ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

A Comprehensive Assessment of America's Infrastructure

2025

REPORT CARD FOR AMERICA'S INFRASTRUCTURE

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

ABOUT ASCE

The American Society of Civil Engineers, founded in 1852, is the country's oldest national civil engineering organization. It represents more than 160,000 civil engineers in private practice, government, industry, and academia who are dedicated to advancing the science and the profession of civil engineering, and protecting public health, safety, and welfare.

Cover photo: Highway aerial drone sunrise over busy road way in Austin, Texas; Roschetzky Photography

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ASCE 2025 REPORT CARD FOR AMERICA'S INFRASTRUCTURE

Introduction

America's infrastructure is the foundation on which our national economy, global competitiveness, and quality of life depend. While often taken for granted when it is working properly, every American household or business immediately feels the impact of just one inefficiency or failure in our built environment. Our infrastructure includes an interconnected system of highways, streets, public buildings, mass transit, ports, airports, inland waterways, water systems, waste facilities, the electric grid, broadband networks, dams, levees, and other public and private facilities. Maintaining these networks is essential to meet economic demands and protect public health and safety. For American families and businesses to thrive, we need a first-class infrastructure system that moves people and goods safely, sustainably, efficiently, and affordably by land, water, and air; energy transmission systems that deliver clean, dependable, low-cost power; and water systems that reliably and safely drive industrial processes, as well as the daily functions of our communities.

Since 1998, ASCE has issued a quadrennial assessment of the United States' infrastructure networks, known as the *Report Card for America's Infrastructure*. For more than two decades, the message behind the unflattering grades was consistent: federal, state, and local governments, in addition to the private sector, have not been prioritizing our interdependent infrastructure systems. In sum, the bill on our infrastructure systems was past due. We needed to reverse the nation's growing infrastructure investment gap to remain competitive in the global marketplace, allow local businesses to thrive, and keep our families safely connected. That message grew louder with each evaluation, through our most recent Report Card release in early 2021.

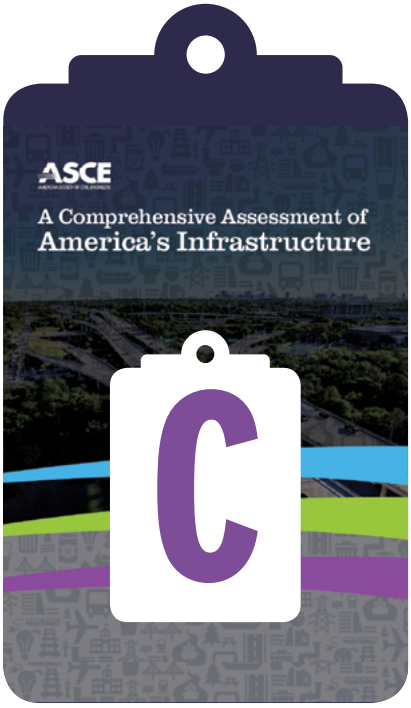
However, in late 2021, the trend began to change. Congress passed the Infrastructure Investment and Jobs Act (IIJA), the most comprehensive federal investment in the nation's infrastructure in U.S. history. The law included many of the solutions to raise the grades featured in ASCE's 2021 Report Card, including robust resources for water infrastructure, transportation, and related areas. A few years later, IIJA investments and policy changes are already improving the performance of our transportation, water, energy, and waste networks. As a result, nearly half of the grades are increasing for the 18 categories we assess in this *2025 Report Card for America's Infrastructure*. This forward momentum is due in large part to the actions of the federal government in partnership with state and local governments and the private sector.

Unfortunately, while significant advancements are being made, we still face a substantial investment gap. The shortfall grows as existing infrastructure systems continue to age and demands on those systems increase. In addition, passage of the IIJA has shed light on key issues affecting our industry. Projects should be modernized or replaced by prioritizing **resilience** to withstand extreme weather. Resilience-focused measures may add to upfront costs but save on sudden, less predictable, and large financial impacts from disaster-related damages. Infrastructure projects take a long time to develop, and stakeholders may hesitate to pursue resilient designs without assurances that current funding levels will be **sustained in the future**. These are just a few of the challenges we continue to face.

The *2025 Report Card for America's Infrastructure* provides a snapshot of how our infrastructure systems are faring and offers solutions for improving the performance of each category. For the second consecutive report, Report Card grades show that U.S. infrastructure is trending in the right direction thanks to comprehensive support, innovative solutions, and bold leadership. Continued action will further improve these networks, unlocking the full potential of our nation's economy and creating opportunities for all Americans.

Founded in 1852, the American Society of Civil Engineers (ASCE) is the country's oldest and largest civil engineering organization. It represents more than 160,000 civil engineers in private practice, government, industry, and academia who are dedicated to advancing the science and profession of civil engineering and protecting public health, safety, and welfare. ASCE comprises 75 domestic and 17 international sections, 159 branches, and 131 younger member groups. The Society advances civil engineering technical specialties through nine institutes and leads with its many professional and public-focused programs. ASCE stands at the forefront of a profession that plans, designs, constructs, and operates society's economic and social engine—the built environment—while protecting and restoring the natural environment.

Key Findings



The 2025 *Report Card for America's Infrastructure* demonstrates that recent federal investments have positively affected many of the infrastructure sectors Americans rely on every day. As a result, incremental improvements were made across some of the historically lowest-graded categories in the Report Card. Almost half of the 18 assessed categories saw increased grades and contributed to an overall grade improvement from C- to C. This is promising momentum, but sustained infrastructure investments are necessary to equip stakeholders with certainty for long-term planning and execution of policies and projects that fully realize the benefits of robust resources.

The 2025 grades range from a B in ports to a D in stormwater and transit. For the first time since 1998, no Report Card categories were rated D–. Among the 18 categories assessed, eight saw grade increases. Many of those categories had been chronically stuck at D- or D for years. This improvement was possible due to the government and private sector prioritizing investments in systems that historically had received little attention. Two categories—energy and rail—were downgraded because of concerns related to capacity, future needs, and safety. Broadband was introduced as a graded category in 2025, coming in at a C+. Although evidence points to improvements throughout infrastructure's system-of-systems, nine categories remained within the D range—a clear sign that more needs to be done to improve the health of America's built environment.

Though distinct in function, the 18 infrastructure categories operate collectively to provide essential services for people and communities. Several key trends appeared in our review that indicate continued gaps exist despite recent infrastructure upgrades. The following trends are worth noting:

1. **Aging infrastructure systems are increasingly vulnerable to natural disasters and extreme weather events, creating unexpected and often avoidable risks to public safety and the economy.** Climate-related challenges are widespread, affecting even regions previously resistant to these events: floods become more intense and occur more often, hurricanes create higher wind loads, and wildfires encroach more unpredictably. Investments in resilient infrastructure are consistently proven to be an effective use of limited public dollars, because they reduce costs in the long term, especially by minimizing rebuilding needs after a significant event. For instance, by adopting the most up-to-date codes and standards, communities will be better equipped to handle disasters and more responsibly deploy public resources.

2. **Recent federal and state investments have had a positive impact, but the full force of increased funding will take years to realize. Sustained investment is key to providing certainty and ensuring planning goes to development, as well as making larger infrastructure projects attainable.** Before recent federal legislation, like 2021's Infrastructure Investment and Jobs Act (IIJA), many of our infrastructure networks had been neglected for decades at the federal level. As time passed and investments failed to keep pace with demands, the backlog of maintenance projects grew. Meanwhile, **demands on infrastructure systems have intensified** apart from maintenance. Community expansion and usage trends, economic growth, unpredictable events, and new technologies have called for new plans and project design. These raised stakes require the federal government to continue prioritizing infrastructure investments. Therefore, federal decision-makers will need to preserve momentum from continued partnerships with state and local governments that match investments and facilitate planning. **Considering the extensive time it takes to study, design, and complete projects, sustained investment at current or higher funding levels will be necessary for infrastructure to continue to improve.**

3. **Unreliable or unavailable data on key performance indicators continues to impact certain infrastructure sectors.** Sectors like school facilities, broadband, energy, levees, stormwater, and public parks continue to lack extensive public data. Robust information on asset conditions, capacity, operations, safety, or resilience enables proactive public discussion on infrastructure. Many infrastructure categories lack a basic inventory of assets and therefore are unable to implement asset management practices. Data—publicly available, routine, and reliable—should be standard across all infrastructure sectors to target investments and allow decision-makers to wisely allocate limited funding to needs. Through enhanced data, both efficiency and effectiveness of assets can be better achieved.

ASCE applauds Congress, state and local policymakers, and the private sector for demonstrating leadership over the past several years and prioritizing our nation's infrastructure. Those investments are starting to have an impact, but our work is not yet complete. As decision-makers look to the future of America's infrastructure, they should weigh the consequences of insufficient support in our most vital networks. For decades, investment at all levels of government and the private sector has failed to keep up with the increasing demands and projects necessary to reach a state of good repair. By incentivizing innovation and maintaining—or in some cases adding—investment, America will sustain recent momentum on our infrastructure systems and ensure they are built for the needs of the 21st century.

About The Report Card for America's Infrastructure

Every four years, America's civil engineers provide a comprehensive assessment of the nation's 18 major infrastructure categories in ASCE's *Report Card for America's Infrastructure.* Using a simple A to F school report card format, the Report Card examines current infrastructure conditions and needs, assigning grades and making recommendations to raise them.

The ASCE Committee on America's Infrastructure is made up of 52 dedicated civil engineers and infrastructure professionals from across the country, with decades of expertise in all categories, who volunteer their time to work with ASCE Infrastructure Initiatives staff to prepare the Report Card. The Committee assesses all relevant data and reports, consults with technical and industry experts, and assigns grades using the following criteria:

Methodology

CAPACITY
Does the infrastructure's capacity meet current and future demands?

CONDITION
What is the infrastructure's existing and near-future physical condition?

FUNDING
What is the current level of funding from all levels of government for the infrastructure category as compared to the estimated funding need?

FUTURE NEED
What is the cost to improve the infrastructure? Will future funding prospects address the need?

OPERATION AND MAINTENANCE
What is the owners' ability to operate and maintain the infrastructure properly? Is the infrastructure in compliance with government regulations?

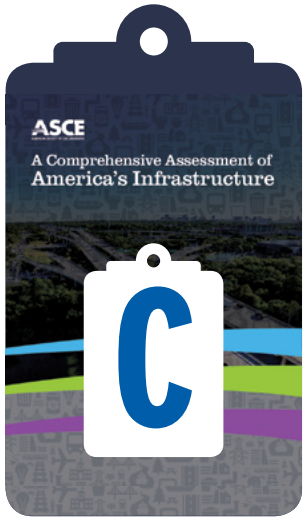
PUBLIC SAFETY
To what extent is the public's safety jeopardized by the condition of the infrastructure and what could be the consequences of failure?

RESILIENCE
What is the infrastructure system's capability to prevent or protect against significant multi-hazard threats and incidents? How able is it to quickly recover and reconstitute critical services with minimum consequences to public safety and health, the economy, and national security?

INNOVATION
What new and innovative techniques, materials, technologies, and delivery methods are being implemented to improve the infrastructure?

In addition to this national Report Card, ASCE's sections and branches prepare state reports on a rolling basis. Visit **InfrastructureReportCard.org** to learn about your state's infrastructure.

The 2025 Report Card for America's Infrastructure



OVERALL GPA

Aviation D+	Bridges C		
Broadband C+	Dams D+	Drinking Water C-	Energy D+
Hazardous Waste C	Inland Waterways C-	Levees D+	Ports B
Public Parks C-	Rail B-	Roads D+	Schools D+
Solid Waste C+	Stormwater D	Transit D	Wastewater D+

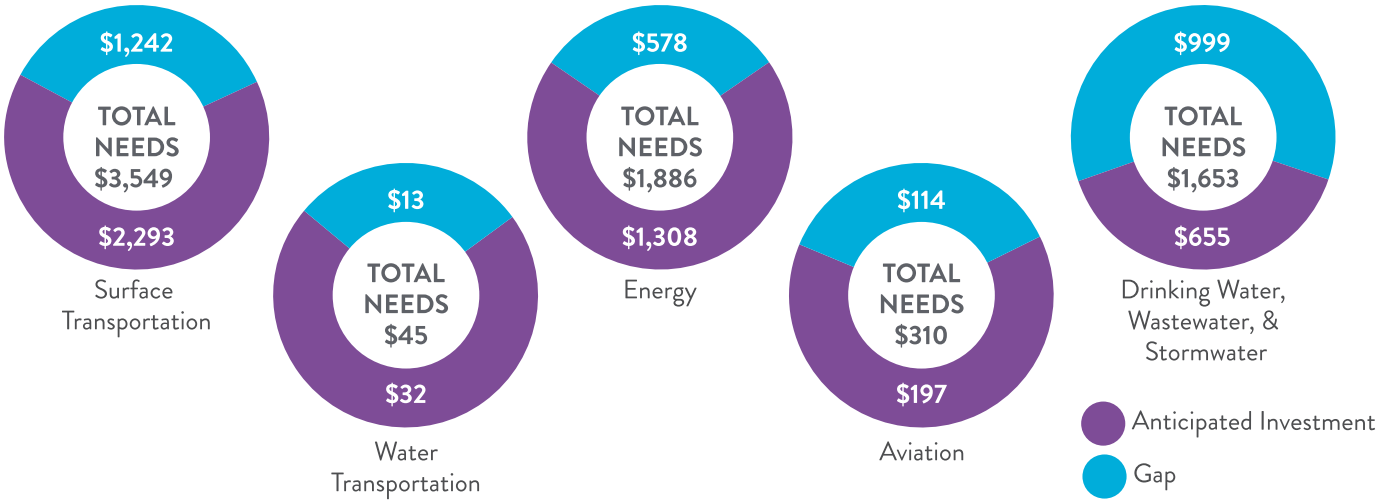
Investment Pays

In 2024, ASCE provided its latest economic estimate on the investment needed for infrastructure categories to reach and maintain a state of good repair, which would be reflected in the Report Card with a B. This data shows progress made in infrastructure, while highlighting increasing needs ahead.

ASCE's 2024 *Bridging the Gap* study, which captures 11 of the 18 Report Card categories, calculated that American families would save $700 annually if Congress "continues to act" with investment levels established in recent fiscal years. That includes appropriation amounts set by the 2021 Infrastructure Investment and Jobs Act (IIJA), 2022 Inflation Reduction Act (IRA), and other legislation. In the two Water Transportation categories, for example – Inland Waterways and Ports – $45 billion would support a full state of good repair, and $32 billion was the anticipated investment over the next 10 years. That leaves a $13 billion gap.

For all 11 infrastructure categories in *Bridging the Gap*, ASCE estimated $2.9 trillion of additional investment would be necessary to achieve good repair. That gap between planned and necessary investments was less than ASCE's 2020 economic study estimated, illustrating the progress made through recent federal investments.

Ten-Year Gaps with Continue to Act Scenario, 2024-33



Total Needs - Anticipated Investment = Gap *Dollars in 2022 Billions* *Columns may not add due to rounding.*

With the *2025 Report Card for America's Infrastructure*, ASCE estimates investment needs total $9.1 trillion for all 18 Report Card categories to reach a state of good repair. Public data and ASCE's 2024 *Bridging the Gap* study forecast $5.4 trillion in public and private investments in the 10-year period, 2024 through 2033, if Congress continues recent funding levels. **This leaves a gap of $3.7 trillion in investments for America's infrastructure if we keep investing at current funding levels.** However, if Congress were to snap back to investment levels in place prior to recent increases in federal spending, that gap would increase significantly. In fact, ASCE's *Bridging the Gap* study, which assesses just 11 of the 18 categories in the 2025 Report Card, finds that the snapback gap would equal the entirety of the 2025 Report Card gap: $3.7 trillion. That figure does not include broadband, dams, levees, hazardous and solid waste, parks, and schools, which represent, at a minimum, an additional gap of $746 billion for a total of $4.4 trillion.

Additionally, in that snapback scenario, ASCE estimates meaningful economic harm: $5 trillion lost in gross economic output over 20 years, 2024-2043, and a reduction of $244 billion in U.S. exports in those same years. Pre-2021 levels of federal investment also mean a job loss of 344,000 in one snapshot year of 2033. The reduced investments would result in $1.9 trillion in lost disposable income for American families within the 20 years studied.

Cumulative Investment Needs

BY INFRASTRUCTURE CATEGORY BASED ON MAINTAINING CURRENT FEDERAL INVESTMENT LEVELS ALL VALUES IN BILLIONS

Infrastructure System	Needs[1]	Funded, 2024-33[2]	Funding Gap, 2024-33
Aviation[3]	$310	$197	$113
Bridges[4]	$538	$165	$373
Broadband[5]	$61	$61	$0
Dams[6]	$185	$20	$166
Drinking Water[7]	$670	$361	$309
Energy[8]	$1,886	$1,308	$578
Hazardous & Solid Waste[9]	$162	$146	$16
Inland Waterways & Ports[10]	$45	$32	$13
Levees[11]	$97	$7	$91
Public Parks[12]	$106	$62	$44
Rail[13]	$145	$113	$32
Roads[14]	$2,233	$1,549	$684
Schools[15]	$1,100	$671	$429
Transit[16]	$618	$466	$152
Wastewater + Stormwater[17]	$983	$293	$690
TOTAL	**$9,139**	**$5,450**	**$3,689**

1. Total needs are estimated as deferred maintenance necessary to reach a system-wide state of good repair. Estimates from publicly available data and not adjusted for inflation.
2. Assumes investments continue at levels from recent appropriations, as shown by public data and based on authorized amounts set by the 2021 Infrastructure Investments and Jobs Act, 2022 Inflation Reduction Act, and other legislation. State and local investments continue at FY2024 levels. Values not adjusted for inflation.
3. Data taken from ASCE *Bridging the Gap* 2024 study.
4. Data taken from ASCE *Bridging the Gap* 2024 study.
5. Data taken from Cartesian and the Fiber Broadband Association.
6. Data taken from the Association of State Dam Safety Officials, Congressional Research Service, U.S. Department of Agriculture, Federal Emergency Management Agency, Congressional Budget Office, and the Associated Press.
7. Data taken from ASCE *Bridging the Gap* 2024 study.
8. Data taken from ASCE *Bridging the Gap* 2024 study.
9. Data taken from the U.S. Environmental Protection Agency, U.S. Department of Defense, U.S. Department of Energy, and Association of State and Territorial Solid Waste Management Officials (ASTSWMO).
10. Data taken from ASCE *Bridging the Gap* 2024 study.
11. Data taken from ASCE *2021 Report Card for America's Infrastructure* and the Congressional Budget Office.
12. Data taken from the National Parks Service, the National Association of State Parks Directors, the Trust for Public Land, Property and Environmental Research Center, and Congressional Research Service.
13. Data taken from ASCE *Bridging the Gap* 2024 study.
14. Data taken from ASCE *Bridging the Gap* 2024 study.
15. Data taken from the 21st Century Schools Fund.
16. Data taken from ASCE *Bridging the Gap* 2024 study
17. Data taken from ASCE *Bridging the Gap* 2024 study.

Recommendations to Raise the Grade

SUSTAIN INVESTMENT

PRIORITIZE RESILIENCE

ADVANCE POLICY AND INNOVATION

SUMMARY

To raise America's infrastructure grades over the next four years, ASCE urges a comprehensive agenda that sustains investment, prioritizes resilience, and advances forward-thinking policies and innovations.

Continued—and in some cases increased—investment is necessary despite significant funding measures being implemented in recent years. Reducing federal and state investment levels, or delaying that support, will escalate the costs and risks of an aging infrastructure system, a scenario American families and businesses cannot afford. Infrastructure investments must be made with consideration of a project's full life cycle, including the impact of more frequent extreme weather.

Public safety and efficient use of public dollars are advanced by building projects that can withstand increasingly severe weather events and natural and man-made hazards. Therefore, **the implementation of best practices for resilience** when planning across a project's intended life cycle is critical.

To realize the benefits of recent infrastructure investments, we must **advance forward-thinking policies and innovations** necessary to build systems today that will provide clean drinking water, ensure safer transportation systems, and produce reliable electricity and broadband over the next 100 years.

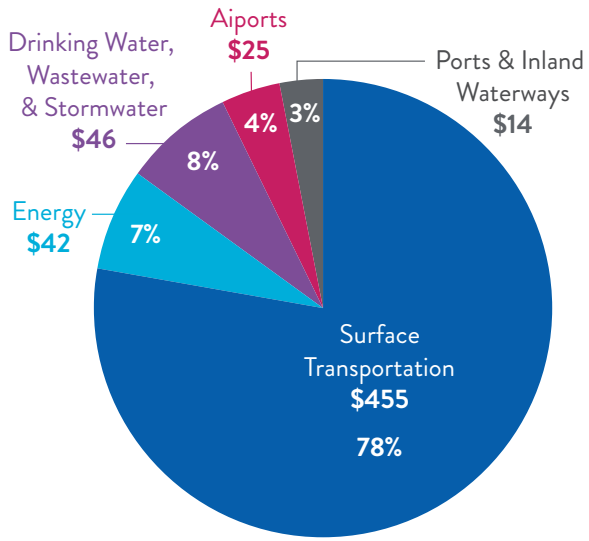
SUSTAIN INVESTMENT

Since ASCE last assessed the condition of the nation's infrastructure systems, Congress passed two sweeping packages to improve the networks that move people and goods across the country, provide clean drinking water to millions of Americans, and ensure that households and businesses have reliable electricity. One of those measures, the 2021 IIJA, set a new standard for federal infrastructure spending. However, the legislation will expire in 2026, and Congress will decide how programs under the IIJA will be funded going forward. The IIJA and Inflation Reduction Act's (IRA) $580 billion in new investment has provided an initial and consequential step in bridging the funding gap between the nation's infrastructure needs and preexisting support. The use of financing options to leverage public dollars, like tax-exempt municipal bonds, continues to increase, and private equity plays an increasingly important financing role.

Government decisions will support or stymie our momentum on infrastructure. A decline in funding from levels in the IIJA and IRA would cost taxpayers and businesses. American households should expect to pay an average of $700 more annually over the next 20 years if federal infrastructure investment snaps back to levels from before those laws. Municipal bonds may also lose investor appeal if Congress adjusts their tax-exempt status.

If the U.S. is serious about achieving an infrastructure system fit for the future, necessary steps must be taken that start with continued, long-term investment. Infrastructure improvements are time-intensive, often requiring multiple years to distribute resources and develop projects from feasibility study to design, on to shovels throwing dirt, and eventually to grand openings. To close the $3.7 trillion 10-year investment gap, meet future needs, and restore our global competitive advantage, we must sustain, or in many cases increase, infrastructure funding and financing options across all levels of government and the private sector.

$580 Billion in New Infrastructure Funding, 2022–2026



Dollars in 2022 Billions

INFRASTRUCTURE INVESTMENTS MUST BE CONSISTENTLY AND WISELY ALLOCATED, BEGINNING WITH THE FOLLOWING STEPS:

- Congress should maintain investment levels provided by the IIJA when the law expires in 2026 and fully fund authorized programs during the annual appropriations process.
- Infrastructure owners and operators must charge rates reflecting the true cost of using, maintaining, and improving infrastructure. They will need to educate the public on the actual cost to deliver those services so they can understand set rates.
- Federal, state, and local governments should expand the use of public–private partnerships for appropriate projects and find opportunities to leverage additional financing tools.
- Congress must reinstate confidence in critical infrastructure programs by addressing the long-term viability of the Highway Trust Fund and ensuring that the State Revolving Funds for Clean Watersheds and Drinking Water are not experiencing revenue losses due to Congressionally designated projects.
- Project owners should include life-cycle costs associated with planning, financing, designing, constructing, operating, maintaining, and decommissioning projects to properly evaluate the full infrastructure cost and the need to plan for the total cost over a project's lifespan to get the most value out of their investments.

PRIORITIZE RESILIENCE

Across the U.S., disasters of greater intensity, duration, and frequency have wreaked havoc on communities of every size and location. In 2024, a total of 27 extreme weather events caused 568 deaths and over $182 billion in damages; since 1980, the U.S. has experienced 403 events amounting to at least $1 billion in damages with a total cost exceeding $2.9 trillion. In addition to life and property losses, disasters strike assets across the infrastructure network, including buildings, roads, bridges, electrical lines, water resources, and rail. Severe flooding, wind, fire, snow, ice, and earthquakes damage and destroy these critical lifelines for residents, businesses, and communities at large.

Measures to mitigate the impacts of natural disasters have led to an increased focus on resilience. The costs associated with building stronger infrastructure and structures demonstrate prudent investment. Every dollar spent on resilience and preparedness saves communities $13 in post-disaster costs, according to a 2024 study.

