The Economic Benefits of Investing in Water Infrastructure

Technical Appendix

Analytical Framework

This study evaluates the economic impacts associated with funding the unmet capital needs of the nation's water and wastewater infrastructure. Impacts quantified in this study include:

- Total jobs, sales, and labor income that would be generated by investments in water infrastructure;
- Costs to businesses per day of disruption in water service; and,
- Long-term productivity savings that businesses and households realize by connecting to utility-scale water infrastructure rather than building the infrastructure themselves.

Findings of this study are based on quantitative analysis and secondary sources. The projected infrastructure spending gap is based on the 2016 report, "Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future" published by the American Society of Civil Engineers (ASCE). The analysis of economic benefits to be generated by capital investments relies on an input-output model to quantify the impacts on businesses directly involved in the design and construction of water infrastructure, and on the broader economy. Costs of service disruption are estimated based on a literature review of empirical investigations that have evaluated sales losses resulting from temporary disruptions in water and wastewater service, including research by the Federal Emergency Management Agency (FEMA). Finally, long-term productivity savings are adapted from ASCE's 2016 study. The table below summarizes the three components of the analysis. The following sections review the sources and methodology for each component of the analysis in greater detail.

Appendix Table A

Components of Economic Analysis

	Investment in Water Infrastructure	Disruption in Water Service	Productivity Savings
Economic Consequence	Growth in jobs and economic output in the water sector and interdependent industries	Temporary loss in economic activity by water-dependent industries	Jobs and sales preserved by avoiding higher costs of decentralized water treatment and supply
Method	Estimate spending and run through input-output model	Apply industry-specific loss factors to daily business sales	Adjust ASCE's estimates to 2017–2040 study period using linear interpolation
Primary Sources	IMPLAN data and software	Federal Emergency Management Agency, "Benefit-Cost Analysis Re-engineering Standard Economic Values" (2011)	ASCE, "Failure to Act: Closing the Infrastructure Investment Gap for America's Future" (2016)

Appendix Table B

Original Baseline Data Provided by American Society of Civil Engineers

	2016	2025	2040
Total Needs	$118 billion	$150 billion	$204 billion
Funded	$40 billion	$45 billion	$52 billion
Funding Gap	$78 billion	$105 billion	$152 billion

Baseline data expressed in constant 2015 dollars. Source: ASCE 2016. Baseline data for 2016 provided separately by the study authors.

Capital Needs and Investment Gap

To determine the current capital needs gap, the study extrapolates from the projection of capital needs and baseline spending from ASCE's 2016 analysis. ASCE estimates the annual funding gap in water infrastructure for years 2016, 2025, and 2040, in 2015 dollars (see original figures in Table B). Annual needs as of 2017 are approximated using linear interpolation and adjusted to 2016 dollars based on the Consumer Price Index (CPI) of the Bureau of Labor Statics Statistics.

This analysis evaluates the economic benefits of funding the water infrastructure gap based on current (2017) annual capital needs. This estimate of annual needs represents the minimum annual investment in water infrastructure required to maintain a good state of repair over the next ten years. Subsequent growth in capital needs projected by ASCE (per Table B) reflects the accumulation of unfunded needs from prior years. These deferred needs are not reflected in Hatch's analysis of the economic impact of funding the water infrastructure gap since needs are assumed to be met in the year that they occur.

ASCE Approach

The following is a brief overview of the ASCE approach to estimating the water infrastructure gap. ASCE's needs estimates draw primarily from three sources:

- *Clean Watersheds Needs Survey (CWNS).* The US Environmental Protection Agency's (EPA) survey of the capital needs of publicly owned wastewater and stormwater utilities conducted every four years, most recently in 2012.
- *Drinking Water Infrastructure and Needs Survey Assessment (DWINSA).* EPA's survey of the capital needs of water utilities, also conducted every four years, most recently in 2011.
- *Clean Water and Drinking Water Infrastructure Gap Analysis (2002).* EPA's analysis of the infrastructure gap from 2000–2019, based on the 1995 DWINSA and 1996 CWNSA.

