed lines show 95% confidence interval. Data cover years 1962-2001. Standard errors are clustered by watershed.

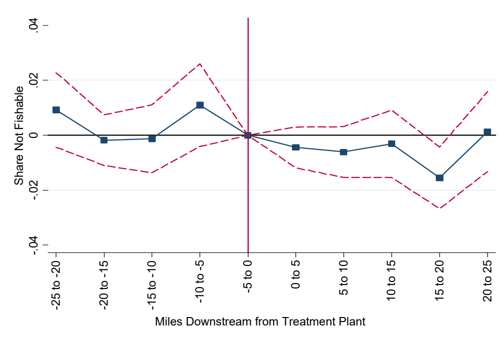
APPENDIX FIGURE V

Effects of Clean Water Act Grants on Water Pollution
by Distance Downstream from Treatment Plant

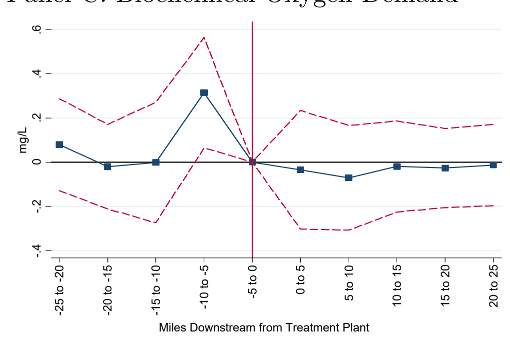
Panel A. Dissolved Oxygen Deficit



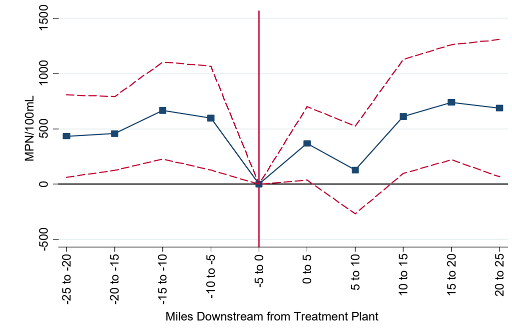
Panel B. Not Fishable



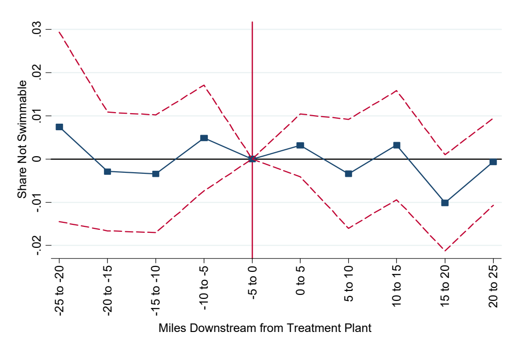
Panel C. Biochemical Oxygen Demand



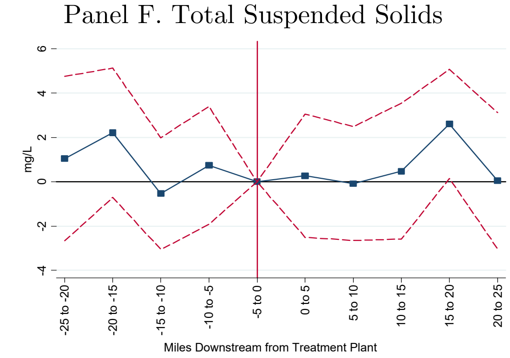
Panel D. Fecal Coliforms



Panel E. Not Swimmable

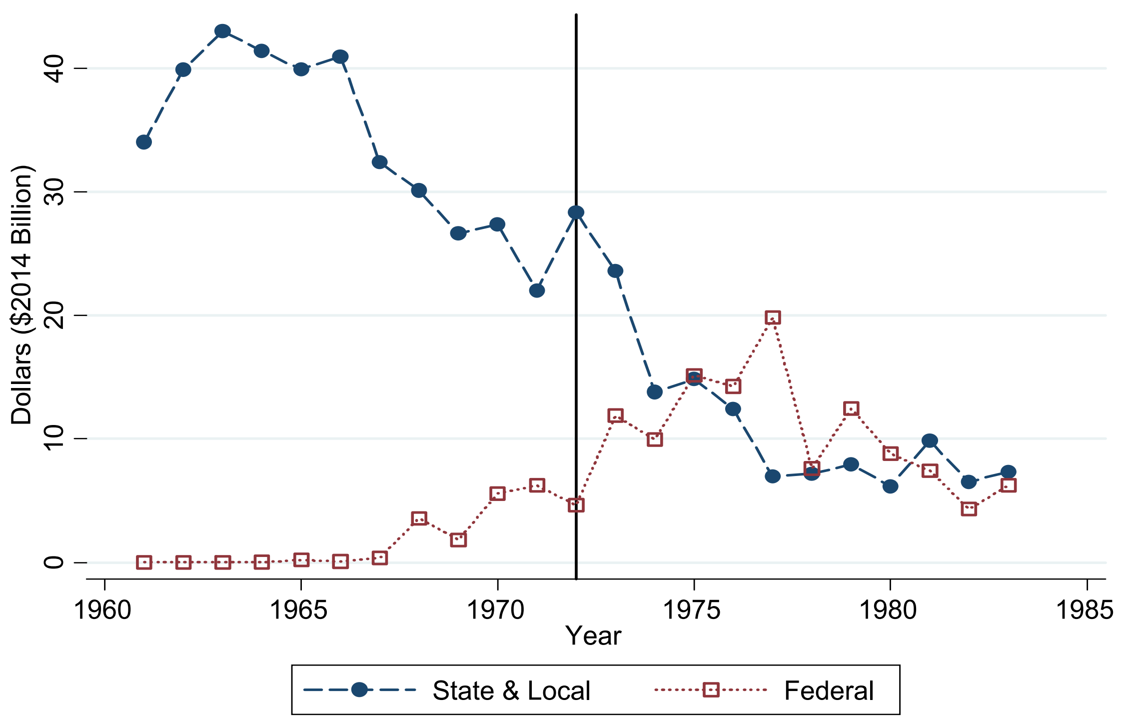


Panel F. Total Suspended Solids



Notes: Graphs show distance-from-plant times cumulative grant indicators from regressions which also control for plant-by-distance, plant-by-year, and distance-by-water basin-by-year fixed effects. These regressions are similar to equation (4) in the text, though with indicators for distance-from-plant rather than years-since-grant. Connected dots show yearly values, dashed lines show 95% confidence interval. Data cover years 1962-2001. Standard errors are clustered by watershed.