More work is needed to integrate resilience that protects against the impacts of extreme weather events. Better outcomes can be realized in disaster recovery and response through project planning and development that prioritizes resilience. This practice enables policymakers to ensure public dollars are used efficiently over a project's lifespan.

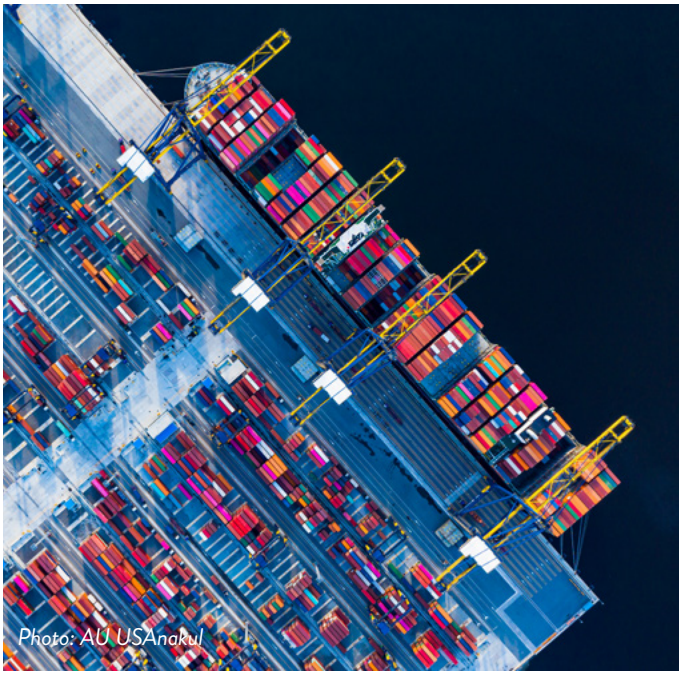


Photo: AU USAnakul

ADVANCEMENTS IN RESILIENCE ACROSS ALL INFRASTRUCTURE SECTORS CAN BE MADE BY:

- Enabling communities, regardless of size, to develop and institute their own resilience pathway across all infrastructure portfolios. This is accomplished by streamlining asset management, incorporating life-cycle cost analysis into routine planning processes, and integrating future conditions, factoring climate impacts into long-term goal setting and capital improvement plans.
- Incentivizing and enforcing the use of the most up-to-date codes and standards, which mitigate risks of major events such as floods, hurricanes, fires, sea level rise, and more.
- Encouraging asset management practices to ensure investments are spent wisely.
- Understanding that our infrastructure is a system-of-systems and encouraging a dynamic, "big picture" perspective that weighs trade-offs across infrastructure sectors while instilling safety from resilience as the highest priority.
- Prioritizing projects that improve the sustainability, safety, and security of systems and communities to ensure continued reliability and enhanced resilience.
- Improving land-use planning across all levels of decision-making to strike a balance between the built and natural environments.
- Enhancing the resilience of various infrastructure sectors by including nature-based or "green" infrastructure solutions.

ADVANCE POLICY AND INNOVATION

Infrastructure improvements rely on both public and private sectors to address needs and advance solutions. Policies provide a basis for projects to be integrated in communities, states, and regions, and those policies should be responsive to the needs of the public and encourage both safety and innovation. To do this effectively, cooperation across all levels of government and the private sector is paramount for a successfully integrated infrastructure network. As engineers work to deliver the infrastructure of the future, new policies will need to accommodate emerging societal trends and environmental conditions, as well as incorporate forward-thinking innovations that can expedite project delivery and enhance safety. Furthermore, policies must recognize and address the need to reduce delays in the project permitting process and ensure that the U.S. has the workforce required to build the infrastructure necessary for the 21st century and beyond.

Photo: Wilasini

POLICYMAKERS AND INFRASTRUCTURE LEADERS MUST WORK TOGETHER TO

- Innovate policies and practices across all levels of government that address common issues in project development and delivery across infrastructure sectors, locations, and environmental conditions.
- Assess current government permitting processes, identify "pain points," and inform strategies to modernize compliance across all infrastructure sectors—working in parallel rather than series—while ensuring appropriate safeguards and protections are in place.
- Address the engineering and construction workforce shortage by implementing strategies and policies that recognize both short-term and long-term recruitment and retention challenges, as well as prioritize STEM opportunities in K-12 education.
- Ensure reliable data is collected and released to the public frequently regarding the condition, capacity, operations, maintenance, safety, and resilience of all infrastructure systems.
- Leverage proven and emerging technologies to make the best use of limited financial and personnel resources.
- Support research and development of innovative materials, technologies, and processes to modernize and extend the life of infrastructure, expedite repairs or replacements, and reduce costs into the future.

Aviation

D+

GRADE COMPARISON

2025: D+

2021: D+

Photo: Port Authority of New York and New Jersey

AVIATION

EXECUTIVE SUMMARY

U.S. domestic air passenger enplanements increased steadily throughout the last decade, from 629.5 million in 2010 to 811.4 million in 2019. Following the COVID-19 pandemic, air travel has fully recovered to 819.5 million in 2023 and continues to increase. Passenger traffic is forecasted to grow 58% to 1.28 billion annual passengers by 2040. The pandemic did not impact air cargo, and 2021 saw the most cargo in history, with 125.3 million metric tons carried.[1] Funding from the 2021 Infrastructure Investment and Jobs Act (IIJA), which provided $25 billion over five years, and local investments are enhancing passenger experience, especially at larger airports. Still, delays continue to be a major problem because of ongoing workforce and modernization challenges. Although modest funding increases in the latest Federal Aviation Administration (FAA) reauthorization is a positive step, the continued failure to raise the cap on the Passenger Facility Charge represents a missed opportunity, because the projected funding gap is $114 billion over the next 10 years and additional resources will be needed to address this deficit.

BACKGROUND

Airport infrastructure extends well beyond the runways and terminals that are familiar to passengers. Airport facilities include runways, taxiways, control towers, firefighting and rescue services, passenger terminals, cargo facilities, general aviation facilities, parking garages, access road networks, public transport, lighting, navigational and approach aids, and various support facilities.

There are 13,144 airports nationwide, but the backbone of the nation's aviation system is the 3,247 that are part of the National Plan of Integrated Airport Systems (NPIAS) as defined by the Federal Aviation Administration (FAA). NPIAS airports include all commercial service airports; all reliever airports, which are built to relieve temporary congestion at commercial service airports; and selected public-owned general aviation airports. Approximately 97% (3,193) of the NPIAS airports are owned by public entities (generally, city, county, or state governments) and less than 2% (54) are privately owned airports.[2]

Because of investments from the IIJA, several high-profile airport construction projects are underway. These include projects to modernize terminals, improve security screen areas, add new parking facilities, improve airport roadways, consolidate rental car facilities, and more. Among the airports undergoing transformation are some of the most traveled nationwide, such as New York's LaGuardia and Kennedy, Los Angeles, Dallas-Fort Worth, Chicago O'Hare, Kansas City, and Seattle-Tacoma.

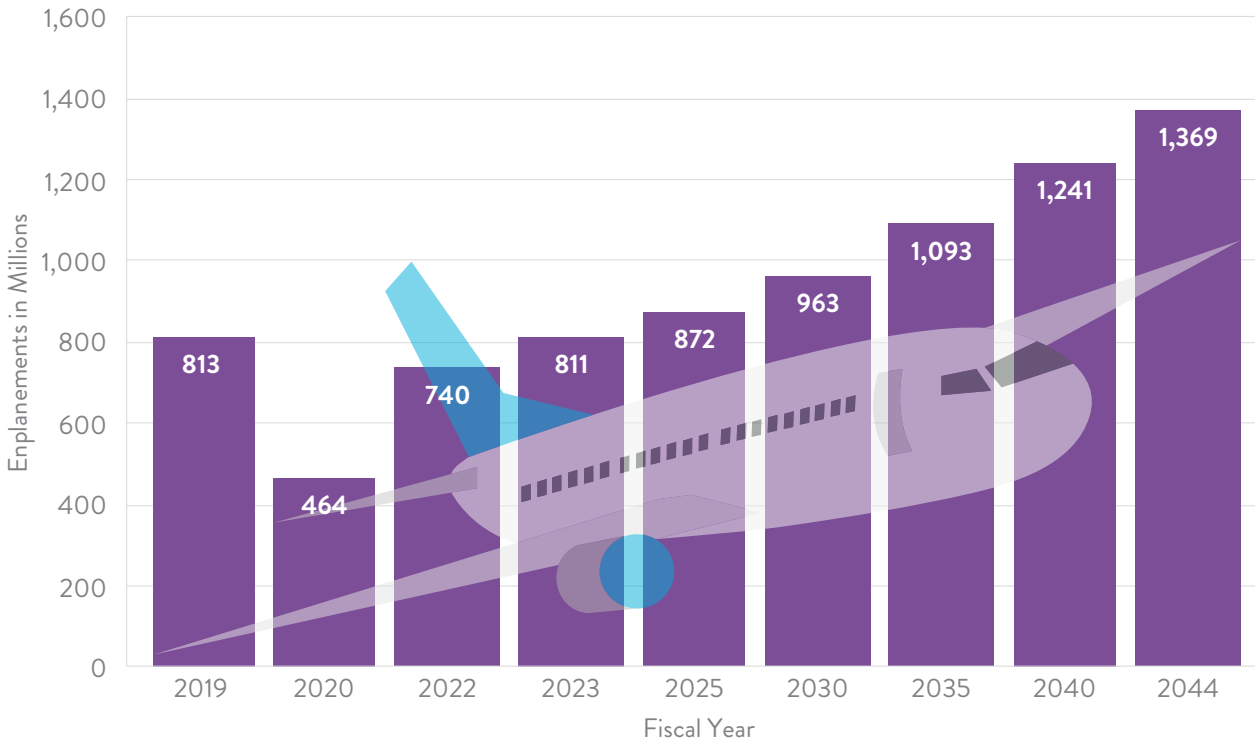
CAPACITY AND CONDITION

In 2019, the U.S. aviation industry contributed 4.9% to the U.S. Gross Domestic Product (GDP) and generated $1.9 trillion in total economic activity, supporting 10 million American workers. At the state level, impacts vary by population, number of airports, aviation manufacturing, tourism, and other aviation-related business activities. In 2020, the pandemic resulted in a significant decrease in the number of passengers at U.S. airports, while overall economic activity and jobs supported saw similar declines, averaging 50% of the previous year's numbers.[3]

U.S. airspace recorded 15.7 million flights in 2023. Domestic U.S. passenger enplanement levels increased steadily throughout 2010, from 629.5 million in 2010 to 811.4 million in 2019. This is followed by the COVID-impacted years with 337.4 million passengers in 2020, 605.9 million in 2021, and fully rebounding back to 819.5 million in 2023.[4] The number of enplanements differs from the number of passengers because passengers may board more than one flight between their origination point and ultimate destination. The FAA projects that passenger traffic will increase at a rate of 2.5% annually between 2023 and 2044 or from 811 million to 1.3 billion. Both existing and new passenger traffic require airports to juggle the responsibilities of maintaining and modernizing legacy assets while also adding new capacity.[5]

The pandemic drove a temporary increase in air cargo operations, and 2021 experienced the most cargo in history, with 125.3 million metric tons carried compared to 120.1 million tons in 2019. For 2022, the amount dropped to 115.9 million metric tons, mostly attributed to the cooling down of the market after a robust growth phase during the pandemic. U.S. air carriers flew 7.3 billion revenue ton miles (RTMs) in 2023 and are expected to increase at an average annual rate of 3%.

US Commercial Domestic Enplanements—Recent and Forecasted



Source: Federal Aviation Administration

The FAA conducted a national capacity evaluation in 2024 and found that 11 airports are expected to be runway capacity–constrained by 2028, increasing to 14 by 2033. An additional 13 airports are at risk of significant congestion through 2033. Airports that exceed 80% of their hourly runway capacity for at least 50% of the time are considered capacity-constrained. Although aircraft operations can continue to grow at capacity-constrained airports, growth will result in increasing levels of congestion and reduced levels of efficiency.[6]

National Capacity Outlook

AIRPORT	2028	2033
Atlanta	Congested	Congested
Boston	Congested	Severe capacity constraints
Baltimore Washington	Congested	Congested
Charlotte	Congested	Congested
Dallas Love Field	Congested	Congested
Washington Reagan National	Congested	Congested
Denver	Congested	Congested
Dallas Fort Worth	Congested	Congested
Newark	Congested	Severe capacity constraints
Fort Lauderdale Hollywood	Congested	Congested
Houston	Congested	Congested
Dulles Washington	Congested	Congested
John F. Kennedy New York	Congested	Severe capacity constraints
Las Vegas	Congested	Severe capacity constraints

AIRPORT	2028	2033
Los Angeles	Congested	Congested
Laguardia New York	Congested	Congested
Chicago Midway	Capacity constrained	Congested
Miami	Congested	Congested
Chicago O'Hare	Congested	Congested
Philadelphia	Capacity constrained	Congested
Phoenix	Congested	Congested
San Diego	Congested	Severe capacity constraints
San Antonio	Congested	Congested
Seattle	Congested	Severe capacity constraints
San Francisco	Congested	Severe capacity constraints
San Jose	Congested	Congested
John Wayne Orange County	Congested	Congested

Not routinely congested

Congested

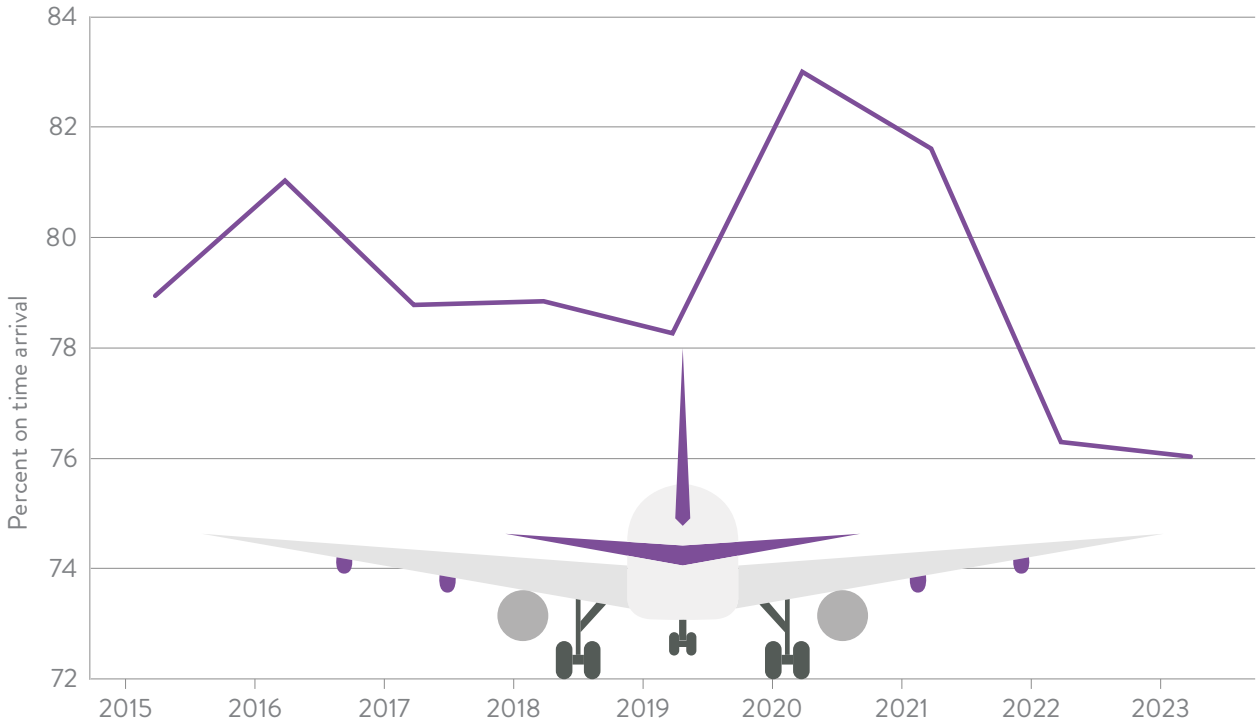
Capacity constrained

Severe capacity constraints

Source: National Plan of Integrated Airport Systems 2025-2029

Another visible measure of aviation capacity is flight delays, which create passenger frustration and have economic costs. Delays are caused by various factors, including late aircraft arrivals, national aviation system delays, air carrier delays, weather-related issues, and airline IT issues. In 2019, 21.7% of flights failed to arrive on time. That percentage increased to 23.2% in 2023.[7]

On time arrival by year—2015-2023



Source: Bureau of Transportation Statistics, On-Time Performance

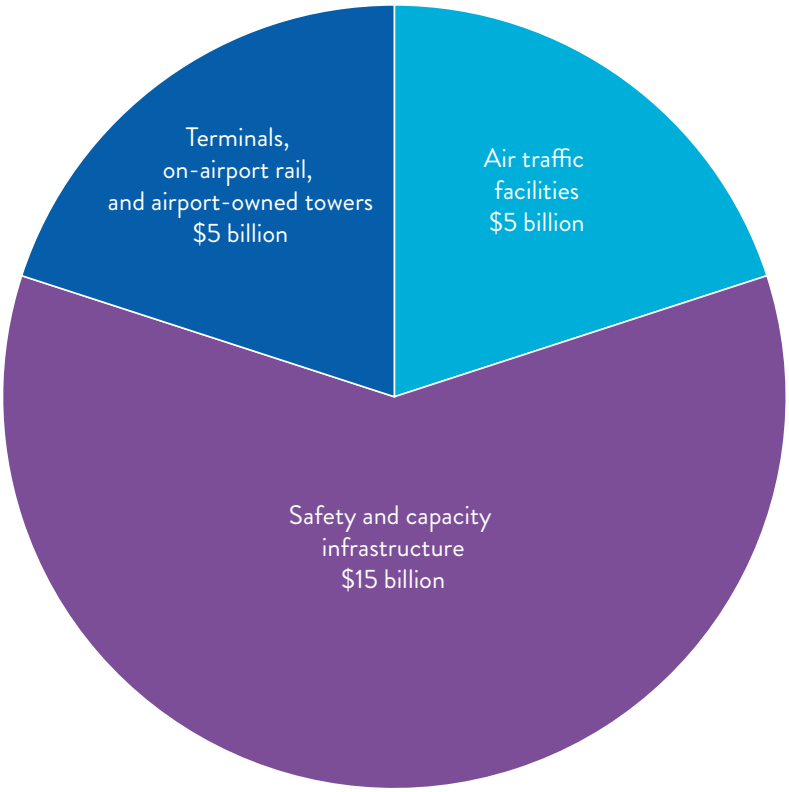
While the FAA has made progress modernizing air traffic management, known as the Next Generation Air Transportation System (NextGen), progress continues to be slowed down by issues ranging from delays in upgrades, removal of outdated equipment, lack of senior staff who are familiar with the older equipment, as well as a lack of materials to repair older equipment. The FAA spent at least $14 billion on NextGen between 2007 and 2022; however, in 2018, costs were expected to more than double to at least $35 billion by 2030. According to the Government Accountability Office (GAO), the FAA needs to provide greater transparency on costs, schedule, and performance goals for NextGen to enhance accountability of the program.[8]

Photo: Stockcake

FUNDING AND FUTURE NEED

Commercial airports are traditionally supported by four sources of funding: airport-generated revenue; general obligation bonds; federal, state, and local grants, which include the Airport Improvement Program (AIP); and Passenger Facility Charges (PFCs). The IIJA provided $25 billion in additional aviation infrastructure investments. This includes $5 billion for air traffic facilities, $15 billion for airport infrastructure to increase safety and expand capacity, and $5 billion for airport terminals, on-airport rail, and airport-owned towers.

IIJA Aviation Funding



Source: Infrastructure Investment and Jobs Act

In 2024, the most recent FAA reauthorization was signed into law, which allocated $105.5 billion for FAA programs through Fiscal Year 2028. The legislation increases AIP funding to $4 billion per year beginning in FY25, a bump from the $3.35 billion per year that had been in place since FY12. AIP provides grants to airports for projects such as airfield and airport access improvements and capacity enhancements. Funding for AIP grants flows from the Airport & Airway Trust Fund (AATF), which receives revenues from various excise taxes imposed on users of the airport system, including the ticket tax of 7.5% on all domestic travel and a flight segment tax of $5.20 in 2025, $22.20 for international segments, and $11.10 for Alaska and Hawaii.[9] However, as airlines have implemented à la carte pricing, ticket price revenue has suffered because the 7.5% tax is not applied to baggage fees, food sales, or other discretionary passenger purchases. If $4.9 billion in baggage fees collected by airlines in 2018 had been subject to the tax, excise tax revenues would have been about $367 million higher that year alone.[10,11]

The other primary source of federal airport funding is the PFC for airport improvements. The PFC's federally mandated cap of $4.50 has been in place since 2001. Increasing the PFC has long been a recommendation of airport supporters, because it permits local airports to set rates and provides funding flexibility. In 2020,

airports collected $2.1 billion in PFCs, down from $3.7 billion in 2018. The flat PFC rate has been in place for nearly 25 years and hinders airports' ability to collect sufficient revenue necessary for repairs. The FAA Reauthorization Act of 2024 failed to increase the PFC cap, but the legislation allows airports that charge the maximum $4.50 fee to keep a larger percentage of their primary entitlements. Previously, airports had to turn back 75% of their AIP apportionment funding, but under the legislation, those airports charging the maximum fee only need to turn back 60%.

Airports reported grant receipts totaling $5.5 billion in 2020 (up from $2.2 billion in 2018). Federal relief legislation steadied what could have been COVID's catastrophic, long-term impact. In 2020 and 2021, federal COVID relief packages provided $20 billion for U.S. airports experiencing a severe downturn in operating revenues. However, most airports used federal relief dollars to offset operating costs and debt service rather than for new capital investment. Beyond federal funding, airports issued $13.3 billion in bonds in 2020.[12]


Photo: ASCE Website

Innovation in airport project delivery methods have added flexibility to airports' ability to finance and construct new facilities. The construction manager at risk (CMAR) delivery method continues to grow in popularity with large, complex airport projects, because the collaborative approach provides potential for schedule and cost-certainty. The CMAR is a single party that acts as both the construction manager and general contractor, responsible for overseeing the project, managing costs, and ensuring the project is completed on time and within budget.