For the surveys referenced above, utilities provide point-in-time estimates of their capital needs over a 20-year period. However, since costs are documented through utilities' capital improvement plans, virtually all needs fall within the first five to ten years.

EPA Underreporting Adjustment Factor

In its 2002 gap analysis, EPA accounted for underreporting by adjusting its needs estimates upwards based on case studies of a subset of utilities and top-down modeling for specific cost items. ASCE's analysis applies the same adjustment factors that EPA developed in 2002 to subsequent CWNS and DWINSA surveys.

ASCE Infrastructure Need Calculators

ASCE calculates water infrastructure needs as follows:

- Drinking water needs from the most recent (2011) EPA survey are increased by a factor of 1.74, the same under-reporting adjustment used in the EPA 2002 gap analysis.
- Clean water needs as reported in the most recent (2012) EPA survey are adjusted in two ways. First, reported Category III needs for infiltration/inflow correction and sewer replacement/rehabilitation are adjusted by a factor of 7.94, the factor used in the EPA 2002 analysis based on EPA's estimate of the costs associated with correcting existing sanitary sewer overflows. Next, total capital needs are adjusted by a factor of 1.73, the factor used by EPA to reflect underreported replacement needs in the 2002 gap analysis.
- Estimated needs are annualized (over 20 years), adjusted for inflation, and increased for real growth to arrive at an estimate of capital needs in the base year.
- Thereafter, annual capital needs are escalated in accordance with a linear projection of historical trends.

ASCE's estimate of capital spending reflects current federal, state, and local spending—including public investments by public utilities and investor-owned utilities—on water and wastewater infrastructure, as published by the Congressional Budget Office and the US Census. The investment gap represents the difference between current needs and current capital spending.

Economic Benefits of Capital Spending

This study quantifies the jobs, sales, and labor income that investments in water infrastructure would generate by meeting the current funding gap. In addition to the impacts on businesses involved in the design and construction of water infrastructure (*direct effects*), the study considers the impacts on suppliers to these businesses (*indirect effects*), as well as the economic activity stimulated by employee spending (*induced effects*).

To estimate direct, indirect, and induced effects, this study relies on the input-output model produced by IMPLAN Group LLC. The IMPLAN model is used to understand the effect that a change in one industry has on sales and employment in other sectors of the economy. The model's calculations are based on multipliers that represent the purchasing relationships between industries, households, and customers, including the production inputs of industries and the personal spending of employees. Given a change in sales to a specific industry, the multipliers are used to quantify the response of all interrelated industries in terms of jobs, sales, and labor income. The subject analysis is based on IMPLAN's most current (2015) multipliers for the national economy. The multipliers draw on a variety of public data sources including the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the Census Bureau. Although many factors, such as supply constraints and technological innovations, can alter purchasing relationships between industries, IMPLAN's simplified model assumes that the inputs required by an industry to produce its final product remain constant over time.

Capital Spending by Category

To estimate economic impacts, the IMPLAN model requires that an initial change in demand be allocated to one or more specific industry sectors. In this case, the capital expenditures associated with filling the water infrastructure gap are allocated to the construction, engineering, and water utility industries based on a 2014 survey of 30 water utilities regarding their capital spending and operating budgets, summarized in the report "National Economic and Labor Impacts of the Water Utility Sector," published by Water Research Foundation and Water Environment Research Foundation in 2014. Capital spending patterns of water utilities that participated in the survey are weighted by region in order to reflect where capital needs are projected to be greatest over the next 20 years. The resulting distribution is summarized in Table C. Each of the following categories is assigned an industry category in the IMPLAN model (such as engineering or construction) to estimate the direct, indirect, and induced effects of the total investment in water infrastructure.