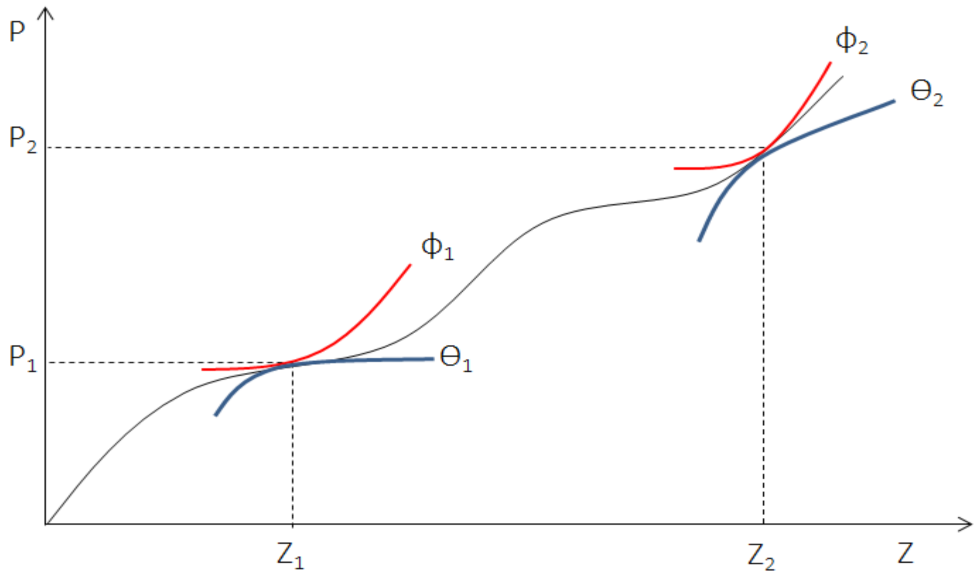
APPENDIX FIGURE VI
Federal and Local Wastewater Treatment Capital Spending 1960-1983



Notes: State and local data from CBO (1985). Federal data from GICS. All values deflated by Engineering News Record construction price index. The vertical black line shows 1972, when the U.S. government passed the Clean Water Act.

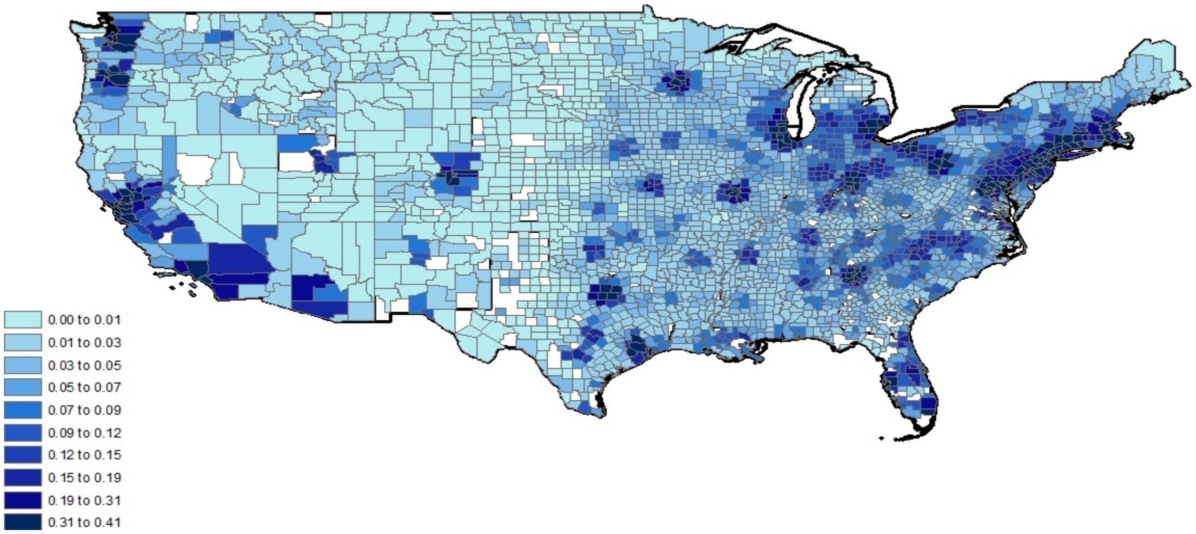
APPENDIX FIGURE VII

The Hedonic Model



APPENDIX FIGURE VIII

Ratio of Change in Housing Values to Grant Costs, by County



Notes: We divide treatment plants into ten deciles based on the population in the year 2000 which is within a 25 mile radius in any direction of the river segments that are up to 25 miles downstream of the plant and on the same river as the plant. For each decile, we calculate the total value of owned homes and rentals satisfying the same criteria (within a 25 mile radius, etc.). To estimate the change in housing values, we apply the regression estimates from column (4) of Table VI, and assume improvements last 30 years. For each decile, we measure costs using the grants data. For each decile, we divide the total change in housing values by total costs. Finally, we calculate the unweighted average of this ratio across all plants in a county, and the map plots the result. Counties in white have no treatment plants or missing data.