FAA's Airport Investment Partnership Program permits the sale or lease of public airports to private entities, but few airports have participated. Public–private

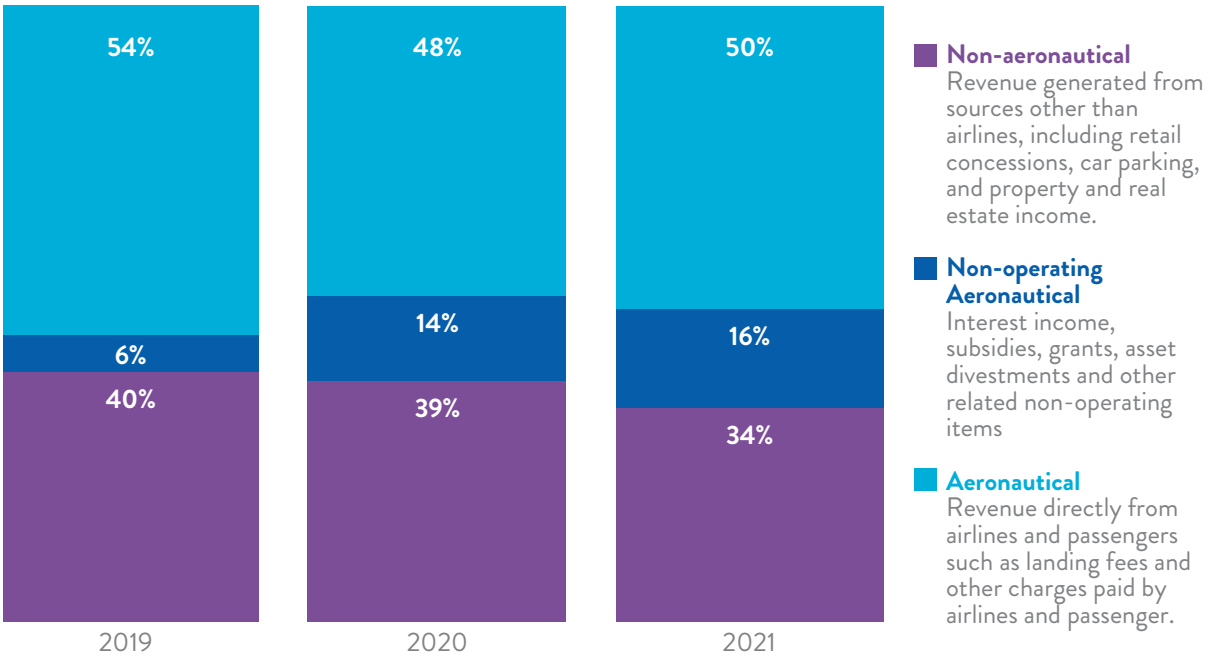

Photo: ASCE Website

partnerships (P3s), on the other hand, are common, especially in the Northeast. After a successful P3 project at LaGuardia, the Port Authority of New York and New Jersey has two new P3s underway at John F. Kennedy International Airport. The New Terminal One project will replace the outdated terminals, with JFK's largest terminal including improved amenities, retail, and dining. The $9.5 billion project will be delivered by a consortium of private entities, with construction debt financing provided by a group of lenders.[13]

Meanwhile, the Essential Air Service (EAS) program was established in 1978 to guarantee that small communities maintain minimal scheduled air service. As of March 2024, there are 111 communities outside Alaska and 65 communities in Alaska that have EAS. The EAS program receives about $39 million for Alaska annually and another $493 million for the rest of the U.S. For EAS communities, this critical program provides access to goods, health care, and schools, which is essential to the economy of the communities served. The FAA Reauthorization Act of 2024 includes $340 million for FY25, $342 million for FY26, $342 million for FY27, and $350 for FY28 for the EAS program.[14]

Photo: Rock Sta

Airport Revenue Sources



Source: ACI World Airport Economics Database

The FAA estimates that $67.5 billion in capital development projects are needed between 2025 and 2029. Comprising everything from surface access and terminal safety to security and others, the $67.5 billion total includes approximately 18,100 projects and reflects development needs for 3,287 existing airports and five new airports.[15] Development needs for an airport are based on eligible and justified projects consistent with the airport's role in the national airport system. ASCE's *Bridging the Gap* economic study projected a need of $310 billion between 2024 and 2033, with projected funding from all sources at $168 billion if IIJA investment levels continue from 2026. That leaves a funding gap of $114 billion, or $162 billion if federal investments snap back to prior levels that year.[16]

In comparison, the Airports Council International–North America (ACI-NA) survey of member airports estimates that the total airport infrastructure needs are $151 billion for the same period. The estimate states that virtually all airports, irrespective of their size and geographical location, need increased capital expenditure to maintain and expand their infrastructure to accommodate airlines and passengers, enhance the efficiency of their processes, and improve service quality and customer experience.[17]

Photo: Federal Aviation Administration

OPERATION AND MAINTENANCE

Airports must meet minimum maintenance and operational standards prescribed by federal, state, and local agencies. For instance, the FAA aims for 93% of NPIAS runway pavements to be in excellent, good, or fair condition. In FY23 97.7% of runways at NPIAS airports are rated excellent, good, or fair, but note that a runway in "poor" condition is still safe for flight operations. It simply requires more frequent inspections and often more intensive pavement maintenance.[18]

The airport staff charged with Operation and Maintenance (O&M) have needs that vary in size, equipment, and funding. Some typical airport O&M-related aspects include pavement maintenance, airfield lighting, pavement marking, snowplowing, landscaping, utilities, and mechanical systems.

Contributing to Operation and Maintenance challenges faced by the nation's aviation system is that air traffic control stations nationwide are short about 3,000 air

traffic controllers. The staffing gap has added to flight delays and concerns that fatigue contributed to a series of recent near collisions. In addition, pilot error and other ground-related factors has contributed to runway incursions.

FAA has about 11,500 controllers who are either fully certified or have reached the stage in training where they can work independently. Staffing plans developed by the FAA and the union representing air traffic controllers call for more than 14,600 controllers to fully staff towers and centers. An FAA Inspector General report found that 20 of 26 (77%) critical facilities are staffed below the agency's 85% threshold, with New York's Terminal Radar Approach Control (TRACON) and Miami Tower at 54% and 66%, respectively. In addition, COVID-19 led to training pauses over nearly two years, significantly increasing controller certification times.[19]

To address workforce challenges, the FAA Reauthorization Act of 2024 directs the FAA to set a goal for new air traffic controllers for FY24–28. In September 2024, the FAA announced that it had exceeded its goal of hiring 1,800 air traffic controllers in 2024, hiring 1,811 controllers. As the largest number of hires in nearly a decade, this marks important progress in the FAA's work to reverse the decades-long air traffic controller staffing decline.

For airports to work properly and serve their passengers and communities effectively, far more than runways are needed. Other infrastructure that needs to be considered as part of maintenance and operational efforts includes roadways, parking lots, parking structures, lighting, security, terminal, and other related functions that serve passengers and communities safely and securely.

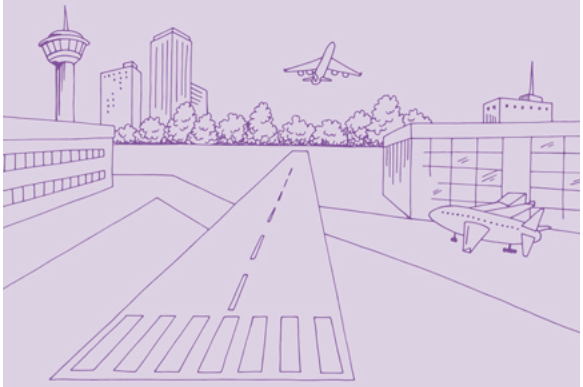


Photo: Port Authority of New York and New Jersey

PUBLIC SAFETY AND RESILIENCE

Airports are a critical component to the movement of goods and people and must be resilient to weather- and human-caused catastrophic events. In addition, airports often serve as a lifeline for urgent relief supplies during emergencies.

The FAA Reauthorization Act of 2024 requires the FAA to work with the National Oceanic and Atmospheric Administration and the U.S. Army Corps of Engineers to assess the resiliency of coastal or flood-prone areas and provides $200 million annually to fund airport resilience and runway safety projects, up from $100 million in the previous authorization.

Furthermore, runway incursions and near misses have been on the rise. According to the FAA, from May 2023 to May 2024, the total number of runway incursions reached 1,115. They ranged from serious close calls, or Category A incidents, to Category D incidents, in which a person or vehicle is present on a surface designated for an aircraft but posed no significant safety risk. These numbers are down from 2023, when there were 1,760 total runway incursions across 54.4 million takeoff and landings in U.S. airspace. In 2023 the FAA issued a Safety Call to Action to take a critical look at the U.S. aerospace system's structure, culture, processes, systems, and integration of safety efforts. In addition, safety programs such as Runway Safety Action Teams (RSAT), Runway Incursion Mitigation (RIM), and Safety Management System (SMS) may be implemented at an airport.[20]

To address these concerns, the 2024 FAA Reauthorization places an emphasis on near misses and runway incursions, issues that have become particularly prevalent over the last couple of years. The bill requires the FAA to establish a Runway Safety Council to develop strategies to address surface safety risks, as well as identify and deploy technologies and equipment that improve onboard situational awareness for flight crew members to enhance the safety of ground operations.

Finally, uncrewed aerial vehicles (UAVs) or drones present a growing threat to commercial and general aviation because they have the potential to disrupt aircraft navigation, communication, and air traffic control systems, not to mention the risk of midair collisions. Congress and the FAA need to develop a drone integration strategy that accommodates both the benefits of drones and protects aviation safety. The FAA Reauthorization Act of 2024 extends the BEYOND program, which focuses on drones moving beyond the visual line of sight and directs the FAA to implement the recommendations made by the GAO to develop a comprehensive drone integration strategy. [21]

INNOVATION

Technological advances play a critical role in improving airport service. However, adjusting to and planning for the ever-changing airport environment is increasingly difficult. To tap into transformative potential, airports understand that it is more than just technology—it is a process centered on people that requires a culture shift and executive-level commitment.[22]

Airport innovations are focused on the flying public, as well as Operation and Maintenance. On the customer side, this includes additional touch screens, wayfinding, and check-in kiosks as well as app-based concessions and remote food delivery. In the area of airport engineering, operations, and maintenance, significant investments in building automation—including control systems and remote sensors to support maintenance optimization and asset reliability along with advancements in design, engineering, and asset management technologies, including Building Information Modeling (BIM), Geographic Information Systems (GIS), and Enterprise Asset Management (EAM)—are driving innovation.

As we look to the future, transformational innovations and evolving technologies like fleet electrification, on-site alternative energy generation, Advanced Air Mobility (AAM) and Electrical Vertical Takeoff and Landing (eVTOL) will impact aviation business models.

RECOMMENDATIONS TO RAISE THE GRADE

- Provide sufficient and flexible federal funding for consistent and long-term investments in airport-wide capacity and state-of-good repair programs, including flexibility for Airport Improvement Program grants, and remove the federally imposed cap on PFCs.
- Support and encourage airports to look at their systems holistically. Formal maintenance and asset life-cycle management plans across the complex interconnected systems within airports are critical for sustaining facility and non-airside pavement assets in adequate condition.
- Provide guidance and funding for formal facility condition assessment programs, including periodic reporting, that is aligned with current approaches used for Airport Pavement Management Programs (PMPs).
- Address aviation workforce needs to ensure operational resiliency, including air traffic controllers and critical airport maintenance and operations personnel.
- Embrace proactive approaches to address sustainability, resiliency, and risk to effectively address challenges presented by extreme weather events and sudden economic shocks.
- Understand and adopt new and emerging technologies to respond to ongoing advancements in aviation and customer technology.

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Bridges

C

GRADE COMPARISON

2025: C

2021: C

Photo: Brent Spence Bridge Corridor Project

BRIDGES

EXECUTIVE SUMMARY

There are more than 623,000 bridges across the country, of which 49.1% are in "fair" condition, 44.1% are in "good" condition, and 6.8% are in "poor" condition.[1] Unfortunately, the nation continues to see the number of fair bridges surpassing those in good condition. As bridges in fair condition continue to age—presenting the possibility of being further downgraded—they also exemplify an opportunity because they can be preserved at a lower cost than bridges in poor condition. Bridges received a substantial boost through the Infrastructure Investment and Jobs Act (IIJA), including $27.5 billion for the Bridge Formula Program and $12.5 billion for the Bridge Investment Program. Despite this infusion of federal funding, bridge-related system rehabilitation needs are estimated at $191 billion.[2] Therefore, strategic asset management planning and routine maintenance are essential to keeping bridge conditions from further declining and avoiding costly repair or rehabilitation work. While the effects of extreme weather events pose threats to bridges, innovative techniques are improving their security and resilience.

BACKGROUND

There are 623,218 bridges in the country, with an average age of about 47 years, that serve as vital connections throughout the transportation system. Many bridges are approaching or have exceeded the 50-year life they were designed for. However, they are still expected to withstand the impacts of a changing climate, continued maintenance challenges, and higher traffic volumes and vehicle weights than they were built to support.

CAPACITY AND CONDITION

In 2024, over 4.9 billion motor vehicle trips were taken daily across the nation's 623,218 bridges, slightly more than the daily trips recorded in 2021. Of these bridges, 49.1% are in fair condition, 44.1% are in good condition, and 6.8% are in poor condition—a number that has continued to decline over the past few years.[3]

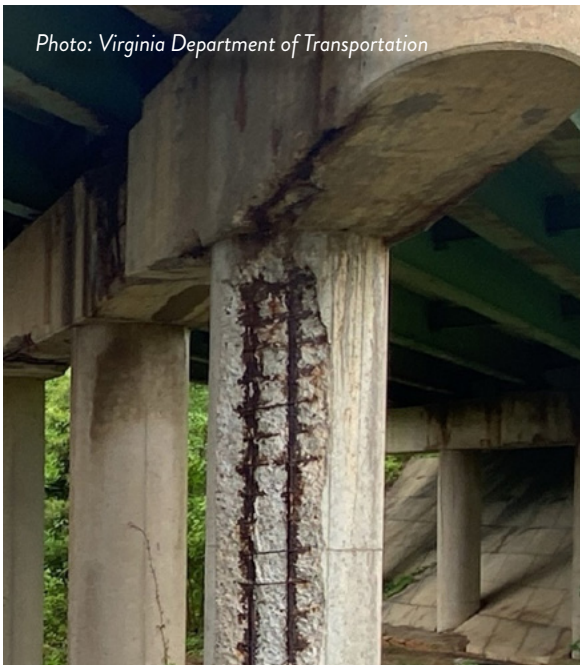
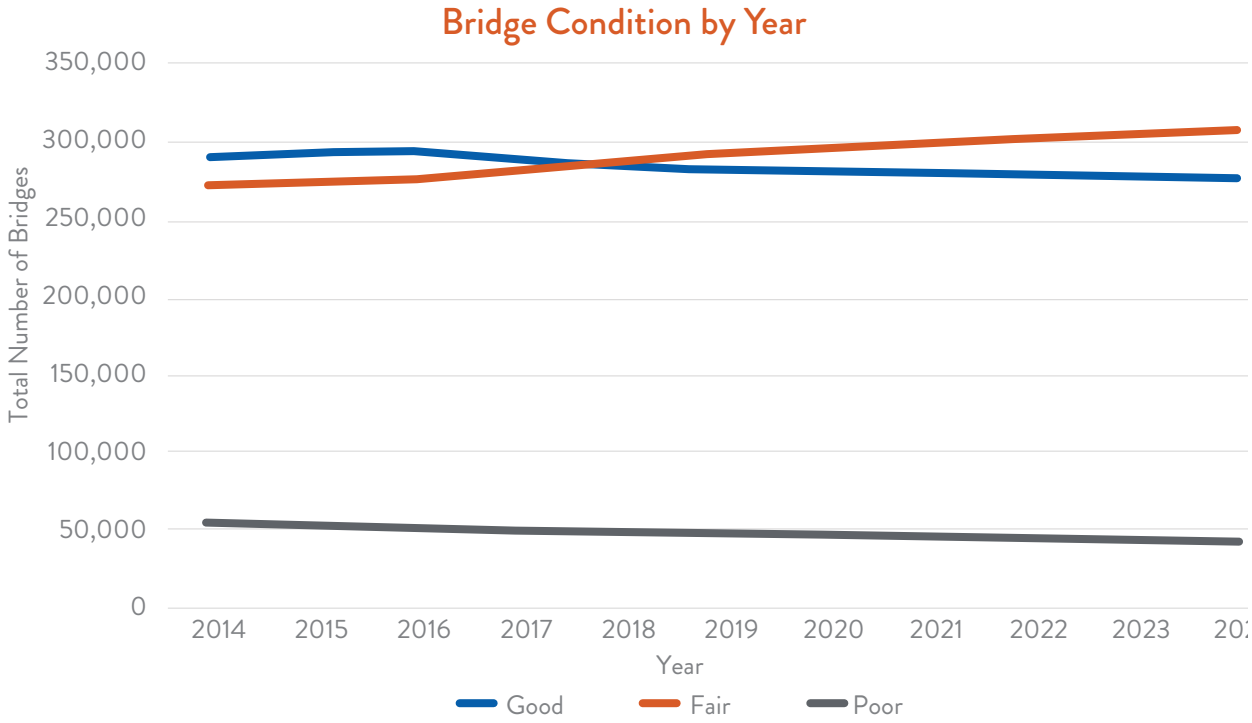


Photo: Virginia Department of Transportation



Source: Federal Highway Administration data

State-owned and locally owned bridges reflect this trend. In 2024, 42.9% of state-owned bridges were in good condition, while 52.6% were rated fair and 4.4% were rated poor. Meanwhile, 45.3% of locally owned bridges were in good condition, 45.8% were rated fair, and another 8.9% were rated poor.

Although bridges in poor condition are not necessarily unsafe, they require replacement or significant rehabilitation work and present a higher risk of future closure or weight restrictions.

Across the nation, the percentage of bridges in poor condition has continued to improve, dropping from 8.7% in 2014[4] to 7.3% in 2020[5] to 6.8% in 2024.[6] Mirroring this trajectory is the percentage of bridge deck area classified as poor. In 2014, some 6.7% of bridge deck area was in poor condition.[7] By 2024, that figure had dropped to 4.9%.[8] More than 168 million trips were taken across poor bridges every day in 2024, which is a decrease from the 178 million trips taken over poor bridges five years ago but still represents 3.4% of daily trips.[9]

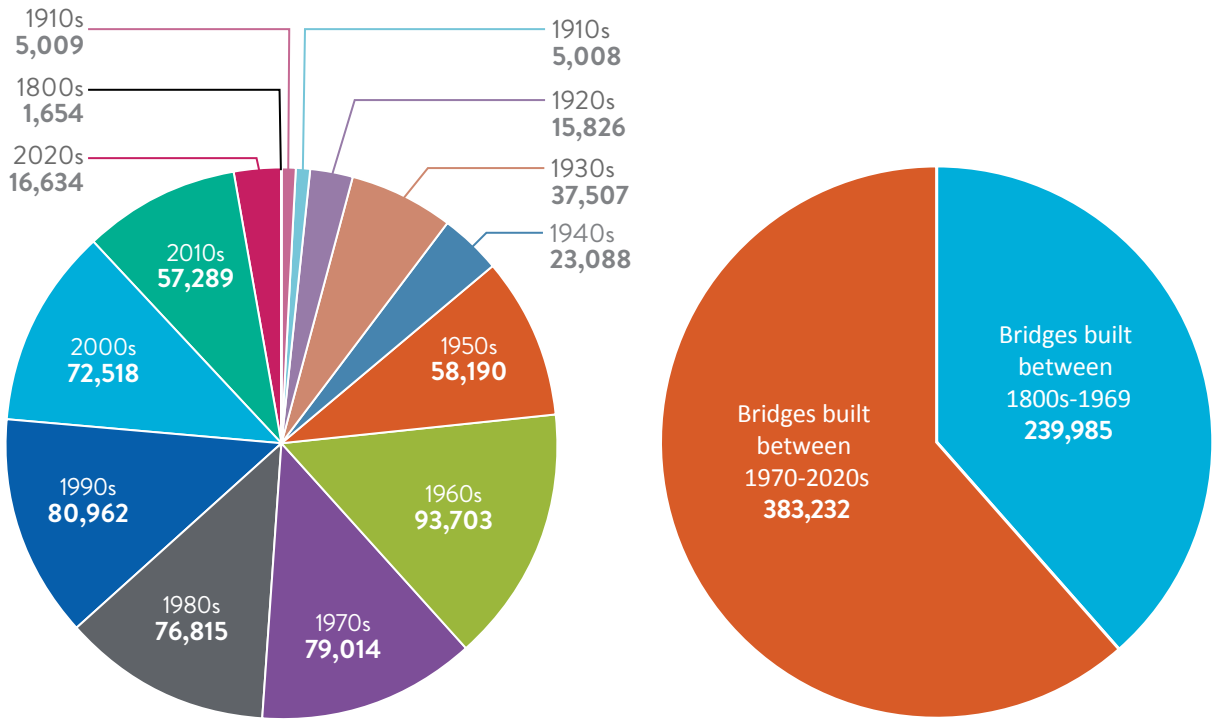
Less encouraging is the trend for bridges in good condition. Over the last few years, while the percentage of bridges in poor condition has decreased, so has the percentage in good condition. Some 44.8% of bridges were in good condition in 2021,[10] while 44.1% were rated in good condition in 2024.

As the number of bridges in good and poor condition has decreased, the number of bridges classified as fair has increased, presenting both challenges and opportunities. Although bridges in fair condition continue to age, with the potential of being downgraded to poor, they can also be preserved at a lower cost than is necessary to address a bridge in poor condition.

Furthermore, 63,085 of the nation's 623,218 bridges were posted for load in 2024, meaning they have restrictions regarding the weight of vehicles that can safely cross.[11] In addition to presenting safety concerns, posted bridges can cause heavy vehicle operators to take alternate routes, increasing travel time for emergency response vehicles, commercial trucks, and school buses.

About a third of the nation's bridge inventory (221,791 spans) needs repair work or replacement.[12] Approximately 45% of bridges have exceeded their planned design lives of 50 years. However, since 2007, new highway bridges are required to have a minimum 75-year design life.[13] Although infrastructure owners have worked to maintain a state of good repair, bridges will need to be kept in service well past their anticipated initial design lives. Between 2014 and 2023, about 4,927 bridges per year were replaced. **At that rate, bridges built today will need to last 126 years.**

Number of Bridges by Period Built



Source: Federal Highway Administration data

FUNDING AND FUTURE NEED

Chronic underinvestment has resulted in a substantial financial need for bridges. The Federal Highway Administration's (FHWA) most recent assessment from 2018 estimated that $1.1 trillion was needed to address an existing backlog of highway and bridge investments.[14] System rehabilitation needs for bridges are estimated at $191.3 billion. As of 2023, FHWA estimates the cost to replace poor bridges totals $69.7 billion, while rehabilitation costs are $47.4 billion.[15] ASCE's *Bridging the Gap* report indicates there is a funding gap of $373 billion over 10 years to bring the nation's bridges into a state of good repair.[16]

Substantial investment in bridges at the federal and state levels has occurred over the last few years, reflecting positive movement to address these immense needs. The IIJA contained a five-year reauthorization of federal surface transportation programs for Fiscal Years 2022–2026 and boosted infrastructure spending via supplemental appropriations. The IIJA also created the Bridge Replacement, Rehabilitation, Preservation, Protection, and Construction Program (Bridge Formula Program), which provides $27.5 billion over five years,[17] and established the competitive Bridge Investment Program, which provides $12.5 billion over five years to help plan, replace, rehabilitate, and preserve bridges.[18] A total of $21.2 billion was apportioned through the Bridge Formula Program between FY22–25. As of November 2024, just over $8 billion has been awarded through the Bridge Investment Program.[19] Since the enactment of the IIJA through the first quarter of FY25, 12,306 new bridge projects have been initiated, ranging from substantial upgrades of significant corridors such as the Brent Spence Bridge, which links Ohio and Kentucky, to smaller studies of bridge needs in Philadelphia and Utah.[20]

Although the federal excise tax rate of 18.4 cents per gallon on gasoline and 24.4 cents per gallon on diesel has not budged since 1993, states have demonstrated initiative in adjusting fuel taxes to generate revenue for transportation infrastructure projects. Between 2013 and 2023, 34 states have approved or adjusted motor fuel tax increases.[21] As vehicles have become more fuel

efficient and electric cars more commonplace over the last 20 years, the purchasing power of the fuel tax has declined. The U.S. federal fuel tax rate is lower than other industrialized countries. For example, Germany's tax on gas is $2.76 per liter, and France's is $2.81 per liter.[22]

Since the purchasing power of fuel taxes has declined, states have enacted additional and alternative transportation funding mechanisms. As of 2024, 39 states have established an electric vehicle registration fee, and eight states have enacted an EV charging station tax or fee.[23] Four states have set up an optional road usage charge (RUC) program, and 18 are conducting pilots, studies, or research on RUC programs.[24]

OPERATION AND MAINTENANCE

To handle bridges' specific needs, state departments of transportation develop and use Transportation Asset Management Plans (TAMPs), which outline systematic, data-based approaches to managing their bridge inventories. The federally required TAMPs predict and set targets for the number of bridges in good or poor condition over the next 10 years. Strategic asset management planning is one of the most cost-effective ways the nation addresses its aging and deteriorating bridge inventory.

Life-cycle cost analysis is a critical component of asset management. When the cost of a bridge replacement, rehabilitation, or repair project is estimated for budgeting purposes without considering the long-term costs of maintenance, operation, and retirement, many decision-makers are left with an underestimated value for their planning purposes. Bridges are costly and complex assets that provide decades of service and using life-cycle cost analysis can minimize long-term costs with a broad up-front picture of the costs over a bridge's lifetime.

Maintenance lessons can be learned from the collapse of Pittsburgh's Fern Hollow Bridge, which took place in January 2022 after experiencing a structural failure. The National Transportation Safety Board (NTSB) concluded that critical lapses in maintenance and oversight by multiple agencies led to the bridge's collapse. Although previous inspections had repeatedly documented issues with the bridge, maintenance and repairs were not performed to resolve these issues. Additionally, Pennsylvania Department of Transportation (PennDOT) contractors conducted inspections that did not comply with guidance and failed to identify fracture-critical areas on the bridge's legs.

Certain states have found success in collaborating with their local government counterparts and tasking them with bridge maintenance decisions. In Louisiana, for example, many of the state's poor condition bridges were on the local system. The state transportation department gave parishes money to manage those bridges, and parishes, in turn, chose to do robust maintenance rather than replacements.[25] The result was that, even with limited resources, parishes could perform maintenance work on bridges to keep them functioning.

PUBLIC SAFETY AND RESILIENCE

Resilience to natural and human-made disasters is essential in designing, rehabilitating, and replacing critical infrastructure, and bridges are no exception. Many of the country's older bridges are susceptible to frequent weather-related disasters such as flooding, potentially resulting in overtopping, washout, and other storm damage. Approximately 22,420 bridges were found to be susceptible to overtopping or having their foundations undermined during extreme storm events.