Appendix Table C

Distribution of Projected Capital Expenditures

Category	Share of Capital Spending
Program Management	5%
Engineering	10%
Construction	73%
Major Equipment	6%
Land Acquisition	1%
Other	5%
Total	**100%**

Source: AECOM 2014, Hatch 2017.

Appendix Table D

Comparison of Jobs per $1 Million Investment in the Water Sector

Study	Expenditure Type	Jobs per $1 million	Year
Gordon 2011	Capital	9.2	2011
Heintz 2009	Capital	15.2	2009
Hatch 2017	**Capital**	**15.5**	**2017**
AECOM 2014	Operating	15.6	2014
AECOM 2014	Op & Cap	15.8	2014
AECOM 2014	Capital	15.9	2014
PA Consulting (low)	Capital	18.1	2009
PA Consulting (high)	Capital	24.1	2009

Impacts expressed in constant 2016 dollars.

Sources:

AECOM. 2014. *National Economic and Labor Impacts of the Water Utility Sector.* Water Research Foundation and Water Environment Research Foundation.

Gordon, E., et al. 2011. *Water Works: Rebuilding Infrastructure, Creating Jobs, Greening the Environment.* Green For All.

Heintz, J., Polin, R., and H. Garrett-Peltier. 2009. *How Infrastructure Investments Support the U.S. Economy: Employment, Productivity and Growth.* Political Economy Research Institute. University of Massachusetts—Amherst.

Heintz, J., Polin, R., and H. Garrett-Peltier. 2011. *The U.S. Employment Effects of Military and Domestic Spending Priorities.* Political Economy Research Institute. University of Massachusetts—Amherst.

PA Consulting Group. 2009. *Sudden Impact: An Assessment of Short-Term Economic Impacts of Water and Wastewater Construction Projects in the U.S.* Clean Water Council.

Comparison to Previous Economic Impact Studies of Water Infrastructure

This study finds that for every $1 million invested in water infrastructure, upwards of fifteen jobs are generated throughout the economy. As shown in Table D, this multiplier aligns with previous studies of investments in water infrastructure and water utility operations. While estimates range, most studies have found that a $1 million investment in water infrastructure supports between 15 and 18 jobs throughout the economy.

Comparison to Studies of Other Infrastructure Sectors

The comparison of the economic impacts of water infrastructure to other public investments, featured in the executive summary is based primarily on two studies published by the University of Massachusetts—Amherst, "How Infrastructure Investments Support the US Economy" (2009) and "The US Employment Effects of Military and Domestic Spending Priorities" (2011). These analyses estimate the impacts of a range of public investments, from health care, to education, to military spending. Like this analysis, both studies rely on the IMPLAN model to quantify aggregate economic impacts. Given their similar approach, the studies provide a fair comparison to this analysis. Findings of the studies are adjusted to current dollars in order to allow for a direct comparison of economic impacts.

Service Disruption Losses

To estimate economic losses associated with temporary disruptions in water and wastewater service, the research team first conducted a literature review of empirical studies that have measured the effect of water and wastewater service disruption on Gross Domestic Product (GDP) and business sales based on actual cases of major service disruptions. From the literature review, the research team derived factors for the percent decrease in sales that specific industries have experienced during a disruption in water or wastewater service. Industry-specific factors representing the estimated decrease in business sales are presented in Table E. Factors for water service disruption are based on the average of factors published in studies by FEMA (2011) and Chang (2002). Wastewater factors are based on those published in FEMA (2011).