APPENDIX TABLE I
WATER POLLUTION DESCRIPTIVE STATISTICS

	Pooled	Biochemical Oxygen Demand	Dissolved Oxygen Deficit	Fecal Coliforms	Total Suspended Solids
	(1)	(2)	(3)	(4)	(5)
Mean	—	3.10	19.85	1,656.46	51.73
Standard Deviation	—	4.26	28.31	7,178.04	132.13
5th Percentile	—	0.30	-15.40	0.00	1.00
95th Percentile	—	10.00	80.46	6,000.00	210.00
Number of Distinct . . .					
Observations	10,991,992	1,285,357	5,883,715	2,086,392	1,736,528
Monitoring Sites	180,075	55,188	154,769	82,153	70,615
River Segments	96,674	35,596	86,941	50,073	44,889
Rivers	46,369	16,987	41,748	25,043	22,343
Mean Years per Monitoring Site	10	11	10	11	10
Mean Readings per Monitoring Site	61	23	38	25	25
Share in Metro Areas	0.26	0.29	0.26	0.25	0.27
Share from each repository:					
Storet Legacy	0.63	0.65	0.62	0.63	0.66
Storet	0.22	0.22	0.23	0.22	0.21
NWIS	0.14	0.14	0.15	0.15	0.12
Share from each type of surface water:					
Rivers	0.83	0.96	0.76	0.92	0.90
Lakes	0.17	0.04	0.24	0.08	0.10
Share of readings from each Census Region:					
Northeast	0.07	0.06	0.08	0.06	0.05
Midwest	0.27	0.23	0.25	0.24	0.39
South	0.50	0.59	0.49	0.53	0.41
West	0.17	0.13	0.18	0.17	0.15
Share of readings from ...					
1962-1971	0.08	0.14	0.08	0.07	0.04
1972-1981	0.32	0.38	0.28	0.43	0.30
1982-1991	0.29	0.26	0.30	0.26	0.31
1992-2001	0.31	0.23	0.34	0.24	0.35
Share of readings from monitoring sites operating in ...					
One Decade	0.28	0.27	0.31	0.28	0.33
Two Decades	0.30	0.30	0.31	0.29	0.31
Three Decades	0.29	0.25	0.29	0.32	0.27
Four Decades	0.13	0.18	0.09	0.11	0.09

Notes: Data cover years 1962-2001. Metro areas are defined as tracts from the 1970 census with non-missing home values data. Dissolved oxygen deficit equals 100 minus dissolved oxygen, measured in percent saturation. River segments are "comid"s, rivers are "levelpathi"s, as defined in the National Hydrography Dataset Plus, Version 2.1.

APPENDIX TABLE II
DESCRIPTIVE STATISTICS FOR TREATMENT PLANTS AND GRANTS

	All (1)	Regression Sample (3)
Number of Plants	18,455	7,074
Number of Grants	20,430	9,670
Mean Number of Grants:		
All Plants	1.11	1.37
Plants with ≥1 Grant	1.99	2.10
Share of Plants Receiving Following Number of Grants:		
None	0.44	0.35
Exactly 1	0.24	0.27
Exactly 2	0.17	0.20
3 to 5	0.13	0.16
6 or More	0.01	0.02
Federal Contribution for a Grant ($2014 Millions)		
Mean	8.05	9.22
5th Percentile	0.03	0.04
50th Percentile	0.86	1.16
95th Percentile	32.30	39.72
Total Cost of a Grant Project ($2014 Millions)		
Mean	26.92	31.09
5th Percentile	0.10	0.12
50th Percentile	2.91	3.91
95th Percentile	108.35	135.76

Notes: Table counts multiple grants to the same plant in a single year as one grant. Total cost of a grant project includes federal contribution, local capital cost, and operating and maintenance costs. Grant values are deflated using the Engineering News Record construction price index. Plants with zero grants, listed in columns (1) and (2), are plants that appear in in 1976, 1978, 1984, 1986, or 1988 Clean Watershed Needs Surveys (CWNS) with strictly positive population served, and which do not appear in the federal grants data. These are the only five years of the CWNS which were collected during the years of the grants program and which have accurate identifier codes for treatment plants. Data cover years 1962-2001.

APPENDIX TABLE III
WATER POLLUTION TRENDS, SENSITIVITY ANALYSIS

	Main Pollution Measures		Other Pollution Measures			
	Dissolved Oxygen Deficit (1)	Not Fishable (2)	Biochemical Oxygen Demand (3)	Fecal Coliforms (4)	Not Swimmable (5)	Total Suspended Solids (6)
1. Main Estimates	-0.240***	-0.005***	-0.065***	-81.097***	-0.005***	-0.915***
	(0.030)	(0.000)	(0.005)	(8.326)	(0.000)	(0.092)
Important Subsamples						
2. Long-Term Stations	-0.190***	-0.005***	-0.069***	-93.915***	-0.005***	-1.013***
(≤1971 to ≥1988)	(0.042)	(0.000)	(0.007)	(12.661)	(0.000)	(0.130)
3. Counties in Balanced Panel	-0.330***	-0.006***	-0.096***	-92.178***	-0.006***	-1.003***
of Home Values Data	(0.046)	(0.000)	(0.008)	(12.067)	(0.000)	(0.126)
4. USGS NWIS Repository	-0.215***	-0.004***	-0.066***	-103.894***	-0.005***	-0.875***
	(0.027)	(0.000)	(0.009)	(16.902)	(0.000)	(0.181)
5. Storet Legacy Repository	-0.279***	-0.005***	-0.067***	-70.937***	-0.005***	-0.889***
	(0.044)	(0.000)	(0.006)	(8.585)	(0.000)	(0.093)
6. Modern Storet Repository	-0.117***	-0.004***	-0.055***	-91.453***	-0.004***	-1.003***
	(0.037)	(0.000)	(0.008)	(12.254)	(0.000)	(0.191)
Standard Water Quality Tests						
7. Exclude Stations with Less	-0.239***	-0.005***	-0.065***	-80.523***	-0.005***	-0.928***
than 25 Readings	(0.030)	(0.000)	(0.005)	(8.415)	(0.000)	(0.096)
8. Stream Gauge Observations,	-0.288***	-0.005***	-0.077***	-97.988***	-0.006***	-0.961***
Control for Flow	(0.024)	(0.000)	(0.009)	(14.882)	(0.000)	(0.214)
9. July-August Only	-0.259***	-0.005***	-0.068***	-86.831***	-0.004***	-0.870***
	(0.045)	(0.000)	(0.007)	(8.603)	(0.000)	(0.105)
10. Readings Below Limit ("BDL")	-0.240***	-0.005***	-0.068***	-80.881***	-0.005***	-0.917***
Equal Half Listed Value	(0.030)	(0.000)	(0.005)	(8.331)	(0.000)	(0.092)
11. Logs, Not Levels	—	—	-0.014***	-0.030***	—	-0.015***
	—	—	(0.002)	(0.002)	—	(0.001)
Other Fishable and Swimmable Definitions						
12. River-Year Means	—	-0.003***	—	—	-0.003***	—
	—	(0.000)	—	—	(0.000)	—
13. River-Year Means,	—	-0.004***	—	—	-0.005***	—
50% Fish/Swim Defn.	—	(0.000)	—	—	(0.000)	—