Bridge failures can negatively affect other infrastructure systems, leading to impacts beyond the cost of replacing the bridge and the loss of human lives. Vessel and truck collisions with bridges, exemplified when a cargo vessel strike caused the Francis Scott Key Bridge in Baltimore to collapse in March 2024, can cost lives, thwart commercial operations at ports, and lead to costly detours for drivers. The potential for these collisions poses an additional challenge to designing and protecting bridges. Fender systems, "dolphins," and islands surrounding piers are options for pier protection, as cargo vessels have grown larger than many bridges were designed to accommodate.

Additionally, bridges are being subjected to trucks heavier than those they were originally designed to carry. These heavier trucks and potential truck convoys threaten to overstress bridge elements, cause metal fatigue and cracking, and decrease the design life of bridges. Bridges could see further stress as future opportunities to platoon connected or autonomous trucks become more commonplace. The great challenge moving forward is to support the hundreds of thousands of existing bridges so they can provide decades of continued, safe service despite a greater frequency of extreme weather events and an increase in design loads.

Bridge failures can negatively affect other infrastructure systems, leading to impacts beyond the cost of replacing the bridge and the loss of human lives.

INNOVATION

Engineers are using innovative design requirements, materials, and technologies to enhance the security and resilience of bridges. Various materials and techniques have been developed to maintain the design life of bridges. Materials that can add strength and durability to bridges include high-performance steel, stainless steel, ultra-high-performance concrete, and self-healing concrete (to fix minor cracks). Improved coatings for steel such as galvanizing or metalizing can also increase design life. Remote monitoring of embedded sensors that have been placed in bridges and ultrasound tests of concrete can help engineers identify problems earlier, while drones present an option to assist in obtaining data during bridge inspections.

Photo: Indiana Department of Transportation

Bridge failures in recent years have provided opportunities to use innovative techniques. For example, innovative construction materials and ingenuity expedited the reopening of Interstate 95 in Philadelphia after a bridge collapsed in June 2023. Workers used foam glass aggregate (made from recycled glass) to build temporary travel lanes, allowing traffic to return to I-95 and relieving congestion.

Photo: Wreckage from the Francis Scott Key Bridge collapse in Baltimore, U.S Army Corps of Engineers, Baltimore District

RECOMMENDATIONS TO RAISE THE GRADE

- Determine the entire life-cycle cost of a bridge to inform smart design decisions and develop a balanced approach for our aging bridge inventory that emphasizes preservation, rehabilitation, and replacement.
- Increase funding from all levels of government to continue bridge repair, rehabilitation, operation, maintenance, and replacement work to maintain a state of good repair and keep bridges from falling into poor condition.
- Continue the use of traditional user fees for transportation funding, such as federal and state motor fuel taxes, while transitioning to more sustainable and equitable innovative user fees, such as alternative energy vehicle fees and RUCs.
- Prioritize rehabilitating and preserving bridges in fair condition, as these bridges can often be maintained at a lower cost than would be required to replace the structure. This prioritization could result in a reduced number of poor bridges and a decreased maintenance backlog while also addressing bridges that have passed or are approaching the end of their design life.
- Urge states to prioritize investing in bridges that are most critical, including those that experience high daily traffic volumes, are located on essential freight corridors, or serve as evacuation routes.
- Encourage states to develop multivariable prioritization formulas for the bridges in their jurisdiction and publish their project lists, including the funding sources and prioritization process that led to the projects' programming.
- Fund research into innovative technologies, materials, and construction techniques to extend and preserve the life of bridges.

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Broadband

C+

Photo: Jason Richard – Wired Fiber Broadband Tower

GRADE COMPARISON

2025: C+

2021: n/a

BROADBAND

EXECUTIVE SUMMARY

As the fabric of work, society, and commerce has moved into the digital realm, a fast and reliable connection to the internet has become essential.[1] In 2000, only 1% of U.S. adults had broadband access at home, compared to 80% today.[2] America's economy requires reliable broadband access, with research showing that the nation would have lost $1.3 trillion in economic growth between 2010 and 2020 if broadband speeds and adoption had remained at 2010 levels.[3] While the total amount of public spending on broadband is difficult to estimate, the private sector has invested approximately $2.2 trillion in broadband infrastructure since 1996, with the Infrastructure Investment and Jobs Act (IIJA) recently providing an additional $65 billion in federal dollars.[4] Yet, broadband access and adoption continue to face several challenges. Estimates show that 10% of households (12.7 million) do not have a broadband subscription, whether at home or on a mobile device.[5] As new investments are deployed to connect the remainder of Americans to broadband, extreme weather poses challenges to internet reliability and new technologies create a rapidly changing environment.

BACKGROUND

In 2024, 96% of U.S. adults said they used the internet.[6] Almost 3,000 internet service providers (ISP) exist in the U.S., yet the bulk of broadband service is delivered by a few large, private ISPs.[7,8] Homes and businesses connect via wired or wireless connections, with numerous technologies delivering services described under the umbrella term *broadband*. In 2025, the Federal Communications Commission (FCC) defines broadband speed as 100 MBps download and 20 MBps uploads for fixed broadband connections transmitted over any technology. For mobile broadband, the connection provided by cellular networks, the FCC has not adopted a benchmark but is evaluating 5G technologies providing 35 Mbps download and 3 Mbps upload speeds.[9]

The economic impact of broadband investment is considerable. The World Bank estimates that a 10% increase in broadband access can lead to a 1.2% increase in gross domestic product (GDP) per capita in developed countries.[10] Meanwhile, rural areas with broadband adoption rates over 80% receive 213% higher business growth, 44% higher GDP growth, and 18% higher per capita income growth.[11,12] In addition, better broadband access can help improve health and life outcomes, such as improving access to telehealth.[13]

The World Bank estimates that a 10% increase in broadband access can lead to a 1.2% increase in gross domestic product (GDP) per capita in developed countries.[10]

CAPACITY AND CONDITION

While broadband technologies have been widely adopted over the past two decades, a digital divide remains based on age, income, education, and geography.[14]

The FCC's June 2024 broadband map shows that 94% of U.S. households can access a broadband connection at home that meets the FCC's high-speed internet definition.[15,16] By the FCC's definition, a 1 GB file should take approximately 80 seconds to download, while the upload speed meets the requirements for video web conferencing applications.[17] Availability can vary significantly based on location, with rural and tribal areas often experiencing lower rates of access compared to urban regions. As recently as 2022, the FCC estimated 24 million Americans lacked fixed broadband service, including 28% of those in rural areas and more than 23% living on tribal lands.[18] Furthermore, regardless of the high availability rate, approximately 15% of U.S. adults do not have a home broadband connection for a variety of reasons, including affordability.[19]

The cost of broadband can vary widely. A 2024 survey found that the average monthly internet cost in the U.S. is $62 for a connection with download speeds of 100 MBps, with the price fluctuating from a low of $20 per month to a high of nearly $300 a month based on internet speeds.[20] Additional fees for installation, equipment rental, or other services can add to the cost to access broadband at home.[21] To help consumers understand their costs, the FCC now requires ISPs to provide easy-to-understand pricing labels, modeled after nutrition facts on food items.[22]

Most U.S. households' access to fixed broadband is delivered through fiber-optic cables, copper telephone lines (DSL), or coaxial cables. Coaxial cables, the same lines that carry cable television, are the most widespread wired technology, and an increasing share of households are using wireless technologies.[23]

Broadband Availability and Speed by Connection Type, June 2024

CONNECTION TYPE	CABLE	DSL	FIBER	FIXED WIRELESS	SATELLITE
Point-of-Use Hardware	Coaxial RF Outlet	RJ-11 Phone Jack	RJ-45 Ethernet Connection	Antenna Console	Satellite Dish
Download Speeds (MBps)	10–10,000	5–120	200–20,000	25–300	12–150
Upload Speeds (MBps)	5–50	1–20	200–20,000	1–50	5–25
Nationwide Availability (%)	82	4	46	47	99
Locations Served (million)	134	7	75	77	163
Change from December 2023 (%)	0	–1	+7	+13	0

Source: Information Technology and Innovation Foundation & Federal Communications Commission

Compared to other infrastructure systems, America's broadband networks are often newer and more frequently replaced or augmented with electronic hardware. The oldest copper lines capable of DSL speeds were installed at the dawn of the commercial internet—a relatively recent 35–40 years ago. Coaxial cables followed in the 1990s with the spread of cable television. Today, the most advanced technology being deployed is fiber-optic wiring, with 78 million U.S. homes connected to fiber, totaling 5.1 million miles of wiring, with another 4.2 million miles expected to be added by 2028.[24] Fiber-to-the-home or hybrid systems often replace older systems, with the oldest fiber lines only a few decades old, suggesting that the physical broadband infrastructure is likely in fair condition.

Broadband technologies differ in their deployment costs depending on factors such as geography or population density, labor costs, property acquisition, rights-of-way permissions, permitting, and other regulatory compliance factors, as well as preparation work in design and engineering.[25] For example, wireless technologies are often more financially viable in less dense areas, where the cost of laying fiber-optic or cable lines to connect relatively few homes can be prohibitive.[26]

Approximate Materials Cost for Last-Mile Broadband Deployment Methods

CONTEXT	METHOD	COST IN 2024 DOLLARS
Buried	Fiber	$2,500 + $5 per foot
	Coaxial	Various
Aerial	Fiber	$200 + $3.50 per foot
All Wired Methods – Hardware + Buildings		$1.5 million
All Wireless Methods – Hardware + Buildings		$200,000 + $75,000 per tower
All Methods – Construction Equipment		$300,000

Source: National Telecommunications and Information Administration, "Costs at-a-Glance: Fiber and Wireless Networks," 2017

Satellite broadband is also being used in remote areas, but it is frequently an expensive option that is generally slower, subject to data caps, and vulnerable to inclement weather.[27,28] A 2024 study noted that 30% of users of one popular satellite internet provider had experienced an internet outage in the previous 90 days compared to 24% for major fiber providers.[29]

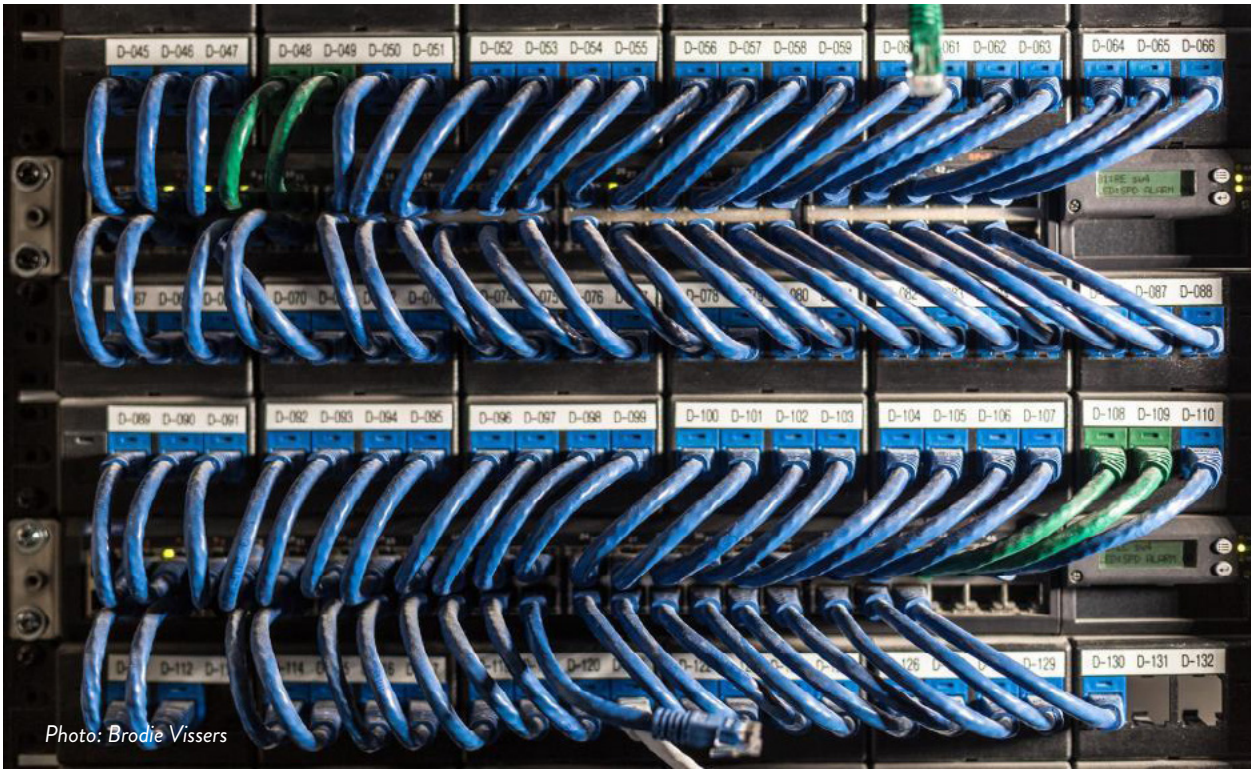


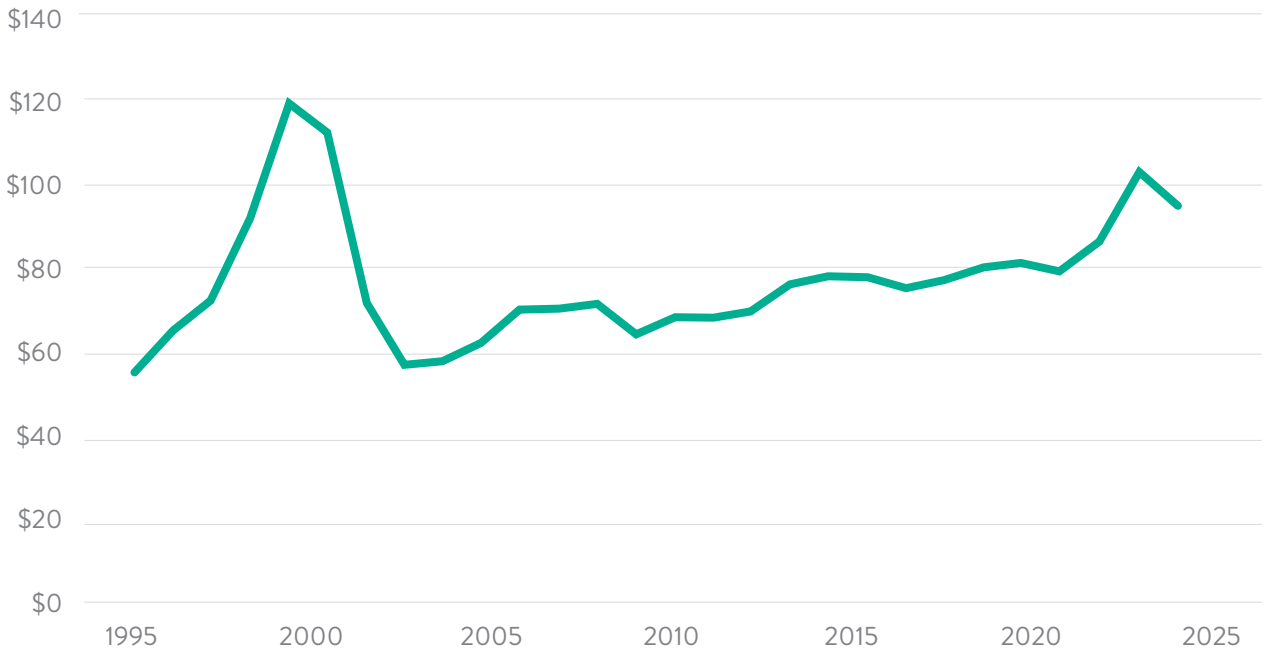
Photo: Brodie Vissers

FUNDING

Some broadband infrastructure in the U.S. is funded by federal, state, and local governments, but private sector ISPs are primarily responsible for building broadband infrastructure and selling internet services to the public.[30] A rising number of municipal broadband networks are administered by local governments, with nearly 450 operating across the country as of January 2024.[31]

Since 1996, ISPs have invested nearly $2.2 trillion in America's broadband infrastructure, and recent federal investments of $65 billion will support continued deployment.[32,33] These federal dollars will be further leveraged by private, state, and local investments; however, that amount is unknown at this time.

U.S. Broadband Provider Capital Expenditures, 1996–2023 ($ Billion)



Source: National Telecommunications and Information Administration

The high cost of deploying broadband infrastructure has historically meant that communities that were more rural, possessed difficult geography, or were otherwise economically less promising struggled to gain access. In response, the FCC, the National Telecommunications and Information Administration (NTIA), and the U.S. Department of Agriculture (USDA) are collaborating to address this inequity. To accelerate the effort, the IIJA allocated $65 billion to improve access to broadband and close the digital divide.[34] Most funding ($42.5 billion) was directed to the NTIA's Broadband Equity, Access, and Deployment (BEAD) Program to expand high-speed internet access through planning, deployment, and adoption programs.[35] As of 2024, the NTIA has begun final approval of projects that qualify for BEAD funding.[36]

The second largest tranche of IIJA funding included $14.2 billion for the FCC to administer the Affordable Connectivity Program (ACP), which modified and replaced the Emergency Broadband Benefit Program.[37] The ACP provided a discount up to $30/month toward internet service for eligible households and up to $75/month for households on qualifying tribal lands.[38] From the program's launch in December 2021 until its funding ran out in June 2024, 23 million households enrolled in the ACP.[39]

FUTURE NEED

It is estimated that it will cost $61 billion to meet the BEAD program's stated goal of universal broadband availability for every American by 2030,[40] with federal capital investments estimated to total $42.5 billion over that same period.[41] Therefore, if current funding levels continue, the nation is well poised to meet today's needs. However, deployment costs are increasing, with some firms seeing costs increase by over 10% for deployment, with materials and labor costs being the largest drivers for the increase.[42,43]

As faster internet technologies are developed, users are simultaneously consuming larger amounts of data, especially related to video. The average monthly broadband consumption per household has more than doubled over the past five years from 276 GB in the fourth quarter of 2018 to 641 GB by the fourth quarter of 2023.[44] As recently as 2010, the average consumer used only 9 GB of data per month.[45] At the current rate of growth, it is estimated the average household will consume more than 1 TB of data per month by 2028.[46] To meet the growing and future demands of the digital world, investments are needed to develop and expand broadband infrastructure.

Recent federal mandates have also affected the installation and operation costs of broadband networks. Two of the most consequential federal provisions are "Rip and Replace" and "Build America, Buy America."

Since 2019, ISPs have been required to remove telecommunications equipment the FCC deems could pose national security risks.[47] This "Rip and Replace," mandate has led to operational challenges and financial burdens for ISPs, particularly smaller providers that previously relied on affordable Chinese equipment. The cost of replacing this equipment can be substantial, and while the federal government has provided some funding to offset these costs, the process has been complex and time-consuming. As of 2024, some ISPs are still in the process of replacing their equipment, and the FCC has highlighted the need for additional funding for the replacement reimbursement program.[48]

Next, the IIJA includes a requirement to source equipment, supplies, and labor from within the U.S. to boost domestic manufacturing. In the case of broadband, many of the requisite components are not currently produced in America. This requirement has added complexity and potentially significant cost increases to broadband projects. To address these concerns, NTIA has issued a "nonavailability waiver" to the BEAD program's Build America, Buy America provisions.[49]

Finally, the challenge of meeting America's future broadband needs is compounded by the shortage of qualified workforce. Research estimates that the industry will require an additional 205,000 jobs over the next five years to build, operate, and maintain these networks.[50] Since 2014, the telecommunication workforce has shrunk by 25%, from 848,000 to 633,700.[51] Several states are responding by deploying resources to meet the workforce shortage. Examples include Louisiana's implementation of a broadband workforce development curriculum for community and technical colleges.[52] ISPs in Alaska also work with unions and trade associations to support telecom apprenticeship programs that consist of classroom and on-the-job training.[53]

Photo: Gordon Chaffin—
Spliced Fiber Broadband Cable

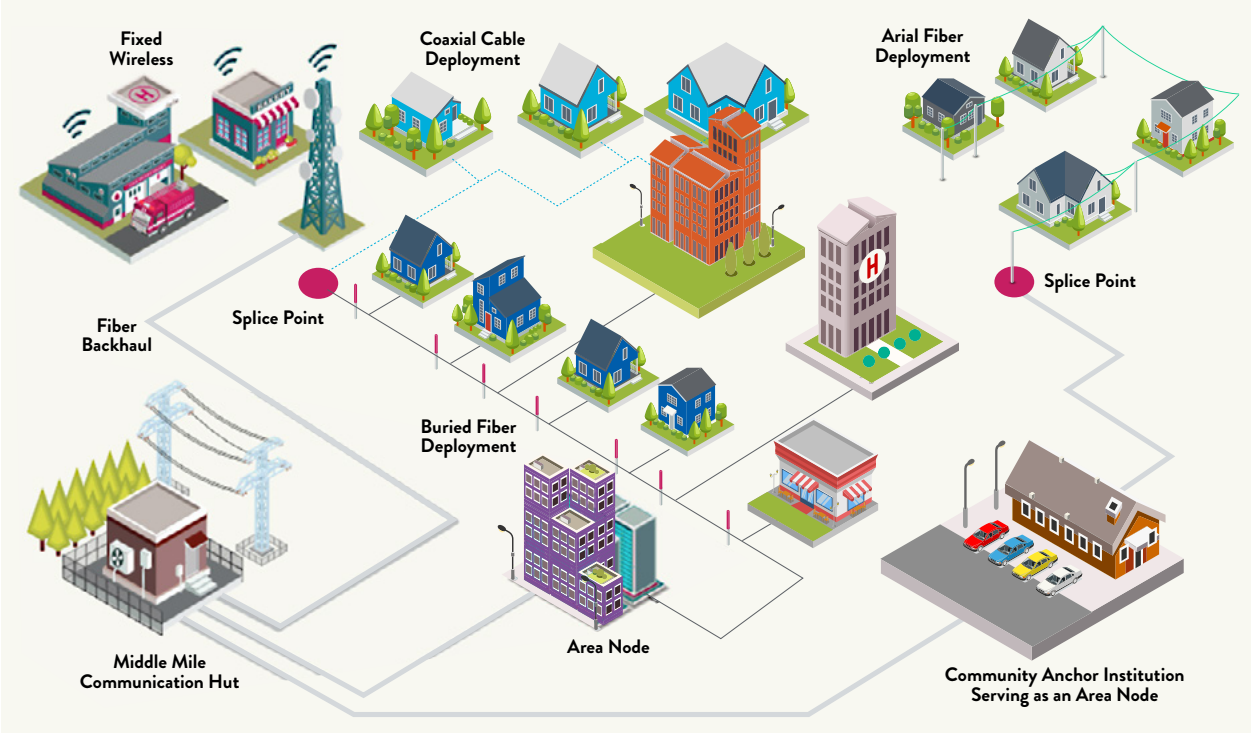
OPERATION AND MAINTENANCE

Depending on the technology deployed, the cost to operate and maintain broadband networks can vary greatly, with fiber-to-home networks generally the most cost-effective method to operate, costing $53 a year per home passed (PHP) versus $107 PHP for hybrid fiber coax and $144 PHP for DSL networks.[54]

Although fiber may be the most cost-effective form of broadband to operate and maintain, it remains the most expensive technology to deploy, with highly variable capital costs depending on geography, density, and the built environment.[55] For example, digging trenches to lay underground fiber-optic cables can be costly and time-intensive, especially when connections are made across rural locations. Distances between settled areas require more miles of fiber-optic cable to connect fewer residences or businesses, and mountainous areas may be cost-intensive if rock drilling is required. The cost of additional fiber deployment can also change if the installed lines are aerial versus underground. In response, fixed wireless service is a fast-growing deployment method, because overall costs are lower in those challenging geographies.

Finally, as networks age, cables and equipment must be maintained or replaced as they fail or reach the end of their life.[56]

Broadband Network Scenarios by Deployment Type



Source: National Telecommunications and Information Administration, "Broadband Network Deployment Engineering," *2022*

PUBLIC SAFETY

The nation's broadband infrastructure provides a target for bad actors looking to damage and disrupt businesses, services, and the economy. For example, in November 2024, Chinese hackers breached at least eight U.S. telecommunications providers and stole customer call and law enforcement surveillance request data. These sorts of data breaches are estimated to cost $4.9 million per impacted organization globally.[57]

Beyond the continued threat of cyber security incidents, public safety depends on the continued operation of broadband during emergencies. When power goes out, so does the last mile of internet infrastructure. Emergency response has been digitized over recent years, meaning first responders have better information to do their jobs, but broadband up-time is more crucial than ever.

Recognizing these challenges, in 2012 Congress created the First Responder Network Authority (First Net). Since 2017, the program has been provided $7 billion to build, deploy, and operate a dedicated nationwide public safety broadband network for use by America's first responders. As of 2024, 29,000 public safety agencies are supported by FirstNet with approximately 6.4 million connections.[58] However, the completion of the dedicated network will require billions more in government funding over the coming years.