Appendix Table E

Percent Decline in Sales during Water/Wastewater Service Disruption

		Drinking Water Service			Wastewater
NAICS	**Industry**	**FEMA (2011)**	**Chang (2002)**	**Average-Assumed**	**FEMA (2011)**
22	Utilities	40%	35%	37%	24%
23	Construction	50%	32%	41%	20%
31-33	**Manufacturing**				
311	Food product manufacturing	70%	58%	64%	70%
312	Beverage and Tobacco Product Manufacturing	70%	58%	64%	70%
313	Textile mills	70%	58%	64%	70%
314	Textile product mills	70%	58%	64%	70%
315	Apparel manufacturing	70%	58%	64%	50%
316	Leather and allied product manufacturing	70%	58%	64%	50%
321	Wood product manufacturing	50%	58%	54%	50%
322	Paper manufacturing	60%	58%	59%	80%
323	Printing and related support	30%	58%	44%	30%
324	Petroleum and coal products manufacturing	50%	58%	54%	50%
325	Chemical manufacturing	80%	58%	69%	80%
326	Plastics and rubber products manufacturing	50%	58%	54%	50%
327	Nonmetallic mineral product manufacturing	50%	58%	54%	50%
331	Primary metal manufacturing	90%	58%	74%	80%
332	Fabricated metal product manufacturing	80%	58%	69%	80%
333	Machinery manufacturing	60%	58%	59%	80%
334	Computer and electronic product manufacturing	90%	58%	74%	90%
335	Electrical equipment appliance manufacturing	90%	58%	74%	90%
336	Transportation Equipment Manufacturing	60%	58%	59%	80%
337	Furniture and related product manufacturing	50%	58%	54%	50%
339	Misc. manufacturing	60%	58%	59%	60%
42	Wholesale trade	20%	49%	34%	10%
44-45	Retail trade	20%	54%	37%	20%
48-49	Transportation and warehouse (excl. postal)	20%	35%	27%	10%
51	Information	20%	35%	27%	20%
52	Finance and insurance	20%	56%	38%	20%
53	Real estate and rental and leasing	20%	56%	38%	20%
54	Professional and technical services	20%	55%	37%	20%
55	Management of companies and enterprises	20%	55%	37%	20%
56	Administrative and waste services	20%	55%	37%	20%
61	Educational services	40%	55%	47%	80%
62	Health care and social assistance	40%	73%	56%	80%
71	Arts, entertainment and recreation	80%	55%	67%	80%
72	Accommodation and food services	80%	55%	67%	80%
81	Other	20%	55%	37%	20%
91	Government	25%	55%	40%	20%
Industry Average		**52%**	**55%**	**53%**	**51%**

Sources:

FEMA (Federal Emergency Management Agency). 2011. *Benefit-Cost Analysis Re-engineering (BCAR) Development of Standard Economic Values.*

Chang, S.E., W.D. Svekla, and M. Shinozuka. 2002. *Linking infrastructure and urban economy: simulation of water-disruption impacts in earthquakes.* Environment and Planning B: Planning and Design, 29, pp. 281–301.

The factors above represent the percent decrease in daily industry sales during a water or wastewater service disruption. Note that the total effect of wastewater and water service disruption is not assumed to be additive. When factors differ between water and wastewater service disruption, the greater effect is assumed to represent the total daily effect. For example, the food and beverage industry is estimated to incur a 64 percent loss in daily sales during a water service disruption and a 70 percent loss in sales during a disruption in wastewater service. The total reduction in sales due to a combined disruption in water and wastewater services is assumed to be 70 percent, the greater of the two factors.

The analysis then multiplies the final disruption factor by aggregate daily sales and GDP for the corresponding industry to determine the aggregate daily loss in sales and GDP. Aggregate industry losses are divided by industry employment to determine the average loss in sales and GDP per employee, per day of water and wastewater service disruption. Employment, sales, and GDP data are derived from the 2015 IMPLAN dataset.

While the overall average daily loss in business sales per employee is estimated to be $230 per employee, impacts vary widely by industry. The following table identifies the industries that would be most impacted by water and wastewater service disruption, based on the potential daily loss in sales per employee. At the top of the list is the petroleum industry, which stands to lose $5,800 per employee per day of water/wastewater service disruption. Within seven days of water service disruption, petroleum manufacturers would experience a sales loss equivalent to one percent of their annual sales. Chemical manufacturers, beverage manufacturers, and transportation manufacturers also rank high in daily losses on a per employee basis.