APPENDIX TABLE III
WATER POLLUTION TRENDS, SENSITIVITY ANALYSIS (CONTINUED)

	Standards		Constituent Pollutants			
	Dissolved Oxygen Deficit	Not Fishable	Biochemical Oxygen Demand	Fecal Coliforms	Not Swimmable	Total Suspended Solids
	(1)	(2)	(3)	(4)	(5)	(6)
Well-Documented USGS Networks						
14. NASQAN Network	-0.237***	-0.004***	-0.040***	-55.013***	-0.007***	-1.615***
	(0.027)	(0.000)	(0.013)	(8.154)	(0.001)	(0.437)
15. NAWQA Network	-0.317***	-0.005***	-0.086***	-91.404***	-0.008***	-0.913***
	(0.037)	(0.001)	(0.021)	(18.533)	(0.001)	(0.311)
16. HBN Network	-0.352***	-0.002***	0.003	0.841	-0.006***	-0.146
(Isolated, Natural Areas)	(0.080)	(0.001)	(0.014)	(1.929)	(0.001)	(0.333)
Other Important Sensitivity Analyses						
17. Cluster by Watershed And	-0.240***	-0.005***	-0.065***	-81.097***	-0.005***	-0.915***
and Year	(0.034)	(0.000)	(0.006)	(10.426)	(0.000)	(0.142)
18. Lakes	-0.069**	-0.001	-0.035***	-4.495**	-0.001*	-0.489***
	(0.035)	(0.000)	(0.008)	(2.041)	(0.001)	(0.146)
19. Weather Controls	-0.239***	-0.005***	-0.065***	-81.692***	-0.005***	-0.977***
	(0.030)	(0.000)	(0.005)	(8.293)	(0.000)	(0.091)
20. County-Year Means,	-0.227***	-0.004***	-0.100***	-100.941***	-0.004***	-1.349***
Population-Weighted	(0.054)	(0.000)	(0.015)	(13.335)	(0.000)	(0.323)
21. Flexible Seasonality and Time	-0.241***	-0.005***	-0.066***	-77.773***	-0.004***	-0.885***
	(0.031)	(0.000)	(0.005)	(7.283)	(0.000)	(0.097)
22. Census Region: Northeast	-0.475***	-0.006***	-0.071***	-75.657**	-0.007***	-0.793***
	(0.126)	(0.001)	(0.011)	(31.541)	(0.001)	(0.159)
23. Census Region: Midwest	-0.261***	-0.005***	-0.064***	-74.061***	-0.005***	-0.783***
	(0.035)	(0.000)	(0.008)	(12.501)	(0.000)	(0.179)
24. Census Region: South	-0.187***	-0.004***	-0.062***	-90.399***	-0.004***	-0.812***
	(0.047)	(0.000)	(0.007)	(12.394)	(0.001)	(0.079)
25. Census Region: West	-0.256***	-0.004***	-0.098***	-56.476***	-0.004***	-1.706***
	(0.056)	(0.000)	(0.020)	(11.308)	(0.001)	(0.291)

Notes: Standard errors are clustered by watershed. Regressions include monitoring site fixed effects, season controls, and hour controls, except where otherwise noted. See text for details. Data cover years 1962-2001. Asterisks denote p-value < 0.10 (*), < 0.05 (**), or < 0.01 (***).

APPENDIX TABLE IV
RESULTS FOR OTHER MEASURES OF WATER POLLUTION

	Trend (1)	Downstream * Cumulative # of Grants (2)
Industrial Pollutants		
1. Lead (μg/L)	-0.099***	-0.336
	(0.004)	(0.541)
Dependent Variable Mean	2.332	22.809
N	477,426	20,524
2. Mercury (μg/L)	-0.011***	0.019
	(0.001)	(0.014)
Dependent Variable Mean	0.265	0.285
N	437,351	16,090
3. Phenols (μg/L)	-2.351**	11.162*
	(1.056)	(6.045)
Dependent Variable Mean	79.095	12.023
N	147,509	6,856
Nutrients		
4. Ammonia (mg/L)	-0.039***	-0.029**
	(0.002)	(0.012)
Dependent Variable Mean	-2.371	0.433
N	1,646,149	35,216
5. Nitrates (mg/L)	0.002	0.023
	(0.002)	(0.035)
Dependent Variable Mean	-1.147	1.175
N	697,682	15,418
6. Nitrite Nitrate (mg/L)	0.004***	0.067**
	(0.001)	(0.032)
Dependent Variable Mean	-1.059	1.321
N	1,453,593	26,782
7. Nitrogen (mg/L)	-0.003**	2.119
	(0.001)	(48.402)
Dependent Variable Mean	3.139	2005.864
N	739,175	7,618
8. Orthophosphate (mg/L)	-0.024***	-0.015*
	(0.003)	(0.008)
Dependent Variable Mean	-3.482	0.224
N	825,871	11,756
9. Phosphorus (mg/L)	-0.006***	0.001
	(0.000)	(0.008)
Dependent Variable Mean	0.248	0.344
N	2,375,437	35,430