Finally, key pieces of physical infrastructure depend on internet-connected sensors. In extreme events, information flow from dam load sensors or a stormwater flow gauge, for example, is essential. These infrastructure components are vulnerable to cyber security threats, as shown in 2024 when water and wastewater facilities were targeted.[59] Operators of key infrastructure face competing priorities, so improving cybersecurity practices is often constrained by limited resources.

RESILIENCE AND INNOVATION

Severe weather and other natural disasters can disrupt or disable critical broadband infrastructure. Broadband infrastructure must be built to withstand more frequent extreme weather events, such as increased precipitation, threatening temperatures, high humidity, and rising sea levels across its service life.[60] To meet the threats

FEDERAL MONEY BOOSTS LONGSTANDING BROADBAND WORK IN WISCONSIN

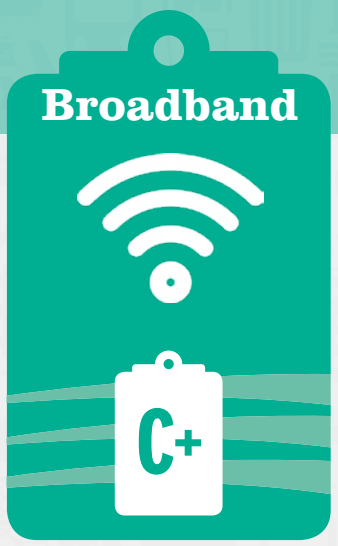
Wisconsin is improving its broadband infrastructure with at least $1 billion in new federal investments from the 2021 IIJA. Since 2014, the Wisconsin Broadband Office has distributed $319 million in grants to deploy broadband infrastructure. Funding has supported 458 projects through new and/or enhanced services to approximately 450,000 homes in the state. Housed within the state's Public Service Commission, Wisconsin's Broadband Office has more extensive data collection abilities than many other states, so decision-makers and the public can better perform oversight and identify investment needs from the private and public sectors. Currently, 32% of Wisconsin locations have access to fiber connections, all of which are broadband speed. But of those connected via cable, 31% do not receive benchmark speed, and fixed wireless only delivers broadband speeds to 14% of Wisconsin residents. Satellite services are usually also available to those same residents, but 98% of low earth orbit connections do not meet the current FCC broadband standard. To connect all Wisconsin locations to broadband, state leaders estimate it will require $1.2 billion in additional investment beyond existing BEAD funds.

presented by extreme weather, hardened features to withstand specific disasters are vital to the health of these critical systems; these include burying vulnerable fiber-optic lines and reinforcing towers. Creating redundant systems, like backup batteries and power generators, help build a more resilient network to handle the rise in extreme weather.[61]

The benefits of investments in resiliency have not been lost on policymakers. The BEAD Program requires states and territories to assess the risks posed by climate-related disasters in their area. In turn, states have created strategies to mitigate risk and increase the resilience of broadband infrastructure.[62] For example, in its draft proposal to the NTIA in December 2023, North Carolina proposed requiring its subgrantees to submit an approved Climate Resiliency Plan, along with an explanation of how the plan factors into a project's total cost.[63] In Louisiana, applicants must estimate the cost of burying fiber-optic cable and incentivize projects that bury at least 90% of new fiber, while California requires project proposals in vulnerable areas to install a 72-hour backup power supply to meet its resiliency standards.[64]

As resiliency improves among broadband infrastructure, government and industry are using broadband to innovate and better connect to more traditional infrastructure categories. The growth of the Internet of Things (IoT), networks of devices, sensors, and other objects that collect and exchange information using broadband technologies, is transforming the way key stakeholders monitor, operate, and maintain infrastructure.[65] For example, California's Yuba Water Agency is using this technology to improve its operation and risk assessment of the New Bullards Bar Dam, the fifth tallest dam in the U.S.[66] Similarly, the city and county of Denver is using IoT sensors to monitor and improve the operation and maintenance of its Highland Bridge, a vital pedestrian bridge in the heart of the city.[67]

Photo: This is Engineering - Farm Robot with Internet



RECOMMENDATIONS TO RAISE THE GRADE

- Incentivize internet service providers to provide better service data for key performance indicators such as delivered speeds and reliability of service.
- Provide dedicated, predictable funding for broadband affordability programs.
- Account for life-cycle costs and possible recovery costs from systems failures when delivering broadband projects.
- Facilitate state-based reporting on the implementation of broadband plans, the use of BEAD, and other federal broadband funding.
- Encourage partnerships with state and local agencies and broadband providers to facilitate service uptake for vulnerable communities.
- Expand Dig Once policies to include broadband deployment plans in more public works projects, specifically transportation, energy, and water improvements that are already requiring work above and below the ground.
- Incentivize the latest up-to-date codes and standards for utility poles and other structures that are often used for broadband deployment.

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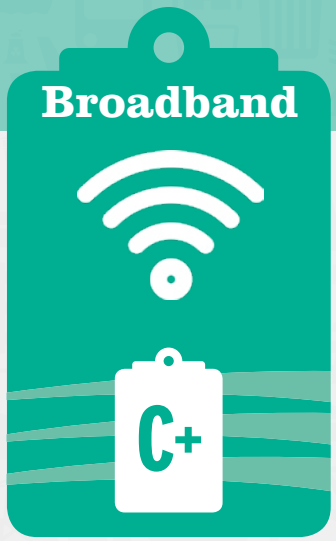

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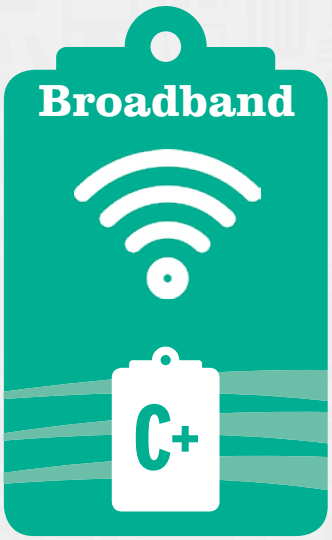

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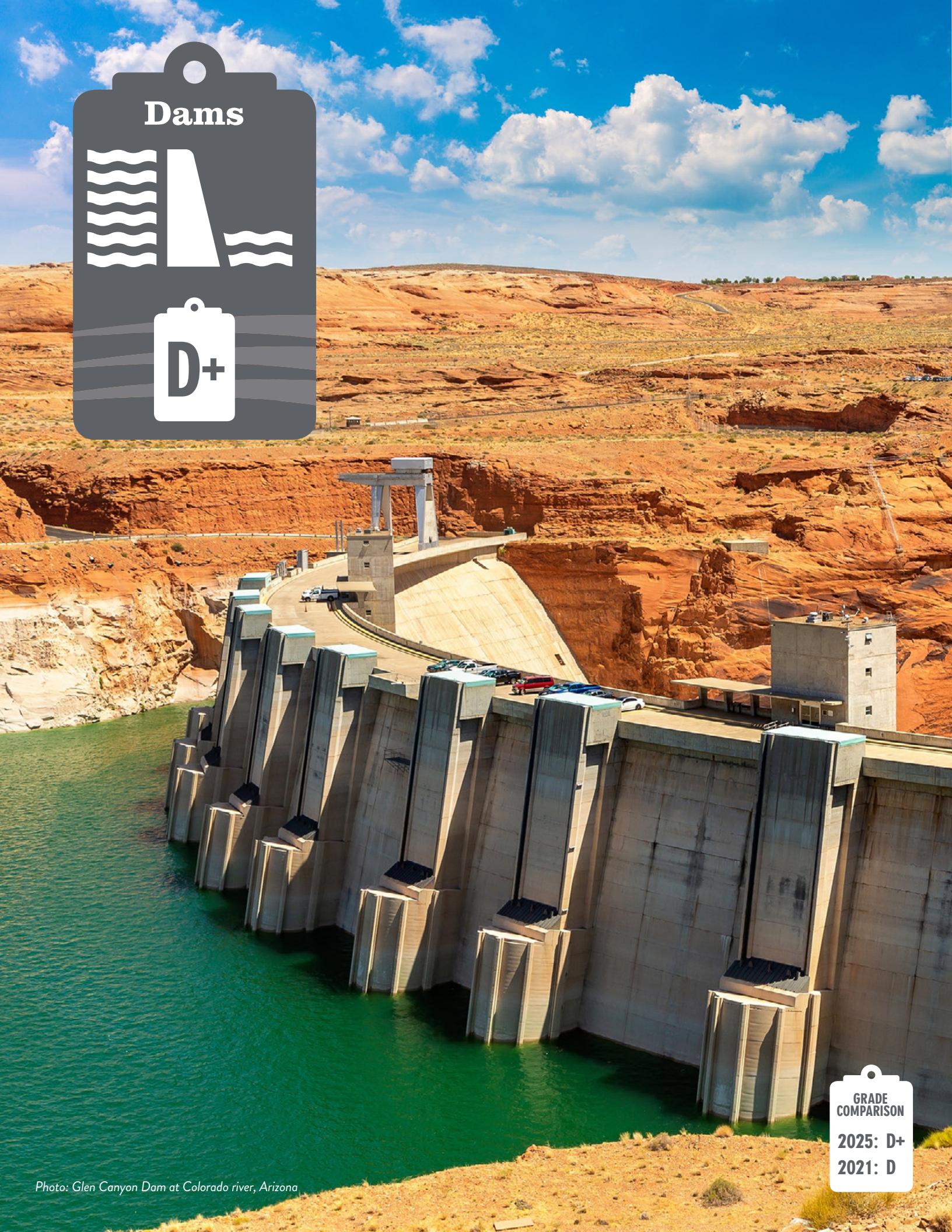


Photo: Glen Canyon Dam at Colorado river, Arizona

DAMS

EXECUTIVE SUMMARY

There are more than 92,000[1] dams in the U.S. that generate electricity, supply drinking water, and protect communities and critical infrastructure. Nearly 17,000 of these dams are considered high hazard potential, meaning there is likelihood of deadly harm to residents and property in the case of a dam failure. The cost of maintaining, upgrading, and repairing these structures has increased significantly since the beginning of the 21st century because of an increase in extreme weather events, growing populations downstream, and the outdated design challenges of aging structures. The average age of our nation's dams is over 60 years, while 7 of 10 dams nationwide are expected to reach 50 years by 2025. The Infrastructure Investment and Jobs Act (IIJA) provided approximately $3 billion to improve dam safety, although Congress redirected $364 million of that funding for other purposes. Furthermore, federal dam safety programs continue to receive annual appropriations below their authorized funding levels. Despite these challenges, IIJA funding, combined with other Congressional actions, provided a needed boost to overall dam safety and rehabilitation. However, without a more significant commitment to dam safety through increased annual investment in inspection, monitoring, planning, and necessary dam repairs, the cost to bring the nation's dams into a state of good repair will continue to rise and downstream communities will face a greater risk of danger from potential dam failure.

BACKGROUND

The U.S. is home to more than 92,000 dams, which are responsible for flood control, irrigation, water supply and conservation, river navigation, hydropower generation, mine waste storage, and recreation. Of those, only 4% are owned by the federal government, with the remaining 95% owned by state or local government, a public utility, or a private owner. More than 16,800 dams are classified as high hazard potentia, meaning that loss of life and significant property destruction is likely in the event of a dam failure. More than 38,000 of the nation's dams support recreational activities and therefore experience significant public access. On average, the nation's dams are 64 years old and need significant repair and upgrades. The structural integrity and performance of many of the nation's dams are increasingly affected by extreme weather, with frequent and intense rain events placing a significant strain on dams and their ability to hold water, threatening the safety of downstream communities.

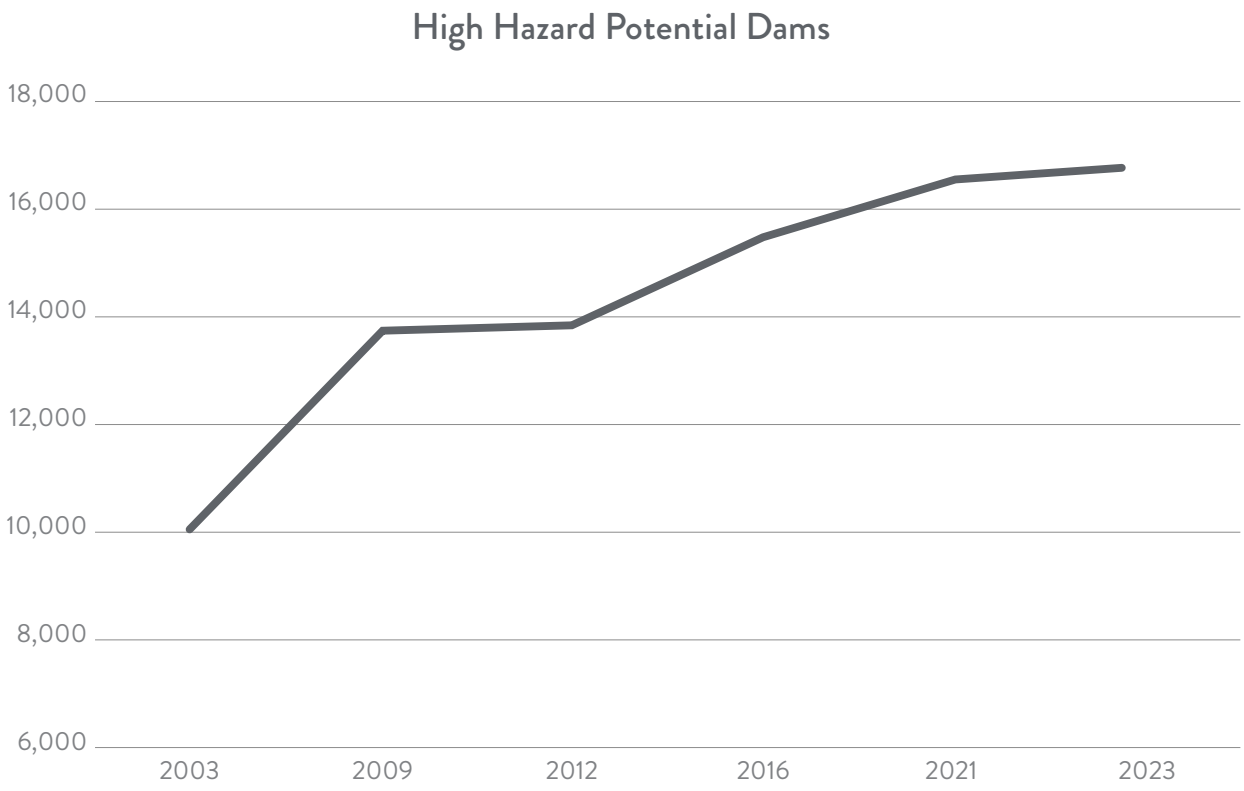
CAPACITY AND CONDITION

Dams are classified by their hazard potential, or the risk posed to downstream communities in the event of a dam failure. In the U.S., more than 16,700 dams are classified as high hazard potential as of August 2024, which means that if one of these dams should fail, the likely result would be loss of life and significant destruction to property. While such a classification highlights risk to communities, hazard potential does not indicate a dam's condition. Approximately 15%, or more than 2,500, of the nation's high hazard–potential dams are assessed to be in poor or unsatisfactory condition.[2] While a dam's hazard potential can often be determined by factors such as downstream development, condition assessments are primarily affected by the relative age of the structure, updated science and techniques for evaluating conditions, weather events, and climate change. High hazard–potential dams nationwide have increased by 20% since 2012, driven mostly by increased development in downstream areas.[3]

On average, the nation's dams are currently 64 years old,[4] and significant repair and upgrades are needed. According to the Association of State Dam Safety Officials (ASDSO), by 2025, 7 of 10 dams in the U.S. will be more than 50 years old.[5] Aging infrastructure and more frequent and intense rain events cause additional strain to the nation's dams. For example, in Vermont, the average age of the state's dams is 89 years. Because of this, many of Vermont's dams were not built using modern codes and standards; thus, they are not designed to withstand increasingly heavy and frequent rain events. Unfortunately, in July 2023, prolonged heavy rainfall over 48 hours produced between three and nine inches of rain in some parts of the state, which resulted in historic flooding and placed significant strain on Vermont's aging dams. Following the flooding, state dam inspectors assessed 400 dams across the state and found that 57 dams were overtopped by flooding, 50 dams sustained "notable damage," and five dams failed.[6]

Photo: Fairfax Falls Hydroelectric Dam, Fairfax, VT, on July 11, 2023, following historic flooding; University of Vermont, Spatial Analysis Laboratory

Increasingly severe rain events are affecting aging dams in other regions of the country as well. Since 2018, heavy rains have resulted in approximately 30 dam failures or near failures across the Midwest.[7] In June 2024, the western abutment of Minnesota's Rapidan Dam failed after several days of heavy rain. The flooding that caused the abutment's failure was the equivalent of a once-in-a-century flooding event and resulted in the destruction of a power station and destroyed part of a riverbank.[8] The Rapidan Dam, which had completed construction in 1910, had gone through several rounds of repairs since 2002 and was assessed to be in poor condition in 2023.[9] In 2021, an engineering report estimated that the cost of repairing the dam would be more than $15 million in addition to more than $6 million that had already been spent on the dam since 2002.[10]



Source: National Inventory of Dams

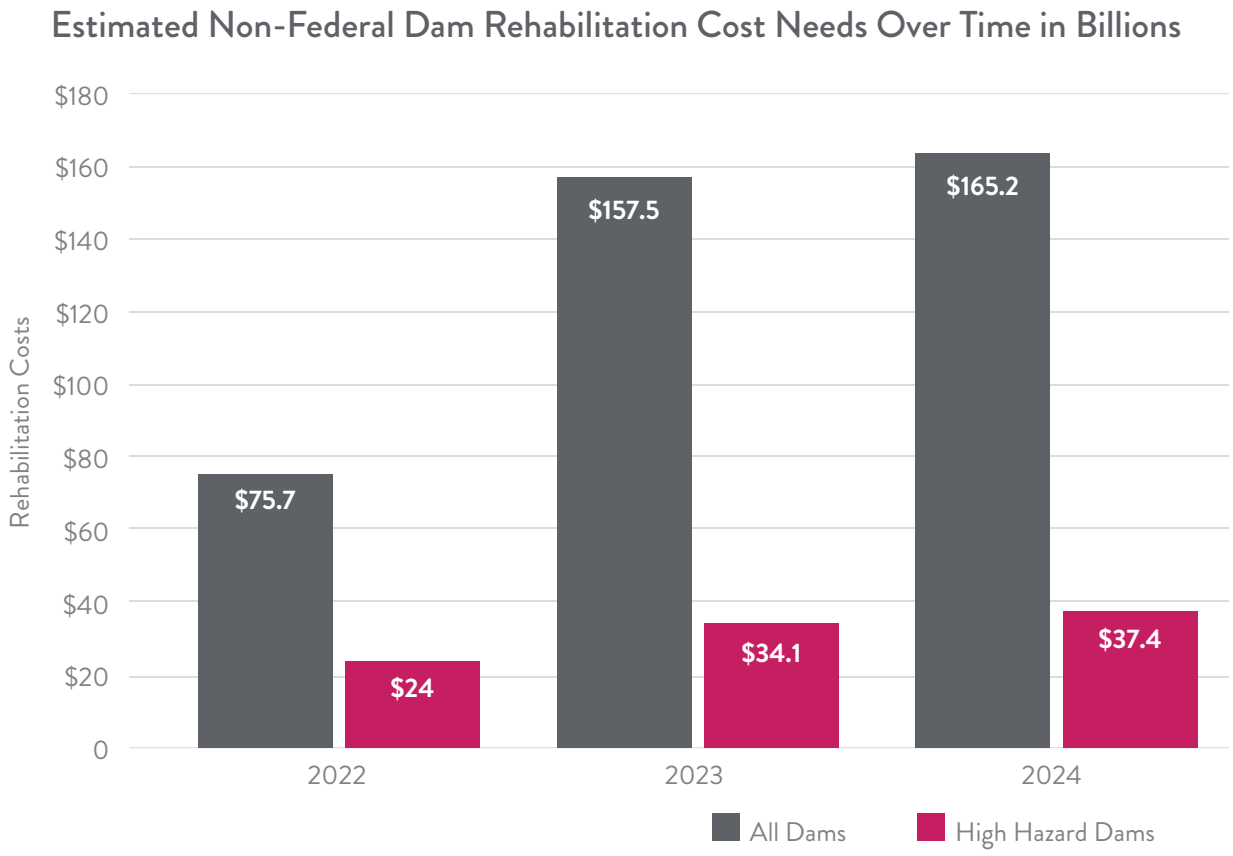
FUNDING AND FUTURE NEED

The National Dam Safety Program (NDSP) is the primary source of federal funding for states to improve their dam safety programs that support activities such as inspection and monitoring, emergency preparedness, and staffing needs. This program is only authorized to receive $13.9 million annually. The High Hazard Potential Dam Rehabilitation Grant Program (HHPD) Grant Program, which provides competitive grants to states to support repairs for dams posing the greatest risk to downstream communities, is authorized at $60 million annually. In 2021, the IIJA provided a total of $800 million for these programs as a one-time injection of much-needed support for dam safety. Furthermore, the U.S. Army Corps of Engineers' Water Infrastructure Financing Program (CWIFP), which supports non-federal dam safety projects through low-interest loans, received $75 million under IIJA. Meanwhile, the Department of Agriculture's Natural Resources Conservation Service administers a dam rehabilitation grant program through its Small Watershed Program, which receives about $10 million annually and $118 million in additional funds through IIJA.

Although there are multiple federal funding streams for dam safety, and the IIJA made historic one-time investments in dam safety, the totality of approved resources has not been made available to sustain the focus on safety needs at chronically underfunded structures. Only a portion of IIJA funding for the NDSP and the HHPD Grant Program will ever go to its intended purpose because nearly 50% of this total was redirected in 2024 by Congress and the U.S. Department of Homeland Security for other purposes.

The NDSP has consistently received less than $10 million in annual funding of its $13.9 million yearly authorization. The HHPD Grant Program has not received anywhere near the $60 million it could receive by law. In fact, the program received no federal funding in both Fiscal Years 2023 and 2024. Failure to fund the HHPD Grant Program diminishes the purchasing power of these investments, resulting in insufficient resources to support state program needs such as hiring qualified engineers to conduct dam inspection and monitoring. The lack of funding will also result in fewer resources to repair and rehabilitate high hazard–potential dams, which means that the condition of many of these dams will continue to deteriorate and raise rehabilitation costs that much higher.

In 2024, ASDSO determined that the current cost of repairing the nation's non-federal dams is $165.2 billion, with $37.4 billion needed for just non-federal, high hazard–potential dams.[11] The cost estimate increased by more than $120 billion between 2003 and 2022 primarily due to the growing number of dams being tracked in the National Inventory of Dams, providing a more accurate picture of total need.[12] Individual dam rehabilitation projects can reach over $1 billion, as was the case to repair California's Oroville Dam after its spillway failed in 2017.[13]



Source: Association of State Dam Safety Officials

OPERATION AND MAINTENANCE

Nearly every state has a fully operational dam safety program. These programs allow states to receive federal funds to perform necessary dam safety operation and maintenance activities such as developing emergency action plans (EAPs), conducting public outreach, and undertaking regular dam inspection and monitoring. Until recently, Alabama was the only state that did not have a state dam safety program. However, in 2023 and 2024, Alabama took legislative action to create an opt-in dam safety program, allowing for inspection and monitoring of state-owned and privately owned dams. These initiatives move the state closer to eligibility for NDSP State Assistance Grants. State dam safety programs are eligible to receive state assistance grants if they meet certain criteria, including authority to require inspection of all dams to for risk every five years.