Appendix Table F

Industries Most Impacted by Service Reliability

NAICS	Industry	Sales saved per employee per day	Days to 1% savings in annual sales
324	Petroleum and coal products manufacturing	$5,800	7
325	Chemical manufacturing	$3,260	5
312	Beverage and tobacco product manufacturing	$1,690	5
336	Transportation equipment manufacturing	$1,530	5
331	Primary metal manufacturing	$1,520	5
334	Computer and electronic product manufacturing	$1,400	4
322	Paper manufacturing	$1,310	5
22	Utilities	$1,200	10
311	Food product manufacturing	$1,010	5
335	Electrical equipment appliance manufacturing	$1,000	4
333	Machinery manufacturing	$950	5
313	Textile mills	$600	5
332	Fabricated metal product manufacturing	$570	5
326	Plastics and rubber products manufacturing	$520	7
327	Nonmetallic mineral product manufacturing	$470	7

Values expressed in 2016 dollars. Source: IMPLAN 2015, FEMA 2011, Aubuchon 2012, Chang 2002.

Appendix Table G

Avoided Household and Business Costs and Associated Productivity Savings

	Aggregate Impacts		Annual Impacts*	
	2017-2026	2027-2040	2017-2026	2027-2040
Avoided Costs to Household/Business	$280 billion	$1,443 billion	$28 billion	$103 billion
Business Sales Preserved	$939 billion	$5,632 billion	$94 billion	$402 billion
GDP Preserved	$624 billion	$3,139 billion	$62 billion	$224 billion
Jobs Preserved			505,000 jobs (2026)	956,000 jobs (2040)

Source: ASCE 2016. Figures presented in 2016 dollars.ASCE figures adjusted for inflation and to reflect 2017-2040 time period.
*Business sales reflect annual averages. Jobs reflect jobs preserved by 2026 and 2040 respectively.

Water-Dependent Industries

To identify commercial and industrial subsectors that rely most on the centralized provision of water and wastewater services, the research team estimates water usage by industry, then compares usage to industry output and employment. Total water delivered to commercial and industrial businesses, as estimated by US Geological Survey (2014), is allocated to specific sectors in proportion to industry spending on water and wastewater services (derived from IMPLAN 2015). Estimated usage is normalized by industry output and jobs to determine the number of gallons required to produce $1,000 in business sales or one job. Industries that require the greatest volume of water deliveries relative to their total sales and total employment are considered more dependent on water utilities. Note that the analysis of water-dependent industries focuses on business use of utility-supplied water; self-supplied water use is excluded from this analysis.

Productivity Savings

In addition to investment-driven economic benefits, keeping water infrastructure in a state of good repair supports national economic productivity through the provision of affordable and reliable water and wastewater service to utility customers. The analysis of productivity savings supported by affordable and reliable water infrastructure is adapted from the 2016 report, "Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future" published by ASCE (2016).

ASCE estimates the costs to households and businesses in the event that centralized water systems fall into disrepair as a result of failure to fill the investment gap. Costs may include the costs of self-supply, higher utility rates, or relocation costs. As a proxy for these costs, ASCE amortizes the projected water infrastructure funding gap over a 20-year period, and assigns approximately 27 percent of costs to households and the remaining annualized costs to businesses. ASCE then deploys an economic model, the Long-Term Interindustry Forecasting Tool (LIFT) developed by the University of Maryland, to determine the aggregate effect on national productivity due to higher commodity prices (in this case, higher water costs) and reduced discretionary spending.

To adapt ASCE's analysis to the 2017–2040 study period, the subject analysis updates ASCE's calculation of household and business costs using the 2017–2040 infrastructure funding gap. From the ASCE report, multipliers are derived for GDP, business sales, and jobs impacts per dollar of household and business costs, and adjusted to 2016 dollars using the Consumer Price Index (BLS 2016). Inflation-adjusted multipliers are applied to the updated household and business costs to estimate aggregate effects on national productivity, including jobs, GDP, and business sales.

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