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APPENDIX TABLE IV
RESULTS FOR OTHER MEASURES OF WATER POLLUTION (CONTINUED)

	Trend (1)	Downstream * Cumulative # of Grants (2)
General Water Quality Measures		
10. Dissolved Chlorides (mg/L)	0.002	-8.638
	(0.001)	(8.205)
Dependent Variable Mean	3.054	106.341
N	1,042,847	16,340
11. Total Chlorides (mg/L)	-0.002	-16.476
	(0.002)	(11.705)
Dependent Variable Mean	3.700	146.167
N	1,530,675	19,602
12. Total Coliforms (count/100mL)	-0.047***	-2841.798
	(0.007)	(2094.212)
Dependent Variable Mean	6.453	33388.102
N	703,289	12,668
13. Color (PCU)	0.001	1.381
	(0.001)	(1.047)
Dependent Variable Mean	3.340	32.260
N	632,713	11,496
14. pH (pH units)	0.007***	-0.006
	(0.001)	(0.005)
Dependent Variable Mean	7.430	7.508
N	6,614,284	65,370
15. Total Dissolved Solids (mg/L)	0.000	-25.729*
	(0.001)	(14.071)
Dependent Variable Mean	5.418	443.611
N	1,884,714	28,186
16. Dissolved Sulfate (mg/L)	-0.001*	-2.283
	(0.001)	(2.482)
Dependent Variable Mean	3.67	102.37
N	805,268	15,964
17. Stream Flow (Instanganeous, CFS)	0.000	-55.421
	(0.001)	(69.426)
Dependent Variable Mean	4.126	2264.543
N	2,019,814	24,180
18. Temperature (F)	0.024***	-0.062
	(0.005)	(0.052)
Dependent Variable Mean	60.061	58.973
N	11,027,029	68,838
19. Turbidity (NTU)	-0.488***	-0.637
	(0.049)	(0.432)
Dependent Variable Mean	21.546	26.419
N	2,433,788	30,592

Notes: Standard errors are clustered by watershed. Data cover years 1962-2001. All pollutants except mercury, phenols, phosphorus, pH, temperature, and turbidity are in logs. Asterisks denote p-value < 0.10 (*), < 0.05 (**), or < 0.01 (***).

APPENDIX TABLE V

WATER POLLUTION UPSTREAM VERSUS DOWNSTREAM OF TREATMENT PLANTS

	Main Pollution Measures		Other Pollution Measures			
	Dissolved Oxygen Deficit	Not Fishable	Biochemical Oxygen Demand	Fecal Coliforms	Not Swimmable	Total Suspended Solids
	(1)	(2)	(3)	(4)	(5)	(6)
Downstream	1.234***	0.040***	0.611***	906.457***	0.052***	5.240***
	(0.370)	(0.004)	(0.088)	(218.677)	(0.005)	(1.245)
N	59,150	63,698	31,452	37,446	63,698	33,392
Dep. Var. Mean	12.02	0.19	3.24	2,162.94	0.46	45.78
Plant-by-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Weather	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Each observation in a regression is a plant-downstream-year tuple. Data cover years 1962-2001. Dissolved oxygen deficit equals 100 minus dissolved oxygen saturation, measured in percentage points. Dependent variable mean is for upstream pollution. Standard errors are clustered by watershed. Asterisks denote p-value < 0.10 (*), < 0.05 (**), or < 0.01 (***).

APPENDIX TABLE VI

SENSITIVITY ANALYSIS: EFFECTS OF CLEAN WATER ACT GRANTS ON WATER POLLUTION

	Main Pollution Measures		Other Pollution Measures			
	Dissolved Oxygen Deficit	Not Fishable	Biochemical Oxygen Demand	Fecal Coliforms	Not Swimmable	Total Suspended Solids
	(1)	(2)	(3)	(4)	(5)	(6)
1. Main Estimates	-0.681***	-0.007**	-0.104**	-204.059**	-0.004*	-0.497
	(0.206)	(0.003)	(0.041)	(98.508)	(0.002)	(0.635)
Important Subsamples						
2. Long-Term Stations	-1.327***	-0.031***	-0.204	-447.958	-0.008**	-1.991
(≤1971 to ≥1988)	(0.307)	(0.011)	(0.128)	(343.889)	(0.003)	(2.006)
3. Facilities with Balanced	-0.698***	-0.007**	-0.095**	-168.291	-0.004	-0.569
Panel of Home Values	(0.216)	(0.003)	(0.045)	(110.788)	(0.002)	(0.728)
4. USGS NWIS Repository	-0.601	-0.014***	0.185	-11.489	-0.021**	4.382**
	(0.864)	(0.005)	(0.213)	(199.026)	(0.010)	(1.802)
5. Storet Legacy Repository	-0.418	-0.007	-0.130**	-243.637*	0.000	-0.782
	(0.254)	(0.005)	(0.063)	(128.624)	(0.003)	(0.552)
6. Modern Storet Repository	-1.076**	-0.007	-0.152*	-371.895**	-0.010*	-0.556
	(0.470)	(0.005)	(0.077)	(163.474)	(0.005)	(0.408)
7. Only Years ≥1972	-0.689***	-0.009***	-0.120**	-102.068	-0.002	-0.403
	(0.211)	(0.003)	(0.057)	(80.653)	(0.002)	(0.666)
Standard Water Quality Tests						
8. Exclude Stations with Less	-0.729***	-0.008***	-0.113**	-131.616	-0.004**	-0.313
than 25 Readings	(0.241)	(0.003)	(0.053)	(122.135)	(0.002)	(0.667)
9. Stream Gauge Observations,	-0.746*	-0.012**	-0.152	-79.395	-0.007	2.690
Control for Flow	(0.443)	(0.006)	(0.129)	(104.851)	(0.006)	(1.901)
10. July-August Only	-1.299***	-0.015***	-0.134**	-102.118	-0.011***	-0.056
	(0.384)	(0.004)	(0.060)	(157.806)	(0.004)	(0.917)
11. Readings Below Limit	-0.683***	-0.007**	-0.103***	-203.296**	-0.004*	-0.499
Equal Half Listed Value	(0.206)	(0.003)	(0.040)	(98.556)	(0.002)	(0.634)
12. Logs, Not Levels	—	—	-0.009	-0.009	—	-0.004
	—	—	(0.007)	(0.024)	—	(0.009)
Other Fishable and Swimmable Definitions						
13. 50% Fishable-Swimmable	—	-0.024***	—	—	0.003	—
Definition	—	(0.005)	—	—	(0.006)	—