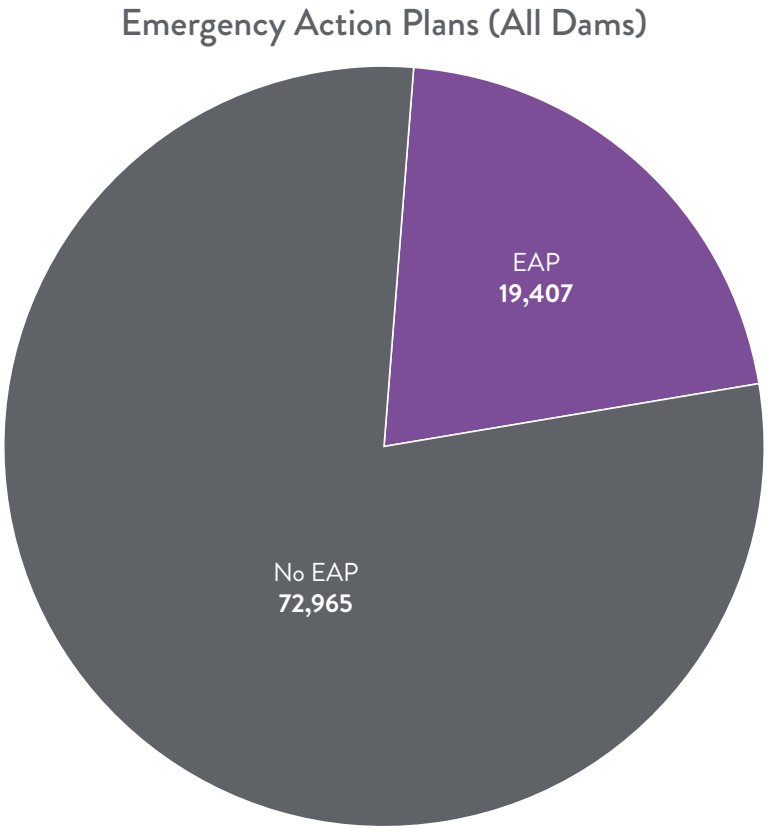
Reduced federal funding for the National Dam Safety Program has limited resources available to states. In turn, reduced funding has compelled states to extend their already constricted resources, putting additional strain on state budgets and stretching state dam safety programs. The consequences of lower funds affect critical components of state dam safety programs such as staffing. State assistance grants may help increase the number of trained engineers on staff to conduct inspections. On average, there are approximately 1,700 regulated dams per state. However, with an average of nine dam inspectors per state, a single dam inspector can be responsible for overseeing the safety of 190 existing dams and the construction of new dams.[14]

Photo: A home before partially collapsing into the Blue Earth River in Mankato, MN, following the 2024 partial failure of the Rapidan Dam; Andrew Weinzierl/AW Aerial

PUBLIC SAFETY

Dam failures can pose significant challenges to impacted communities. In addition to causing billions of dollars in economic losses and the potential loss of life, dam failures can result in damage to interconnected infrastructure systems. Flooding from dam failures can impact bridges and roadways, threaten drinking water supplies, place excessive strain on stormwater infrastructure, and damage levee systems that protect floodplains. Emergency action plans are critical to minimizing damage caused by a dam failure. EAPs identify potential emergency conditions at a dam, specify preplanned actions to reduce property damage and loss of life should those conditions occur, and are initiated in the event of an impending dam failure or other uncontrolled release of water. In May 2020, the Edenville Dam in Michigan failed after significant rainfall. It was later determined that an exercise as part of the dam's EAP was critical to informing evacuation plans, which led to "well-organized and orderly" evacuations of downstream communities.[15] As a result, there were no reported casualties. As of 2024, more than 11,000 state-regulated high hazard–potential dams (nearly 82% of state-regulated high hazard dams, about equal to 2021) have an EAP.[16]

"Low-head dams" pose ongoing safety concerns. A low-head dam is a relatively small, man-made structure spanning a river or stream where water flows over the entire length of the dam. Moderate-to-high flows over these dams create turbulent and recirculating currents that can pull and trap individuals underwater. Because low-head dams can be inconspicuous, people are often unaware of the dangers of these structures. Fortunately, Congress recognized this danger, and in 2022 the Water Resources Development Act authorized the creation of a National Low-Head Dam Inventory, and in 2024 passed legislation to incorporate low-head dams into the National Inventory of Dams. This new inventory will allow not only for low-head dams to be better identified but also will allow for clear warnings about the presence of low-head dams and the danger they pose to human life. Congress authorized $30 million to establish the inventory, and U.S. Army Corps of Engineers received $400,000 in FY24 appropriations to begin work on the inventory.



Source: National Inventory of Dams

Photo: Great Falls Park,McLean, VA; Mark Stenglein

RESILIENCE AND INNOVATION

Worsening rainfall patterns and flooding increasingly strain the structural integrity of the nation's dams. Heavy rainfall contributed to the failure of the Rapidan Dam in Minnesota in 2024, the Edenville Dam in Michigan in 2020, and the Oroville Dam's flood control outlet spillways in 2017. The intensity and frequency of extreme precipitation and flooding are projected to continue increasing in several regions. Further, in many areas (e.g., West, Northwest, the New Madrid zone), non-climatic hazards like earthquakes compound the risk posed by climatic extremes to the nation's dams.

In 2022, Congress took action to address this challenge by passing the Providing Research and Estimates of Changes in Precipitation (PRECIP) Act to help improve how the National Oceanic and Atmospheric Administration (NOAA) estimates probable maximum precipitation (PMP) to better account for changes in rain frequency and intensity. In 2024, the National Academies of Science, Engineering, and Medicine published a report on the current state of PMP estimation and its shortcomings. The report recommended a phased approach to modernizing PMP to a long-term model-based approach that accounts for the effects of extreme weather on precipitation and PMP estimates.[17] Through this renewed effort, enhanced collection of more accurate data on rainfall events will be critical to the engineering community in designing dams and developing better standards, ultimately leading to the construction of dams better able to withstand increased water levels, resulting in fewer flood-related incidents.

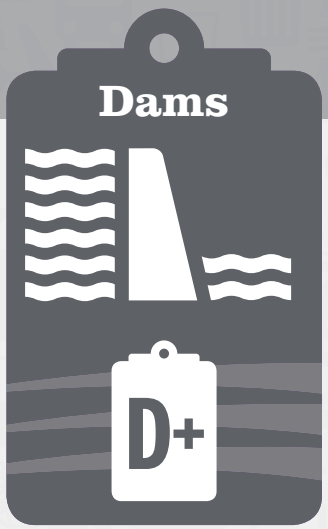
In recent years, dam safety officials and engineers have increasingly used risk-informed decision-making (RIDM) as an approach to dam safety. RIDM approaches decision-making by identifying and assessing existing risks, determining if those risks are tolerable (e.g., impracticable, cost-effective based on improvements gained), and whether existing risk mitigation measures are adequate. Since the 2017 failure of the Oroville Dam spillway, there have been more federal and state efforts to incorporate RIDM into dam management

practices, such as comprehensive inspections over visual inspections.[18] However, implementing RIDM comes with challenges requiring both significant financial resources, which many smaller state and federal agencies do not have, and very particular dam inspection expertise.[19]

Greater use of unmanned aerial vehicles (UAVs) or drones also provides innovative new approaches to dam safety. The ability to equip drones with equipment such as sensors, cameras, and infrared lenses can provide better access to higher and harder to access dam structures and can provide a lower-cost way to improve safety for dam inspectors.[20] Drones also have the potential to be used to prevent invasive plant and vegetation growth around dams. In recent years, the Tennessee Valley Authority has worked with dam safety professionals to test the use of drones to deploy herbicides to control vegetation growth around dam embankments, because the root structures of trees and heavy brush can pose dangers to structures and dam safety.[21]

Removal is also an increasingly appealing option for dams that no longer provide significant benefits. The IIJA made nearly $900 million available to support dam removal projects. Dam removal can produce tangible benefits such as restoring riverine ecosystems and removing hazards incited by dam failure. Removal is also an intervention that can restore or rectify environmental conditions caused by dam construction and ongoing operations placed on nearby communities. In 2014, the City of Manchester, Iowa, removed a 110-year-old low-head dam along the Maquoketa River, resulting in restored riverbanks, improved habitats for fish and other wildlife, and increased access to the river for recreational purposes through the development of a whitewater park.[22] On the other hand, dam removal may also produce unintended consequences such as excessive reservoir erosion, release of toxic and contaminated sediment, increased prevalence of invasive species, and ensuing legal conflicts.[23] Significant uncertainty remains about both the unintended consequences and long-term effects of dam removal, primarily due to limited experience with and lack of data from extensive monitoring of such projects, especially for large dams. It is essential to carefully examine key benefits and trade-offs, set practical goals for environmental recovery after removal, recognize limitations, and ensure effective data sharing from past and future dam removal projects. Cooperation and public engagement should be emphasized throughout planning for dam removal projects to ensure that dams do not become irreversible structures for decades to come. As a result, decision-making regarding dam removal can prioritize better projects balancing public safety with environmental concerns.[24]

Photo: Clementine Dam in Auburn, CA; Karen Donohue



RECOMMENDATIONS TO RAISE THE GRADE

- Fully fund the National Dam Safety Program and High Hazard Potential Dam Rehabilitation Grant Program, ensuring that adequate federal funds can support state dam safety programs and repairs to dams most in need and that pose the most significant risk to communities.
- Continue to build on progress by ensuring that all high hazard–potential dams have an emergency action plan by 2030.
- Complete implementation of a National Low-Head Dam Inventory by 2030, as authorized and prescribed in the Water Resources Development Acts of 2022 and 2024.
- Modernize methods of estimating probable maximum precipitation, as laid out in the 2024 report from the National Academies, to better determine the effects of extreme shifts in rainfall patterns, leading to better data for the engineering community to use in dam design and development of resiliency measures.
- Encourage improved land use planning at the local level so that communication about how dams affect local areas is more accurately known and considered in future planning.
- Carefully examine key benefits and trade-offs of dam removal and set practical goals for environmental recovery after removal, ensure effective data sharing from removal projects, and emphasize public engagement and cooperation throughout the removal process to balance public safety with environmental concerns.

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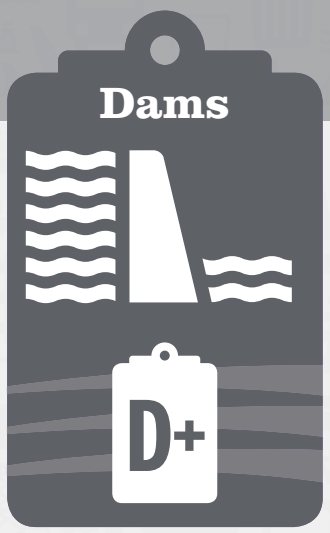

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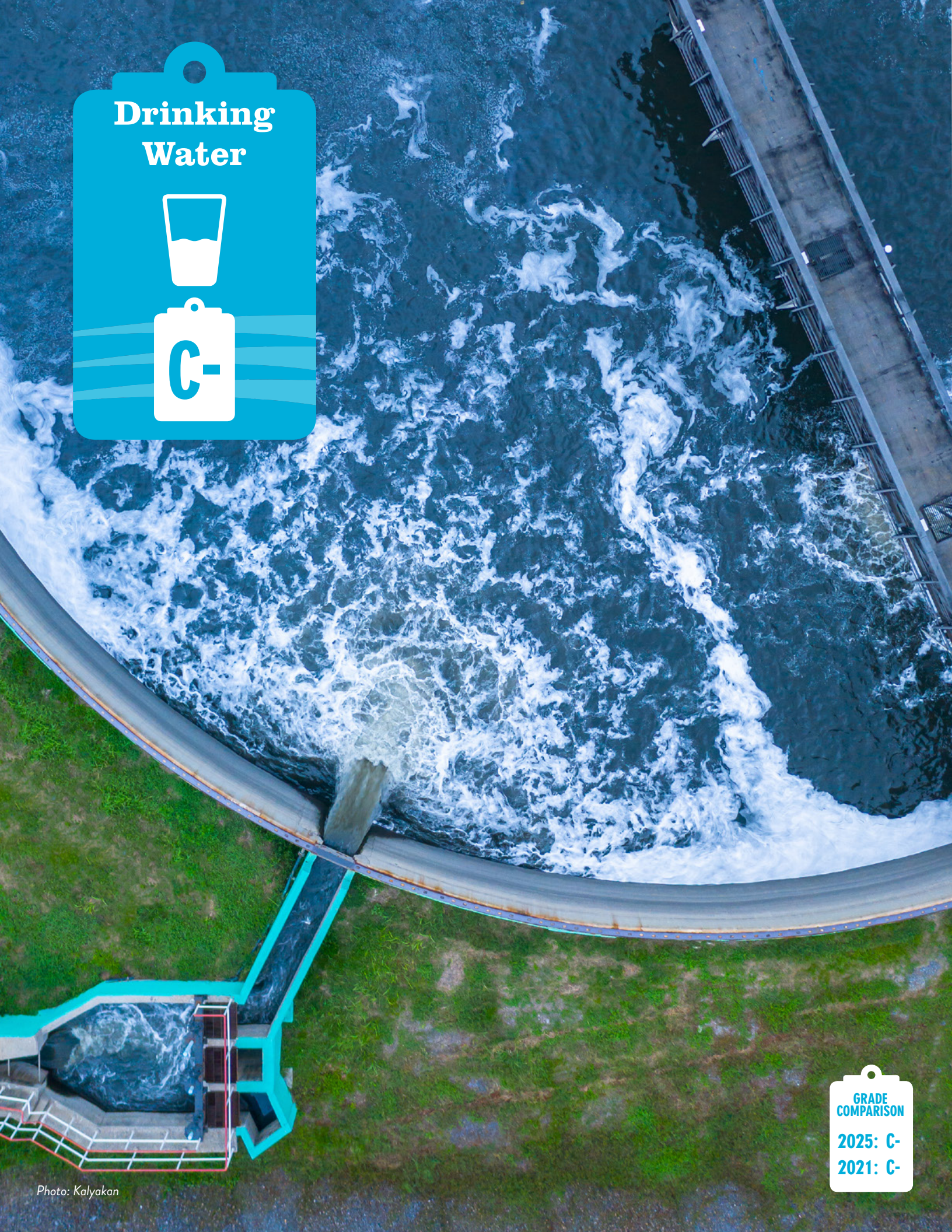
Drinking Water

C-



GRADE COMPARISON

2025: C-

2021: C-

Photo: Kalyakan

DRINKING WATER

EXECUTIVE SUMMARY

The nation's water infrastructure is aging and underfunded. More than 9 million existing lead service lines pose health concerns, and in 2023, the Environmental Protection Agency (EPA) determined that the nation's water infrastructure needs stand at $625 billion over 20 years. That exceeds EPA's 2018 assessment by more than $150 billion. The 2021 Infrastructure Investment and Jobs Act (IIJA) invested more than $30 billion for drinking water capital improvements, removal of lead service lines, and addressing emerging contaminants such as per- and polyfluoroalkyl substances (PFAS). However, funding shortfalls continue in state revolving funds that support drinking water. Challenges to utilities include aging infrastructure, emerging contaminants, and the increasingly severe effects of extreme weather. Many drinking water utilities are actively improving infrastructure through innovations such as asset failure prediction technologies, which improve the ability to identify issues before they become failures. Unfortunately, only about 30% of utilities have fully implemented an asset management plan, and just under half are in the process of implementing one. Federal agencies and programs are also able to provide financial and technical support to utilities meeting new regulations and replacing dangerous pipes, so the burden of rate increases does not fall too harshly on the public water systems of small communities.

BACKGROUND

The nation's drinking water infrastructure comprises more than 2 million miles of underground pipes and are operated by nearly 150,000 public water systems. These centralized systems provide service to 90% of the population, and half of these systems serve communities of fewer than 500 people.[1] Another 43 million people, approximately 15% of the population, rely on private wells as their primary source of drinking water.[2] However, because there is no federal regulation for private wells, data on water quality and performance is scarce. Utilities pay operation and maintenance expenses through user rates and rely on state and federal financing and grant programs to support infrastructure upgrades and maintain the safety of drinking water supplies. However, many of those programs are funded at flat or reduced levels annually. Large water utilities in thriving communities may also access the bond market for capital projects.

CAPACITY AND CONDITION

Drinking water infrastructure in the U.S. comprises more than 2 million miles of underground transmission and distribution lines. Some of the nation's oldest pipes were laid in the 19th century, and pipes laid post–World War II have an average lifespan of 75 to 100 years, meaning that many of even the newer pipe segments are reaching or have reached the end of their design life. As of 2023, the average life expectancy of these pipes is just over 78 years, which is 6 years less than in 2018.[3]

Access to clean, safe drinking water is essential to protecting public health and safety. This critical resource is provided by water systems of various sizes and drawn from different sources. Approximately 93% of systems serve communities under 10,000 people.[4] About 140 million people in the U.S. rely on groundwater sources for their drinking water, with 50% of that water coming from 68 regionally extensive aquifers.[5]

A 2018 study found that approximately 39 billion gallons of water per day were withdrawn from surface water or groundwater sources for public supply between 2000 and 2015. However, a 2024 reanalysis showed that initial estimates did not fully account for growing populations in urban centers served by public water systems. This new analysis reveals that total public-supply withdrawals grew by more than 7.5% between 2000 and 2020, indicating that estimates from the 2018 study should have been higher than reported.[6]

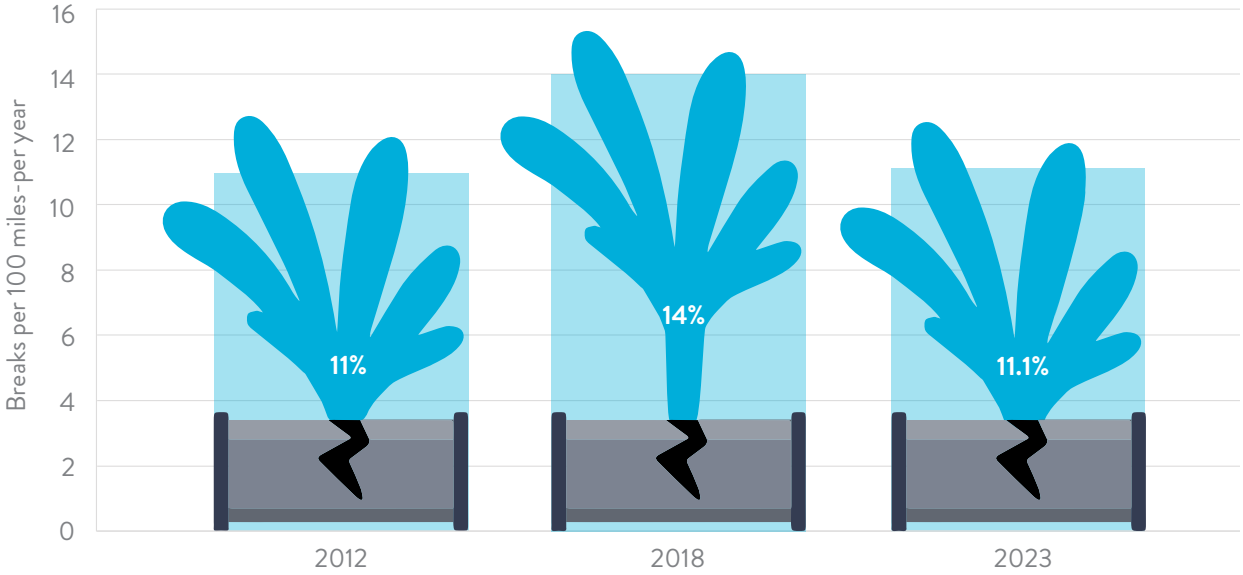
Aging infrastructure, extreme weather events, and costs associated with regulatory compliance place increased strain on the nation's water systems. Over half of the nation's public water systems have identified rehabilitation and replacement of aging infrastructure as their most critical challenge.[7] Aging infrastructure is also a leading contributor to water loss. Approximately 126 billion cubic meters of water (or approximately 33.3 trillion gallons) is lost annually, resulting in more than $187 billion in lost revenue.[8] Additionally, nearly 20% of installed water mains (a little more than 450,000 miles of pipe) were reported to have exceeded their useful lives but are still awaiting replacement due to inadequate funding.[9]

The 2022 rupture of a southeast Michigan drinking water pipeline brought attention to aging water infrastructure in the state; Great Lakes Water Authority

However, addressing aging or failing infrastructure is showing signs of progress. Since 2018, there has been a 20% annual reduction in water main breaks per 100 miles of pipe.[10] Much of this reduction resulted from a nearly 8% decrease in the use of cast iron and asbestos cement pipes, which are responsible for the highest rates of breakage across all pipe materials, between 2018 and 2023.[11] These pipes have been replaced by ductile iron and polyvinyl chloride (PVC), which are the most commonly used materials. However, ductile iron remains vulnerable to highly corrosive soil, with ductile iron pipes experiencing a break rate six times higher than when placed in less corrosive soil.[12] This could help explain why there are still approximately 240,000 water main breaks per year, resulting in roughly $2.6 billion in repair and maintenance costs. That does, however, represent an overall decrease in water main breaks, which was estimated to be between 250,000 and 300,000 per year in the U.S. in 2018.

Photo: Small Diameter Water Main Replacement– Washington DC.; DC Water

Water Main Break Rates Over Time



Source: Utah Water Research Laboratory, Utah State University

FUNDING

Water utilities primarily pay to operate and maintain water infrastructure through user rates. Utilities charge rates to cover the infrastructure and other operating expenses, including treatment plants, underground pipes, water storage, and the workforce that operates and maintains the system. Between 2012 and 2023, monthly household water bills increased by roughly 64%, standing at an average of $51, primarily due to increased labor costs and pressure from inflation.[13] Just over 47% of water utilities reported an increase in per-account water sales, significantly more than the 28% that reported increases in 2020, before the start of the COVID-19 pandemic.[14] Despite this, only 20% of water utilities reported being fully able to cover the cost of drinking water services.[15]

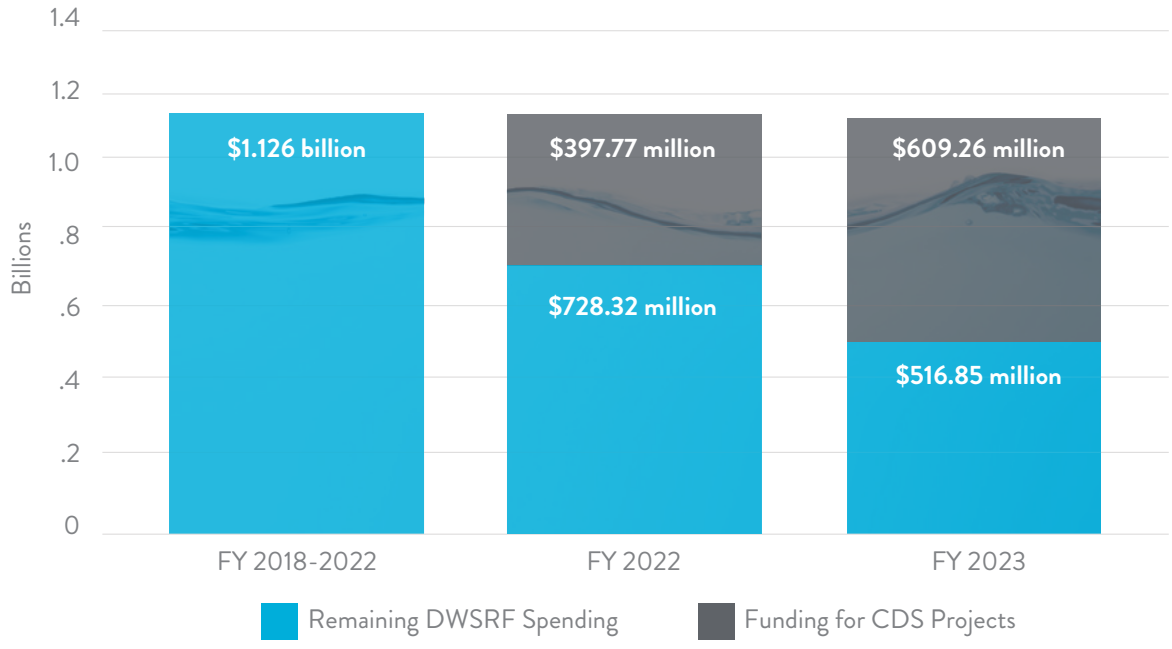
Smaller utilities often face more vexing challenges than larger utilities. Smaller, disadvantaged communities usually face water rates that exceed levels considered affordable because there is such a small base of ratepayers. Larger systems can spread costs over a larger population and provide lower costs per customer.[16]

At the federal level, the U.S. provides financing support through the Drinking Water State Revolving Fund (DWSRF) program. The DWSRF program provides states capitalization to finance low-interest loans for drinking water infrastructure projects. States are required to provide a 20% match of federal funds, and they may also set aside 31% of their capitalization grants for non-infrastructure needs. In 2021, the DWSRF was reauthorized under the IIJA at $15 billion over 5 years in federal appropriations over five years. Additionally, IIJA appropriated an additional $31 billion for the DWSRF to support additional capitalization, remove lead service lines, and address emerging contaminants over five years. The law also requires that states provide 49% of DWSRF general program funds and lead service line replacement funds to disadvantaged communities through grants or forgivable loans.

Although IIJA funds provide a needed boost for drinking water infrastructure, annual congressional appropriations for the DWSRF have fallen below the one-time investments in the infrastructure law. Since Fiscal Year 2022, the program has been appropriated at more than $1 billion below authorized funding levels. Additionally, DWSRF funding totals include designated Congressionally Directed Spending (CDS) for water infrastructure projects, colloquially referred to as earmarks, distributed essentially as grants. The practice reduces the total annual capitalization funds that go directly to states for their revolving fund programs, thus reducing funds available for state projects and taking decision-making away from the state entities that are most familiar with community needs. Between FY22 and FY23, more than $1 billion was taken from the DWSRF program for earmarks, resulting in a nearly 45% reduction in capitalization grants for states and an almost 45% reduction in set-asides.[17]

Some large water utilities with strong financial positions choose to access bond financing for large infrastructure projects. This is a viable option for a very small portion of total utilities and offers some benefits over the compliance necessary to access DWSRF.