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APPENDIX TABLE VI

SENSITIVITY ANALYSIS: EFFECTS OF CLEAN WATER ACT GRANTS ON WATER POLLUTION (CONTINUED)

	Main Pollution Measures		Other Pollution Measures			
	Dissolved Oxygen Deficit	Not Fishable	Biochemical Oxygen Demand	Fecal Coliforms	Not Swimmable	Total Suspended Solids
	(1)	(2)	(3)	(4)	(5)	(6)
Other Distances Upstream and Downstream of Treatment Plant						
14. Separate by Downstream Dist.						
0 to 25 Miles Downstream	-0.609***	-0.009***	-0.089**	-242.452***	-0.002	-1.109**
	(0.187)	(0.002)	(0.038)	(76.392)	(0.002)	(0.503)
25 to 50 Miles Downstream	-0.122	0.007	-0.066*	144.737	0.004	-0.112
	(0.318)	(0.005)	(0.037)	(105.492)	(0.004)	(1.175)
50 to 75 Miles Downstream	0.029	0.002	-0.030	147.027	0.001	-0.073
	(0.259)	(0.004)	(0.051)	(99.837)	(0.003)	(0.935)
75 to 100 Miles Downstream	0.845	0.000	-0.195	-109.594	0.006	0.047
	(0.654)	(0.005)	(0.129)	(121.537)	(0.008)	(1.120)
15. Plants with Monitors > 10 Mi. Upstream and Downstream	-0.744***	-0.008***	-0.119***	-232.851**	-0.005**	-0.203
	(0.218)	(0.003)	(0.039)	(112.330)	(0.002)	(0.556)
Other Specifications for Measuring Grants						
16. Grants for Construction	-1.180***	-0.010***	-0.127**	-116.894	-0.006**	-0.360
	(0.222)	(0.004)	(0.051)	(130.419)	(0.003)	(0.787)
17. Cumulative number of grants						
One	-0.853*	-0.009	0.034	-513.221*	-0.011	1.213
	(0.509)	(0.007)	(0.119)	(284.849)	(0.008)	(2.011)
Two	-1.066	-0.021**	-0.222	-574.140*	-0.017	0.779
	(0.675)	(0.011)	(0.158)	(336.056)	(0.011)	(2.586)
Three	-0.996	-0.009	-0.334*	-437.879	-0.017	0.562
	(0.942)	(0.013)	(0.173)	(395.305)	(0.014)	(3.482)
Four	-2.168**	-0.028**	-0.336	-755.137	-0.023	-6.278*
	(1.008)	(0.013)	(0.259)	(499.611)	(0.015)	(3.586)
Five or More	-4.006***	-0.043**	-0.539	-1115.660	-0.027*	-5.797
18. Control for Cumulative Upstream Grants	-0.803***	-0.008***	-0.099**	-279.674***	-0.002	-0.673
	(0.214)	(0.003)	(0.048)	(89.902)	(0.003)	(0.654)
19. Cumulative Grants by Grant Project Amount						
$0 to $0.4 million	1.124*	0.011	-0.115	-77.641	0.012	1.976
	(0.626)	(0.008)	(0.171)	(374.399)	(0.008)	(2.814)
$0.4 to $3.5 million	-0.592	-0.005	-0.172*	-76.235	-0.002	0.208
	(0.517)	(0.006)	(0.099)	(234.044)	(0.006)	(1.419)
> $3.5 Million	-0.971***	-0.009***	-0.090**	-249.046*	-0.006**	-0.714
	(0.213)	(0.003)	(0.044)	(143.616)	(0.003)	(0.705)
20. Log Cumulative Real Grant Dollars ($Bn)	-0.942***	-0.009**	-0.055	-300.132*	-0.008	-1.232
	(0.309)	(0.004)	(0.077)	(180.673)	(0.005)	(1.197)

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APPENDIX TABLE VI

SENSITIVITY ANALYSIS: EFFECTS OF CLEAN WATER ACT GRANTS ON WATER POLLUTION (CONTINUED)

	Main Pollution Measures		Other Pollution Measures			
	Dissolved Oxygen Deficit (1)	Not Fishable (2)	Biochemical Oxygen Demand (3)	Fecal Coliforms (4)	Not Swimmable (5)	Total Suspended Solids (6)
Other Important Sensitivity Analyses						
21. Differences-in-Differences	-0.619***	-0.009***	-0.083	-288.184***	-0.003*	-0.924**
Downstream Areas Only	(0.157)	(0.002)	(0.057)	(71.059)	(0.002)	(0.407)
22. Cluster by Watershed	-0.681***	-0.007**	-0.104**	-204.059**	-0.004*	-0.497
and Year	(0.201)	(0.003)	(0.039)	(84.722)	(0.002)	(0.608)
23. Include Monitors on	-0.264	-0.004**	0.001	-198.913*	0.001	0.279
Other Rivers	(0.191)	(0.002)	(0.048)	(104.392)	(0.002)	(0.745)
24. Exclude Plants with	-0.627**	-0.007**	-0.074	-268.193*	-0.003	-0.233
No Grants	(0.252)	(0.003)	(0.054)	(160.472)	(0.003)	(0.773)
25. Unweighted	-0.793***	-0.004**	-0.108**	-316.697**	-0.003	-0.738
	(0.194)	(0.002)	(0.053)	(133.596)	(0.003)	(1.214)
26. Control for Downstream *. . .	-0.814***	-0.009***	-0.110***	-219.371***	-0.007***	-0.369
Nonattainment, Industrial	(0.180)	(0.003)	(0.036)	(70.975)	(0.002)	(0.607)
Sources, Population						

Notes: "Long Term Stations" includes only stations which begin operating by 1971 and continue through at least 1988. "Control for Stream Gauge Flow" includes only stations which report instantaneous stream flow at the same time they report pollution, and it controls for streamflow. "Include Monitors on Other Rivers" includes monitors on rivers different than the treatment plant, but that eventually flow into or out of the treatment plant s river. Data cover years 1962-2001. Standard errors are clustered by watershed. Asterisks denote p-value < 0.10 (*), < 0.05 (**), or < 0.01 (***).

APPENDIX TABLE VII

HETEROGENEITY OF CLEAN WATER ACT GRANTS ON WATER POLLUTION AND HOME VALUES

	Regressions				Fitted Values		
Dependent Variable	Dissolved Oxygen Deficit (1)	Not Fishable (2)	Log Mean Home Values (3)	Log Mean Rents (4)	Cost Per Unit Dissolved Oxygen (5)	Cost Per River-Mile Fishable (6)	Change in Housing Values / Costs (7)
1. Cumulative Grants	0.129	-0.011	-0.00019	-0.00068	—	—	—
	(0.404)	(0.010)	(0.00081)	(0.00044)	—	—	—
... * Grant Projects	-0.874**	-0.010	0.00052	0.00067	0.74	2.54	0.25
Above $1.2 Million	(0.432)	(0.012)	(0.00082)	(0.00043)	[0.51 , 1.32]	[1.66 , 5.46]	(0.26)
2. Cumulative Grants	-0.589	-0.043***	0.00101	-0.00061	---	---	---
	(0.564)	(0.014)	(0.00113)	(0.00048)	---	---	---
... * Baseline Treatment:	-0.076	0.025*	-0.00128	0.00047	0.42	1.60	-0.42
Secondary	(0.595)	(0.015)	(0.00115)	(0.00051)	[0.24 , 1.69]	[0.94 , 5.57]	(0.67)
... * Baseline Treatment:	-1.266	-0.008	-0.00103	-0.00015	0.20	0.72	-0.35
Tertiary	(0.948)	(0.034)	(0.00137)	(0.00054)	[0.11 , 0.70]	[0.35, ∞)	(1.00)
3. Cumulative Grants	-0.379	-0.008	0.00054	-0.00024	---	---	---
	(0.231)	(0.007)	(0.00085)	(0.00033)	---	---	---
... * Baseline Pollution	-0.264	-0.015	-0.00033	0.00011	0.75	2.13	0.19
Above Median	(0.297)	(0.009)	(0.00095)	(0.00043)	[0.47 , 1.90]	[1.40 , 4.52]	(0.43)
4. Cumulative Grants	-0.510**	-0.008	-0.00014	0.00016	---	---	---
	(0.202)	(0.008)	(0.00076)	(0.00036)	---	---	---
... * State Authority to	-0.122	-0.012	0.00030	-0.00050	0.52	1.65	0.07
Administer NPDES	(0.173)	(0.007)	(0.00091)	(0.00042)	[0.35 , 1.06]	[1.10 , 3.27]	(0.44)
5. Cumulative Grants	-0.441**	-0.018***	0.00016	-0.00005	---	---	---
	(0.185)	(0.006)	(0.00035)	(0.00019)	---	---	---
... * Outdoor Fishing or	-0.438	-0.003	0.00038	-0.00020	0.42	1.73	0.53
Swimming is Common	(0.281)	(0.012)	(0.00063)	(0.00026)	[0.28 , 0.84]	[0.92 , 15.89]	(0.68)
6. Cumulative Grants	-0.632***	-0.012**	0.00015	-0.00016	---	---	---
	(0.166)	(0.005)	(0.00048)	(0.00021)	---	---	---
... * States with Pro-	0.044	-0.017*	0.00026	0.00010	0.53	1.08	0.32
Environmental Views	(0.322)	(0.010)	(0.00062)	(0.00027)	[0.28 , 5.78]	[0.71 , 2.26]	(0.33)
7. Cumulative Grants	-0.027	-0.020	-0.00074	-0.00340**	---	---	---
	(0.500)	(0.014)	(0.00241)	(0.00133)	---	---	---
... * Declining Urban	0.381	-0.003	-0.00091	-0.00007	N.A.	8.99	-3.04
Areas	(0.390)	(0.011)	(0.00069)	(0.00037)	N.A.	[3.65, ∞)	(2.81)
... * High Amenity Areas	-0.628	0.003	0.00110	0.00335**	0.91	3.55	0.40
	(0.532)	(0.015)	(0.00243)	(0.00134)	[0.54 , 2.91]	[2.06 , 13.09]	(0.45)
8. Cumulative Grants	-0.644*	-0.017	0.00012	-0.00023	0.59	2.31	0.05
(Reference: West)	(0.354)	(0.013)	(0.00079)	(0.00031)	[0.29 , ∞]	[0.90, ∞]	(0.87)
... * Midwest	-0.446	-0.009	0.00012	0.00030	0.30	1.28	0.29
	(0.421)	(0.016)	(0.00090)	(0.00035)	[0.22 , 0.49]	[0.79 , 3.48]	(0.45)
... * South	0.486	-0.003	0.00084	-0.00033	2.12	1.70	0.84
	(0.446)	(0.017)	(0.00106)	(0.00046)	[0.48 , ∞]	[0.82 , 20.02]	(0.77)
... * Northeast	0.579	0.014	-0.00022	0.00032	13.00	28.86	-0.08
	(0.475)	(0.016)	(0.00112)	(0.00046)	[1.23 , ∞]	[3.89 , ∞]	(0.86)

Notes: Each row 1-8 comes from a separate regression. Rows also control for downstream*year indicators interacted with the variable examined in each row. The median grant project is $1.2 million. Data cover 1962-2001. Dollars are in $2014 Columns (5) and (6) are in million dollars. Asterisks in columns (1)-(4) denote p-value < 0.10 (*), < 0.05 (**), or < 0.01 (***). Columns (5)-(7) reflect the sum of the reference category and the interaction term of interest. Brackets in columns (5)-(6) show 95% confidence regions. N.A. indicates non-positive cost-effectiveness.