DWSRF Funds Redirected to Congressionally Directed Spending (in billions)



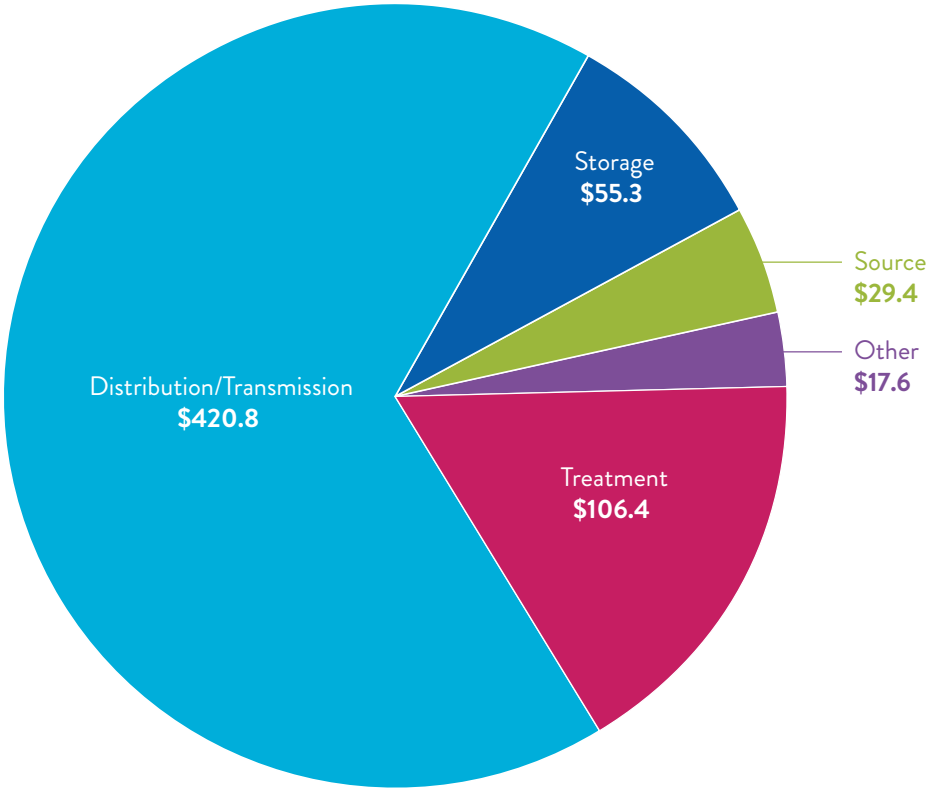
Source: Association of State Drinking Water Administrators

Another financing tool used by the EPA to support drinking water projects is the Water Infrastructure Finance and Innovation Act (WIFIA) program, which provides sponsors of large projects (generally over $20 million) with financing. Like the DWSRF, WIFIA was reauthorized under IIJA. Unlike the DWSRF, however, WIFIA has received more funding from Congress than its authorized levels. WIFIA received $69 million in FY22, $76 million in FY23, and $72 million in FY24. Even with the slight decrease in FY24, federal appropriations were significantly higher than the authorized annual level of $50 million. As of December 2023, the WIFIA program supported $43 billion in total water infrastructure investments, including $840 million to address lead in drinking water, and eliminated 100 water main breaks annually.[18]

FUTURE NEED

ASCE's 2024 *Bridging the Gap* economic study found that the projected gap between drinking water infrastructure needs and investments in 2024 stood at $309 billion and is expected to grow to $620 billion by 2043.[19] According to the EPA's 2023 national needs assessment, America needs $625 billion over the next 20 years to reach a state of good repair. That is 30% more than its previous assessment in 2018.[20] While this provides a snapshot of the nation's needs and does not contain data from every public water system in the country, the most recent assessment had a response rate of 97% of utilities from whom data was requested.[21] Water distribution and transmission infrastructure accounts for $421 billion (67%) of total future needs, followed by treatment needs accounting for 55.3 billion (17%).[22]

Total 20-Year State Need by Infrastructure Project Category *(in billions; January 2021 dollars)*



Source: U.S. Environmental Protection Agency

OPERATION AND MAINTENANCE

Water utilities are taking steps to improve responsiveness to maintenance challenges. The sector is using industry-related expertise, data, and predictive technologies to streamline the process of defect detection and asset failure prediction. These efforts are reducing reactive replacements and improving proactive, planned maintenance. Industry guidelines encourage 65% scheduled to 35% reactive maintenance. From 2015 to 2023, the portion of utilities that have improved their ability to track the planned-to-reactive maintenance ratio has increased from 37% to 42%. Furthermore, of the utilities tracking this ratio, more are seeing improvements in their ratio: 21% growing to 27% over the same period.[23] Finally, approximately 70% of water utilities have a pipe replacement program, indicating that utilities are taking a proactive approach to replacing aging and failing infrastructure.[24]

Despite some progress, workforce challenges remain an issue. In 2020, EPA found that approximately one-third of the nation's drinking water and wastewater workforce will become eligible to retire over the decade.[25] The median age of the water workforce is 48 years old, slightly older than the national average across occupations, whereas only 10% of the water workforce is under the age of 24.[26] Efforts have been made in recent years to address these challenges. At the federal level, in 2024, EPA made $20 million available to 13 workforce development organizations in 11 states and the District of Columbia through its Innovative Water Infrastructure Workforce Development Program that supports activities such as internship and apprenticeship programs, K-12 higher education programs, and other activities to help address water utility employment needs. States are also taking on the challenge of building their water workforce pipeline. In 2023, Texas passed a law allowing high school students who meet training and testing requirements to obtain provisional water or wastewater operator licenses while still in school, followed by obtaining a permanent license when they turn 18 and graduate from high school.[27]

Additionally, asset management serves as a valuable tool to minimize the costs of owning and operating infrastructure systems while meeting customer needs. Asset management plans can help improve decision-making to benefit ratepayers and communities.[28] Many states require utilities to implement asset management plans as a condition of receiving public funds, but no such federal requirement exists. In 2024, 13 states required some form of asset management for drinking water utilities, whereas 22 states provided financial assistance to support the development of asset management plans either through DWSRFs or other state funding mechanisms.[29] Overall, just over 30% of utilities have fully implemented an asset management plan, and just under half are in the process of implementing one.[30]

PUBLIC SAFETY

Since 1974, the EPA has regulated the nation's public drinking water supply through the Safe Drinking Water Act (SDWA). In 2022, only 4% of public water systems reported violations of a health-based drinking water standard where a contaminant was detected that exceeded allowable limits or water treatment requirements were not met, roughly equal to 2020 and 2021.[31]

In 2023, the EPA found that 9.2 million lead service lines are in operation across the country, and the following year the federal government set a goal to remove all lead service lines within 10 years.[32] In recent years, several U.S. cities have used federal funds and are taking a proactive approach to lead service line replacement. Since 2016, Pittsburgh, Denver, and Detroit have removed more than 45,000 lead service lines from their systems. According to a recent survey, 68% of utilities implement lead service line replacement programs, and 38% reported that planned capital improvement projects include lead service line replacement.[33] However, many utilities across the nation, typically those with younger systems, do not have lead service lines.

EPA estimates that removing all lead service lines would cost $45 billion, and removing lead service lines connected to private residences often falls to the homeowner, with an average cost of about $10,000.[34] Some cities, such as Milwaukee, WI, have implemented programs to cover the costs of lead service line removal for homeowners. At the same time, many cities have held off on similar programs

U.S. CITIES LEAD THE WAY ON LEAD SERVICE LINE REMOVAL

According to a recent survey, just over 66% of water utilities are implementing lead service line replacement programs.

PITTSBURGH, PA

Since 2016, Pittsburgh has replaced more than 11,000 lead service lines from its water system. The city has set a goal of removing all lead service lines by 2026.

DETROIT, MI

Detroit has replaced nearly 9,500 lead service lines since 2018, including more than 5,000 in 2024 alone. Detroit's lead service line replacement program prioritizes removal in neighborhoods populated by vulnerable communities such as children, the elderly, and low income earners.

DENVER, CO

Denver has replaced more than 25,000 lead service lines since 2020. In addition, the city provides free water filters for residents to use for the first 6 months after a lead service line is removed, and has expanded public outreach and communication to provide guidance about the program.

because such assistance can be deemed taxable income, which significantly increases tax burdens on families.[35] Removal is further complicated because there is no database of homes with lead service lines. A few cities, including Washington, DC, and Cleveland and Cincinnati, OH, have more detailed maps of lead service lines within their network. Free lead testing kits also increase surveillance ability, such as those provided by Cincinnati.[36]

Utilities also face ongoing challenges addressing emerging contaminants, such as per- and polyfluoroalkyl substances (PFAS), and the regulatory requirements needed to remain in compliance with SDWA. These substances, which have been widely used in the manufacture of many everyday products, have been shown to pose significant health risks and can easily contaminate water supplies, soil, and air. A recent study found that at least one PFAS can be detected in 45% of all U.S. drinking water.[37] It is estimated that water supplies at nearly 7,500 locations nationwide contain PFAS, affecting more than 130 million people.[38] IIJA appropriated $9 billion to address challenges posed by PFAS and other contaminants, and EPA has announced new enforcement thresholds for certain PFAS to be removed from drinking water under SDWA as part of the first-ever National Drinking Water Standard for PFAS. A key challenge, however, is that monitoring and eliminating these substances will likely fall to utilities. Many utilities may be unable to take on this financial burden because the estimated annual cost to install treatment systems to remove these substances is more than $3.8 billion.[39] Although federal funds are available, a larger and more sustained federal effort to assist utilities with PFAS clean-up may be required.

Drinking water systems are also becoming a more frequent target of cyberattacks. Cyber threats pose risks of treatment, distribution, and storage disruptions; damage to critical components such as pumps and valves; and altering levels of chemicals in water supplies to dangerous amounts.[40] Water systems nationwide have experienced attempts to breach their cyber defenses. In response, 82% of water utilities have developed and, in many cases, fully incorporated cybersecurity plans.[41] However, since September 2023, EPA has reported that more than 70% of water systems that have been inspected violate SDWA Risk and Resilience Assessment requirements.[42]

RESILIENCE AND INNOVATION

The effects of more extreme and frequent weather events continue to place stress on the nation's water systems, making resilience key. Increasingly powerful hurricanes, high winds, and more frequent flooding can lead to pipe breakage, can cause poor water quality, and can impede the efficient operation of water systems. Drought conditions that produce more frequent wildfires can impact physical infrastructure and water quality.[43] In 2018, Congress passed the America's Water Infrastructure Act, which required drinking water utilities to complete risk and resilience assessments of their systems. Utilities serving populations with at least 50,000 people were required to certify completion of these assessments by 2020; utilities serving 3,300 to 50,000 people were required to certify by 2021. However, by 2023 only 72% of utilities had implemented or were in the process of preparing risk and resilience assessments.[44] Utilities are required to complete these assessments every five years and will be required to submit their latest assessments by 2025 (2026 for smaller utilities). Despite this, in 2024, utilities ranked increasing their systems' resilience to climate extremes and other uncertainties as a top priority.[45]

Nationwide, utilities are embracing the greater use of digital technology and data-driven decision-making. In 2023, 43% of utilities planned to install new IT systems for water treatment or update existing systems, and 46% planned to install or update digital meter reading systems.[46] These innovations support greater efficiency of water utilities and can help improve water quality, keep rates low, and reduce a utility's carbon footprint.

Photo: chekart

RECOMMENDATIONS TO RAISE THE GRADE

- Direct an annual appropriation of $3.4 billion to the DWSRF program and ensure congressionally directed spending for community projects does not reduce the amounts made available to states.
- Increase federal and local support to recruit, train, and retain the next generation of the drinking water sector workforce to help offset expected retirements.
- Develop and fund affordability programs to ensure low-income and vulnerable communities do not bear a disproportionate burden of rate increases.
- Provide federal support for monitoring and removal of PFAS from public water systems, especially for smaller systems serving low-income communities.
- Continue to prioritize funding and assistance for removing and replacing lead service lines to improve public health and safety.
- Enforce the requirement that all drinking water utilities complete risk and resilience assessments of their systems per the America's Water Infrastructure Act.
- Increase the number of utilities updating or installing digital technologies to improve system operations and efficiency.
- Where possible and feasible, efforts should be made to merge smaller public water systems to expand ratepayer bases, thereby providing a greater ability to meet water utility demands.
- Provide expanded and more sustained grant funding for public water utilities to cover the cost of monitoring and removing PFAS from drinking water.
- Increase the number of states that require asset management plans for drinking water utilities and create or expand state funding mechanisms to support the development and implementation of asset management plans.

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Energy

D+

GRADE COMPARISON

2025: D+

2021: C-

Photo: Wikimedia

ENERGY

EXECUTIVE SUMMARY

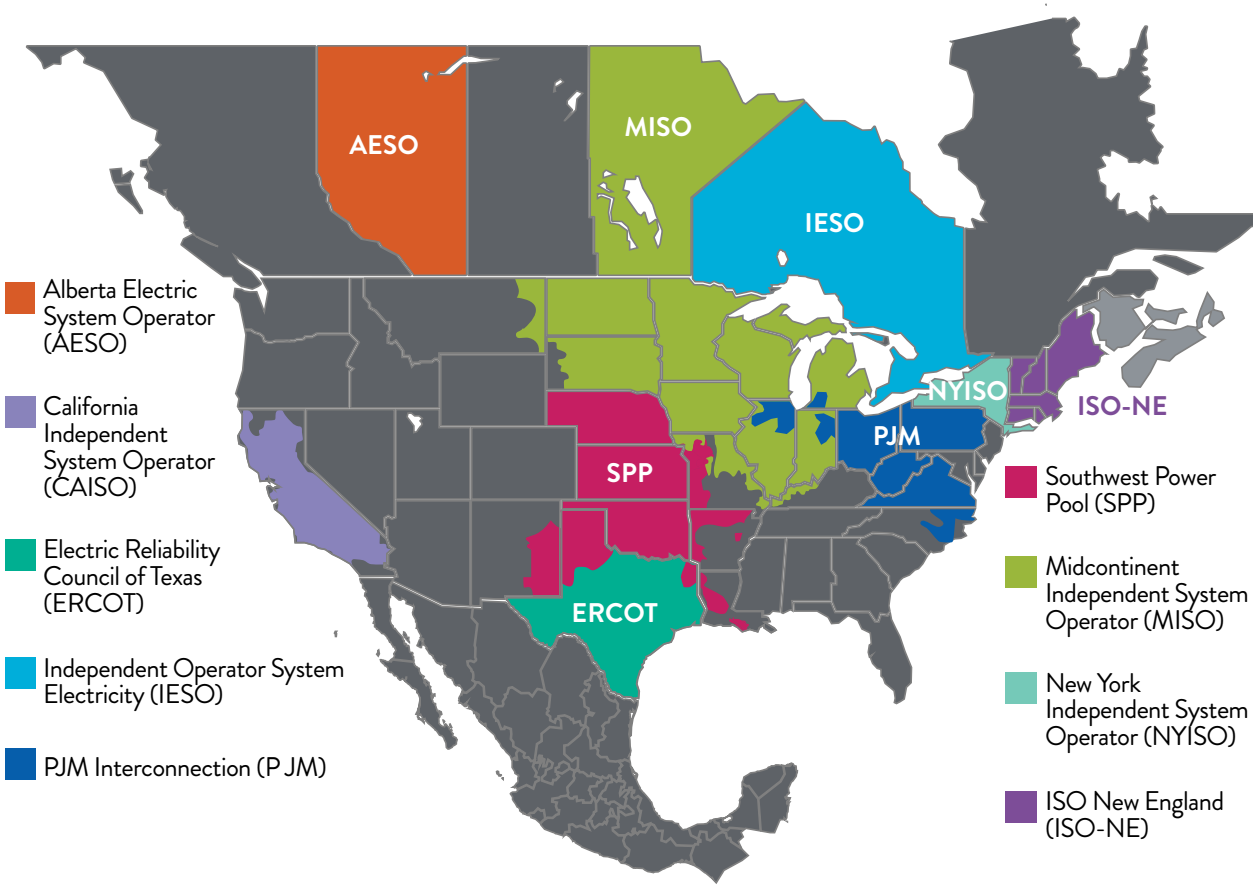
As Americans increasingly depend on electrification in their daily lives, energy demand is experiencing its highest growth in two decades.[1] An increase in electric vehicles (EVs) and a rise in data centers will demand 35 gigawatts (GW) of electricity by 2030 alone, up from 17 GW in 2022.[2] This rapid acceleration, compounded by federal and state net-zero greenhouse gas emissions goals, means utilities will need to double existing transmission capacity to connect new renewable generation sources. Transmission investments have risen by $5 billion from 2017 to 2022,[3] and the Infrastructure Investment and Jobs Act (IIJA) and Inflation Reduction Act (IRA) are supporting renewable technologies and grid hardening measures. New investments come as weather accounts for 80% of electricity outages since 2000, most of which occurred in the last decade and within distribution systems that deliver power in the last miles from transmission systems to homes and businesses.[4] Interregional connections accelerated by streamlined regulatory review, rigorous design standards, and resilient technologies must be implemented to ensure reliability in the years ahead.

BACKGROUND

U.S. energy infrastructure consists of facilities and related infrastructure needed to generate electricity from various sources (natural gas, petroleum, coal, solar, wind, nuclear, hydroelectricity), and transmission and distribution (T&D) networks needed to move this energy from its source to communities nationwide. To best serve the needs of the public, balanced investments in both generation and T&D systems are essential to ensure reliable performance. These investments, largely driven by user rates, can prevent disruptions to energy services that have become critical to the nation's safety, health, and economic efficiency. Energy interruptions bear significant costs on U.S. industries and consumers, as even a brief power outage increases production costs and disrupts supply chains.[5]

Photo: Summit Art Creations

ISO/RTO U.S. Map



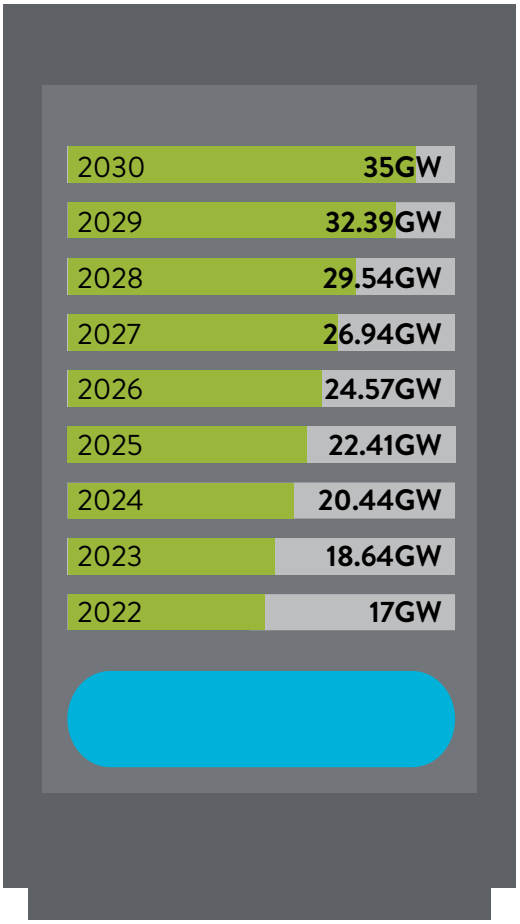
CAPACITY, CONDITION, OPERATION, AND MAINTENANCE

Energy Generation

The U.S. is undergoing a transformational shift in how energy is used and generated through more than 12,500 utility-scale electric power plants.[6] Consumers and businesses are growing increasingly reliant on data storage facilities, artificial intelligence (AI), and electrified products such as EVs, to name just a few examples of advancements adding immense strain to an already fragile and aging electric grid. Data centers alone are expected to demand 35 GW of electricity by 2030, up from 17 GW in 2022,[7] growing roughly 10% per year.

Electricity peak demand growth is at its highest point in two decades. After years of stable growth, summer and winter peak demands are expected to increase 15% and 18%, respectively, by 2034. Yet, traditional resources such as coal needed to supply that demand are being retired, and new weather-dependent resources are merely replacing the lost generation rather than matching demand growth.[8]

Surging Data Center Energy Demands



These rising energy demands are occurring in conjunction with national and state policy changes meant to reduce carbon emissions and reliance on fossil fuels, which have historically served as the most reliable energy sources. Renewable sources have become more efficient and cost-effective in recent years, coinciding with 22 states and the District of Columbia (DC) establishing net-zero carbon emission goals. In addition, 29 states and DC have adopted Renewable Portfolio Standards (RPS),[9] which encourage improved reliability of renewable systems. Grants and subsidies from the 2022 IRA have further incentivized renewable energy generation. Consumer trends and policy changes are beginning to have an effect. U.S. energy-related CO_2 emissions declined by 3% in 2023, largely credited to the decrease of coal-fired generation.[10]

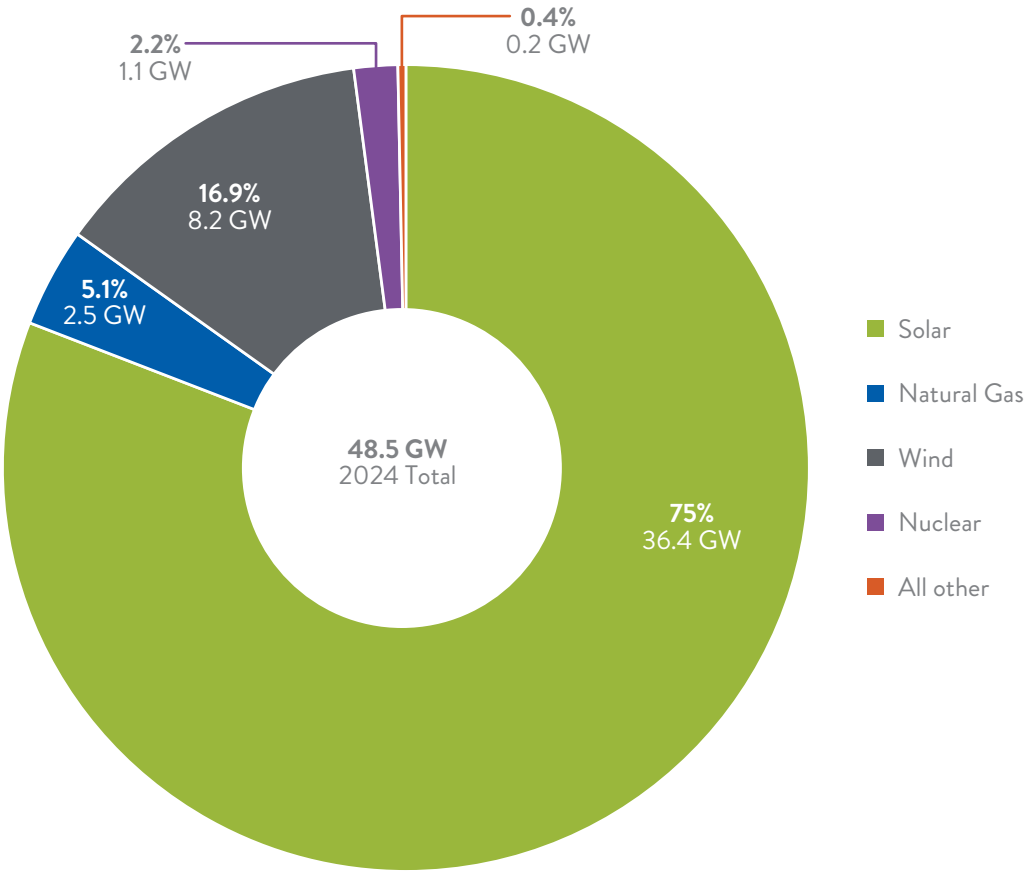
New generation or storage projects must submit interconnection requests to be added to the grid. The lengthy request process, which can take an average of 35 months to complete,[11] and coordination with all stakeholders is cited by developers as the leading cause of project delays and cancellations, and this has led to interconnection queues increasing nearly eightfold in the past decade and by 30% in 2023 alone.[12] Nearly 2,600 GW of generation and storage capacity is seeking grid interconnection. The Federal Energy Regulatory Commission (FERC) adopted interconnection reforms in 2023 to speed up this process, but they have not taken effect in most regions.