APPENDIX TABLE VIII
SENSITIVITY ANALYSIS, HOME VALUES

	Log Home Values			Log Rents			Mean Family Income	Families on Public Assistance	College Graduates (%)	Black (%)	Population Under Age 6 (%)	Population Age 65 or Older (%)
	0.25 Mi.	1 Mi.	25 Mi.	0.25 Mi.	1 Mi.	25 Mi.						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1. Main Estimates	0.0008	0.0025*	0.0002	-0.0008	0.0001	-0.0001	-0.0002	0.0000	0.0000	-0.0001	0.0000	0.0000
	(0.0014)	(0.0013)	(0.0003)	(0.0008)	(0.0007)	(0.0002)	(0.0003)	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0000)
2. Exclude 1-Mile Radius	—	0.0023*	0.0002	—	0.0000	-0.0001	-0.0002	0.0000	0.0000	-0.0001	0.0000	0.0000
Around Treatment Plant	—	(0.0013)	(0.0003)	—	(0.0007)	(0.0002)	(0.0003)	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0000)
3. Cluster by Watershed	0.0008	0.0025	0.0002	-0.0008	0.0001	-0.0001	-0.0002	0.0000	0.0000	-0.0001	0.0000	0.0000
and Year	(0.0033)	(0.0027)	(0.0005)	(0.0013)	(0.0011)	(0.0002)	(0.0004)	(0.0001)	(0.0002)	(0.0002)	(0.0000)	(0.0000)
4. No baseline controls	-0.0002	0.0016	0.0000	0.0000	0.0005	-0.0003	-0.0013**	0.0001	-0.0002	0.0003	0.0000	0.0000
	(0.0025)	(0.0023)	(0.0006)	(0.0017)	(0.0013)	(0.0003)	(0.0005)	(0.0001)	(0.0002)	(0.0002)	(0.0000)	(0.0001)
5. Triple-Difference	0.0057*	0.0067**	0.0010	0.0025*	0.0016	0.0000	-0.0007	0.0000	0.0000	0.0003	0.0000	0.0000
Regression	(0.0033)	(0.0031)	(0.0012)	(0.0015)	(0.0015)	(0.0006)	(0.0006)	(0.0001)	(0.0003)	(0.0005)	(0.0000)	(0.0001)
6. OLS	0.0049***	0.0042***	0.0010	0.0015	0.0011	-0.0001	-0.0001	-0.0001	0.0001	-0.0002	0.0000	0.0001
	(0.0017)	(0.0016)	(0.0008)	(0.0012)	(0.0012)	(0.0007)	(0.0004)	(0.0001)	(0.0002)	(0.0002)	(0.0000)	(0.0001)
7. Year Fixed Effects and	0.0008	0.0025*	0.0002	-0.0008	0.0001	-0.0001	-0.0002	0.0000	0.0000	-0.0001	0.0000	0.0000
Basin-by-Year Trends	(0.0014)	(0.0013)	(0.0003)	(0.0008)	(0.0007)	(0.0002)	(0.0003)	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0000)
8. Grants Given in 1972	-0.0106	-0.0030	0.0018	0.0036	0.0043	0.0009	0.0012	-0.0008***	0.0005	-0.0001	-0.0001	0.0001
	(0.0083)	(0.0078)	(0.0026)	(0.0052)	(0.0051)	(0.0014)	(0.0017)	(0.0002)	(0.0006)	(0.0006)	(0.0001)	(0.0002)
9. Plants Without Grants,	-0.0046	-0.0044	-0.0008	0.0010	-0.0005	0.0001	0.0006	-0.0001	-0.0001	0.0000	0.0000	0.0001
1987 Effect	(0.0043)	(0.0044)	(0.0012)	(0.0026)	(0.0022)	(0.0006)	(0.0009)	(0.0001)	(0.0003)	(0.0004)	(0.0000)	(0.0001)
10. Effect 10+ Years	0.0017	0.0015	0.0002	0.0002	0.0001	0.0001	0.0001	0.0000	0.0001**	0.0000	0.0000	0.0000
After a Grant	(0.0018)	(0.0015)	(0.0003)	(0.0006)	(0.0005)	(0.0001)	(0.0002)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)
11. Urban treatment plants	—	—	0.0000	—	—	-0.0002	-0.0001	0.0000	0.0000	-0.0001	0.0000	0.0000
	—	—	(0.0003)	—	—	(0.0001)	(0.0002)	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0000)
12. Urban treatment plants	—	—	0.0000	—	—	-0.0002	-0.0001	0.0000	0.0000	-0.0001	0.0000	0.0000
excluding own-town	—	—	(0.0003)	—	—	(0.0001)	(0.0002)	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0000)

Notes: Unless otherwise noted, all regressions include homes within 25 miles of the river of interest. Regression specification corresponds to column (4) of Table V. Regressions weighted by denominator of response variable. Rows 11-12 are limited to treatment plants located in a Census designated Place (city, town, or village); row 12 excludes housing units in the same Census-designated Place as the treatment plant. Data includes decennial census years 1970-2000. Standard errors clustered by watershed. Asterisks denote p-value < 0.10 (*), < 0.05 (**), or < 0.01 (***).