Photo: USDA

Despite the turn to industrial and consumer electrification, natural gas still plays a dominant role in energy generation, providing 42.3% of total energy generation in the U.S. in 2023. In 2022, the nation's 3 million miles of natural gas pipelines delivered more than 29 trillion cubic feet of natural gas to more than 78 million consumers.[13] The U.S. has 129 operable refineries, down from 135 in 2020, which produced just over 19 million barrels per day in 2023, about 1 million less than in 2020.[14]

Roughly half of the existing gas pipeline network was installed in the 1950s and 1960s, further emphasizing the need to invest in maintenance, upgrades, and expansion of the network to reduce the risk of delivery bottlenecks or leakage events, which are still occurring with some regularity.[15] Oil and gas system improvements are primarily funded by regulated owner rates and limited recovery; upgrade investments are typically driven by urgency and necessity rather than through asset management and life-cycle cost-based planning. For example, following Winter Storm Uri in Texas in 2021, the state's Public Utilities Commission required power plants to winterize to prevent future blackouts from occurring, but lawmakers did not require the Texas Railroad Commission, which regulates the gas industry, to quickly impose weatherization standards.[16]

Electric-Generating Capacity Additions for 2024



Source: US Energy Information Administration

More than 36 GW of solar is expected to be added to the grid in 2024, nearly doubling 2023's 18.4 GW increase, which itself was a record. Developers and power plant owners are making record yearly expansions to utility-scale electric-generating capacity and battery storage capacity. In 2024, the U.S. nearly doubled its existing 15.5 GW battery storage capacity with an additional 14.3 GW coming online.

Solar is expected to compose 58% of new electric energy capacity additions in 2024. Wind will add 8.2 GW of capacity in 2024, 13% of new energy capacity, after a record addition of more than 14 GW in both 2020 and 2021. Natural gas is expected to add 2.5 GW of planned capacity additions, the lowest annually added in 25 years.

Transitioning to renewable energy also has emphasized energy storage to safeguard the grid when renewable sources are not at peak performance. There are approximately 40 GW of battery storage in the U.S., with 8 GW installed in 2023. Utility-scale batteries now account for 48% of all energy storage in the U.S., up from just 6% in 2018.[17]

The remaining 22 GW of energy storage comes from pumped storage hydropower (PSH), which has the lowest impact to global warming of any energy storage technologies.[18]

The U.S. currently has 43 PSH plants with the potential to double PSH capacity. For example, Alaska has 1,800 suitable locations for new PSH facilities to bolster the state's energy reliability.[19] The majority of PSH plants were built in the 1970s,[20] and U.S. PSH investment has been stagnant since the 1990s, in part due to increased costs and permitting. Since the passage of the IRA, PSH projects are now eligible for a tax credit of up to 30% the project cost.[21]

NERC reports over 83 GW of fossil-fired and nuclear generator retirements are currently anticipated through 2033. Increased renewable and natural gas generation has offset the loss of coal-fired generation, but sector wide generation outlooks fail to keep up with surging demands. The time to plan, go through lengthy environmental review and permitting processes, construct and bring a renewable energy resource online, and go through interconnection requests can take anywhere from 2 to 4 years for solar[22] or onshore wind projects and 5 to 10 years for offshore wind.[23] Constructing a data center, which consumes the equivalent of 80,000 homes' worth of energy,[24] can be completed in just over one year,[25] creating capacity challenges.

Electric vehicles are also complicating the energy sector's ability to maintain sufficient capacity. In March 2021, an Executive Order was issued that 50% of all cars sold in the U.S. by 2030 must be net-zero greenhouse gas emitters. The IIJA allocated $7.5 billion to build a national network of EV chargers, but some estimates indicate the nation will need closer to $40 billion in charging infrastructure investment to achieve 100% passenger EV sales by 2035.[26]

Transmission and Distribution

Energy is channeled through the nation's 600,000 miles of transmission lines (240,000 miles of which are considered high-voltage lines) and more than 5.5 million miles of local distribution lines with over 180 million power poles. Transmission lines are frequently referred to as the "interstate highway" of the electric grid, while the smaller distribution lines they feed into, often referred to as the "last mile" of the grid, would be akin to local roads taking you directly to your destination. As of 2024, more than 28,000 miles of transmission development is anticipated over the next 10 years, which is significantly higher than 2023's 10-year estimate of 18,675 miles.[27] Most of this development is in the planning stage to connect to new sources.

Photo: Transmission Line; Anna Denecke

Substation transformers and distribution transformers are responsible for stepping up or down voltage levels from transmission lines or isolating electrical circuits during transfer to the distribution network. Substation transformers are facilities that convert high-voltage power to manageable levels for the distribution network, whereas distribution transformers are smaller devices attached to distribution poles that further convert voltage to safe and efficient levels for industrial, commercial, and residential users. More than 79,000 substation transformer facilities exist in the U.S.,[28] and these facilities are vulnerable to intentional attacks and damage from severe weather events.

There are more than 60 million distribution transformers nationwide, which could triple by 2050 to account for rising demands.[29] The U.S. currently faces a shortage

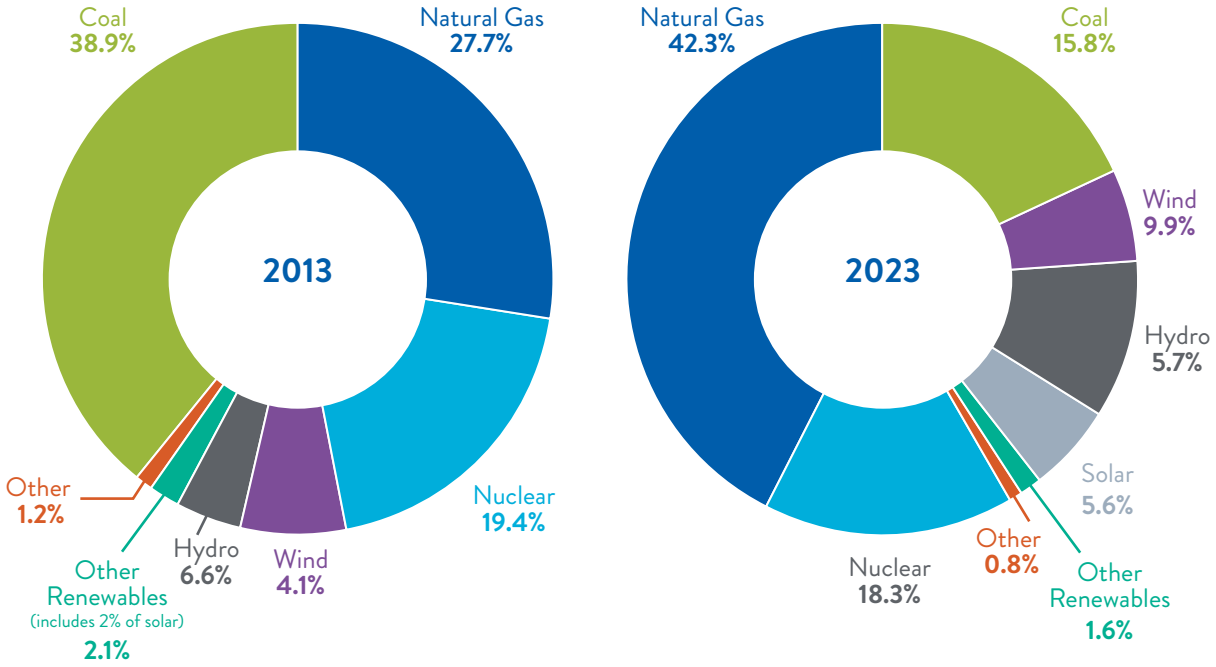
of distribution transformers owing to supply chain bottlenecks and few domestic manufacturers to choose from. Distribution transformer capacity will need to rise 160%–250% by 2050 to meet anticipated needs,[30] but inventory backlogs threaten the ability to meet current or future demands. As of June 2024, acquiring new transformers faces lead times ranging from 80 to 210 weeks (120 weeks on average), up from 50 weeks in 2021.[31] The cost of transformers has risen 60%–80% since January 2020. Transformer installation delays will slow down implementation of new energy projects and put the grid at risk if in-place transformers fail.

Electricity T&D losses averaged about 5% of the electricity transmitted and distributed in the U.S. in 2018–2022.[32] In addition, 70% of power transformers are 25 years or older, 60% of circuit breakers are 30 years or older, and 70% of transmission lines are 25 years or older.

As energy demands grow, aging assets need to be replaced or modernized. Experienced employees retire, and utilities expect to add 10,700 power-line installer and repair job openings each year over the next decade.[33] Energy sector jobs grew by 3% in 2023, which is 50% more than all U.S. employment growth. Energy jobs jumped from 8.1 million in 2022 to 8.35 million in 2023.[34]

Despite making up only 6% of the number of electricity providers, investor-owned utilities (IOUs) serve 72% of U.S. electricity consumers, with the remaining 28% owned by government utilities, independent power producers, or cooperatively owned utilities.

Transforming the Energy Mix



Source: Edison Electric Institute

Efforts are ramping up to increase interregional transmission lines. This includes a recent $1.3 billion IIJA investment to construct three proposed interregional lines across six states: the 175-mile Southline Transmission Project (New Mexico to Arizona); the 211-mile Twin States Clean Energy Link (New England to Quebec, Canada); and the 214-mile Cross-Tie Transmission Line (Utah to Nevada).[35] An additional 35 GW of transfer capability across the U.S. would improve reliability during extreme weather events.[36]

In 2022, Americans experienced roughly 5.5 hours of electricity disruptions, down from 7.5 hours in 2021.[37] Failures within distribution systems make up 92% of electric service interruptions, largely due to severe weather events, vegetation, vandalism, and less stringent standards than are applied to the transmission network.[38]

Photo: Photovoltaic power plant and wind turbine farm; Yuri Hoyda

Freezing conditions from Winter Storm Elliott (2022) disrupted service in the Southeast and Mid-Atlantic, but interregional transmission systems helped some areas maintain power, particularly those served by the PJM Interconnection RTO, which only reported forced outages of 24% of its total capacity in the Mid-Atlantic region thanks to contributions from the neighboring Midcontinent Independent System Operator (MISO).

FUNDING AND FUTURE NEED

Utility operators rely on rate payers to fund maintenance, capital improvement, and expansion projects for both energy generation and T&D systems. Commercial rates and residential rates differ to account for the loads they require, as commercial users often purchase in bulk and can negotiate rates.

In 2023, electric utilities requested $13.51 billion in rate increases, and gas utilities requested $4.62 billion. Increased rates reflect significant capital expenditure plans to update aging infrastructure, install new technologies to accommodate the clean energy transition, and prepare for extreme weather events.[39]

Although some regions have chosen to freeze or slow rate increases to promote affordability for businesses and residents, this can lead to more extreme rate increases to catch up on lost revenue, which are difficult for consumers to adjust to.

Energy Generation

State Renewable Portfolio Standards (adopted by 29 states and DC) and federal decarbonization initiatives, coupled with surging energy demands, are leading to rapidly escalating funding needs in the generation and T&D sectors, despite an influx of investments. Even if funding levels established by the IIJA and IRA are reauthorized in 2026, the energy sector faces a $578 billion investment gap by 2033, which climbs to $702 billion by 2033 if the nation "snaps back" to pre-IIJA/IRA funding levels when the bills expire.[40]

The 2022 IRA allocated $386 billion for climate and energy spending, with most of that funding dedicated toward new or expanded tax credits that promote clean energy generation, electrification, green technology retrofits for homes and buildings, greater use of clean fuels, and wider adoption of and preparation for EVs. Rural electric cooperatives received more than $13

billion to advance clean energy generation and resilience, reliability, and affordability initiatives.

The IIJA allocated $1 billion over five years in grant funding to the first-ever Natural Gas Distribution Infrastructure Safety and Modernization (NGDISM) grant program to repair, rehabilitate, or replace natural gas distribution pipeline systems. Despite being the leading source of energy generation, initiatives to move toward renewable or clean energy sources have reduced the incentive to expand or modernize natural gas pipelines. Lack of rehabilitation or capital improvement projects can jeopardize energy stability throughout the U.S., especially with so many refineries and pipelines located along the Gulf of Mexico, frequently exposed to extreme storms.

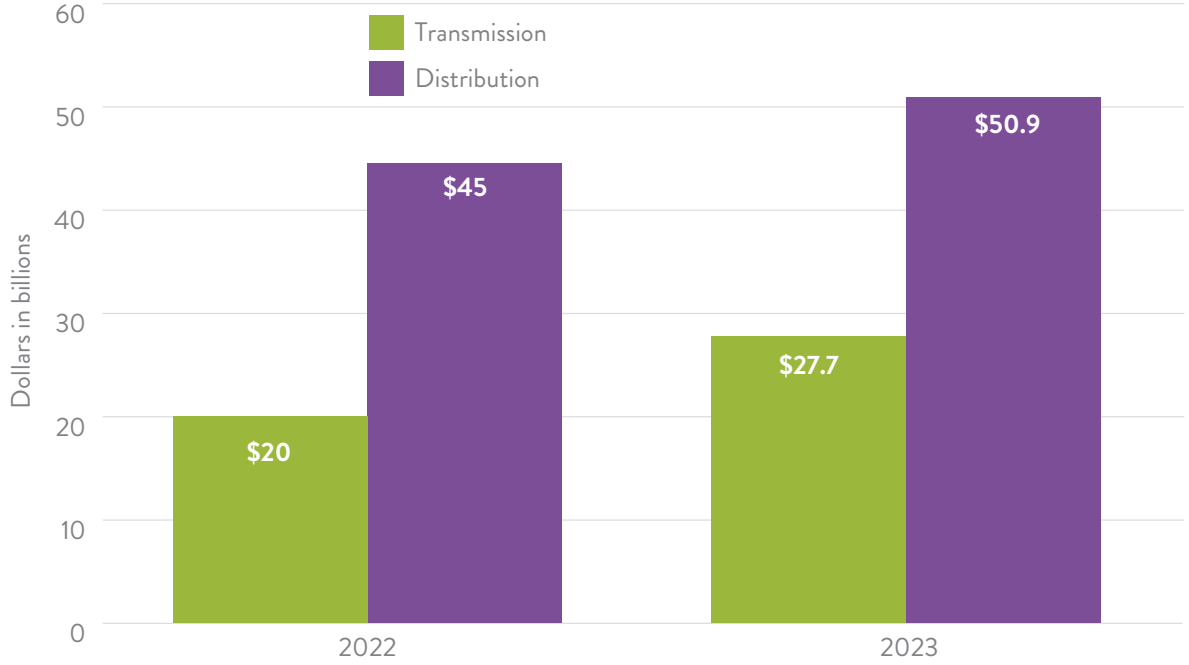
As U.S. power producers shift away from fossil fuels, the economics of renewable energy have dramatically improved. Between 2012 and 2022, solar and battery costs declined 80%, while offshore wind and onshore wind costs went down by 73% and 57%, respectively.[41] In October 2020, the Energy Information Administration (EIA) announced that solar generation had surpassed combined cycle natural gas generation as the lowest-cost generation available.

Transmission and Distribution

In 2022, IOUs spent $26.7 billion on transmission investment, up from $25.1 billion in 2021. These utilities are projected to spend $32.1 billion in 2026, marking a total of $121 billion in transmission construction investments by IOUs between 2023 and 2026.[42] Distribution investments by IOUs are also rising, from $46.1 billion in 2021 to $47.6 billion in 2022. Adaptation, hardening, and resilience measures made up 34% of transmission investments and 37% of distribution investments by IOUs in 2022.

U.S. utilities combined to spend $27.7 billion on transmission and $50.9 billion on distribution infrastructure in 2023. In comparison, utilities spent $20 billion on transmission systems and $44.5 billion on distribution in 2022, marking significant increases to replace aging equipment, modernize existing assets to be more resilient, and install new lines and transformers.[43] In 2023, utilities spent $11.8 billion on underground power lines and $7.5 billion on distribution transformers, a 23% increase on transformer investments since 2022 owing to supply chain issues. They also invested $6.1 billion in substation equipment, a 15% increase from 2022.

U.S. Utilities T&D Investments



Source: Edison Electric Institute

The IIJA allocated $73 billion from 2021 to 2026 to modernize the electric grid, build thousands of miles of new power lines, and expand renewable energy. Much of the funding is dedicated to hardening T&D lines to be more resilient. Hardening measures include undergrounding overhead power lines, implementing fire-resistant technologies, and replacing poles and other structures with stronger, more durable materials.

PUBLIC SAFETY

Energy Generation

Despite oil and gas pipelines aging beyond their intended design lives and severe weather events increasing in frequency, the Pipeline and Hazardous Materials Safety Administration (PHMSA) indicates that significant pipeline incidents are decreasing in frequency.[44] The per-year average of serious pipeline incidents from 2021 to 2023 is 266, compared to the 5-year (2019–2023) average of 280 per year and 10-year (2014–2023) average of 294 per year.

Annual fatalities from these incidents have stayed level at 12, while injuries are lower on average between 2021 to 2023 at 30 per year, compared to 33 from 2019 to 2023 and 50 from 2014 to 2023. Since 2021, significant pipeline incidents have caused more than $1.6 billion in property damages, with 2022 accounting for nearly $1.2 billion of the share.[45]

Transmission and Distribution

Although power outages in 2022 were down from 2021, any form of power outage can have health and safety risks. As experienced during Winter Storm Uri in Texas, electricity is required to run hospitals, heat in freezing temperatures, cool air in extreme heat, and keep alarm systems active. Electric reliability is also necessary for managing water systems, opening locks along inland waterways, and managing dams during storms.

T&D systems and electric substations have been the subject of vandalism and cybersecurity breaches in recent years, bringing into question the safety of consumers and businesses who depend on these services.[46] DOE reports that 95 human-related electric disturbances took place in the first half of 2023, the most of any six-month stretch in the 21st century.[47] In response, the IIJA invested more than $1 billion in cybersecurity measures for programs such as the Cyber Response and Recover Fund, the Department of Homeland Security (DHS) Science and Technology Directorate for Research and Development, DHS's Cybersecurity and Infrastructure Security Agency, and Office of the National Cyber Director.[48] Mitigating these threats is essential as hackers become more advanced and AI increases cyber vulnerability, while consumers rely on electricity for an increasing number of daily functions. More interconnections between regions provides additional access points for hackers and can increase the likelihood of cybersecurity failures, broadening the need for sharing information between grid operators and cybersecurity specialists.

Photo: Kiewit Corporation

RESILIENCE AND INNOVATION

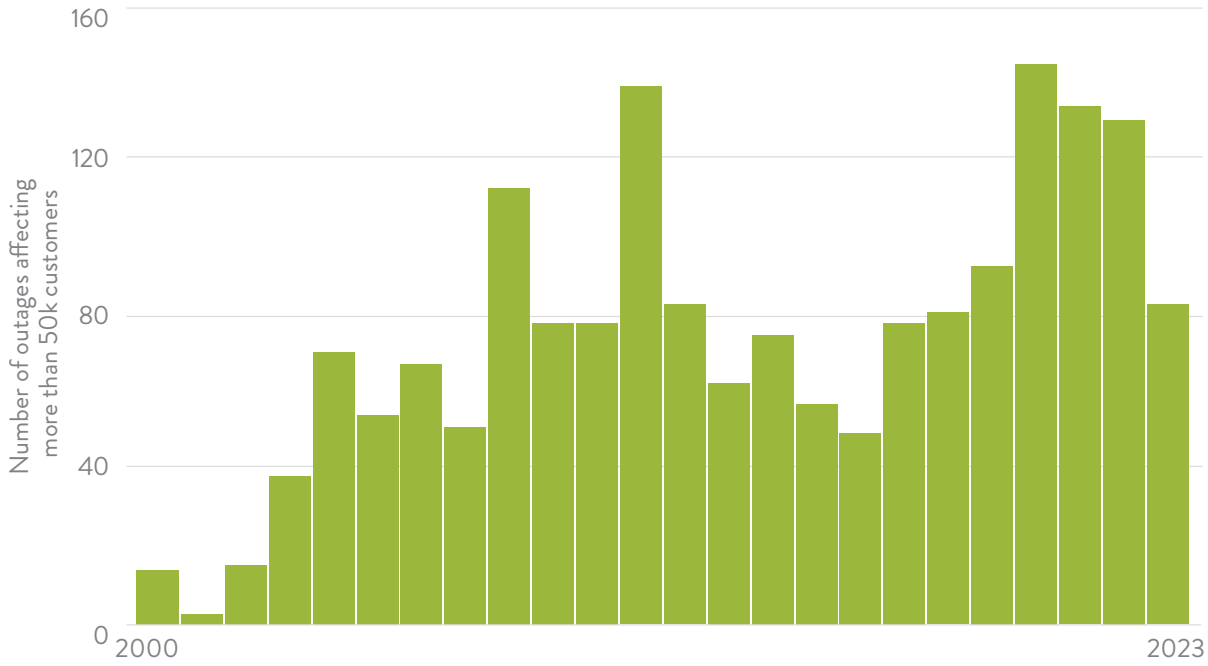
Energy Generation

As severe weather events become more frequent, U.S. energy operators must build networks with stronger materials and techniques to mitigate those threats.

For example, the solar industry is losing $2.5 billion annually from equipment underperformance, often caused by thinner panels being hit by hailstones.[49] Installing panels with higher tilt angles can make them more hail-resilient by mitigating direct impacts,[50] but this tactic also makes panels more susceptible to wind. Wind turbines have been known to catch fire, although rare, and turbine blades cannot be recycled, although technologies are emerging to address this issue,[51] which has harmful environmental impacts.[52]

Microgrids only make up 0.3% of U.S. electricity but are gaining popularity, growing 11% from 2018 to 2022 and providing 3.1 GW of power. The 460 microgrids currently in the U.S. are one way to combat extreme weather events, as they are less susceptible to single failure points because the source is more localized.[53] However, densely populated areas typically do not have the space for a microgrid, and communities that rely on them must have dedicated electricians able to provide swift repairs in the event of damage or outages or risk prolonged power outages.

Weather-Related Major U.S. Power Outages



Source: US Department of Energy Form

Transmission and Distribution

Between 2000 and 2023, 80% of U.S. power outages stemmed from weather events, such as severe wind, rain, and thunderstorms; snow, ice, and freezing rain; hurricanes; and extreme heat.[54] The U.S. experienced two times more weather-related outages during the last 10 years (2014–2023) than during the prior 10 years (2000–2009).

The IIJA invested heavily in grid resilience, establishing the $10.5 billion Grid Resilience and Innovation Partnerships (GRIP) Program. Roughly $5 billion was administered to GRIP for projects that demonstrate innovative hardening and resilience approaches to transmission, storage, and distribution infrastructure. The law also allocates $1 billion over 5 years to modernize and improve rural grid resilience.

Consensus-based codes, standards, and manuals of practice are available to help build more resilient T&D networks; however, these are often not required, leading to system failures in the face of extreme weather events.

Power lines under 60 feet in height, which make up most wood poles in the country, are not required to be built to withstand severe storms and are often impacted by encroaching vegetation, leading to frequent failures. More than 90,000 wood distribution poles were destroyed in Louisiana during Hurricane Katrina, and more than 65,000 poles were destroyed across New York and New Jersey in Superstorm Sandy.[55] After Hurricane Katrina, local provider Entergy raised its rates by 7.5% to account for the damages incurred,[56] including destroyed wood poles. Although wood poles can typically be reinstalled quicker than alternate materials, they are often rebuilt to the same low reliability level, setting up a cycle of failure followed by restoration that is not sustainable.

To restore power as quickly as possible, building codes currently do not require providers to replace fallen poles with stronger poles that are less likely to fail. Instead, historically, a pole is allowed to be replaced under the same specifications that were used for installing the destroyed or damaged pole.

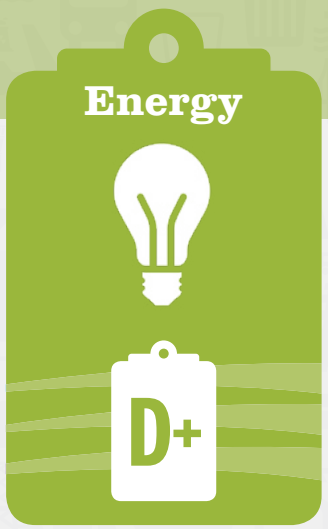
For resiliency solutions, advancement in smart grid technologies can improve operational efficiency and reduce the risks of outage events. By identifying potential risks in real time, providers can predict and address problems before they arise. Smart Grid Grants through the GRIP Program has announced $3 billion across 34 projects nationwide meant to improve and expand smart grid technologies.[57]

Furthermore, artificial intelligence has the potential to further enhance smart grid functionality. AI can identify peaks of production and consumption in renewable energy; forecast power loads and generation with more precision; automate switching to reroute energy or isolate affected areas before severe damages occur during outage events; and detect intrusion and malware associated with cyberattacks.[58]

Finally, undergrounding power lines improves grid reliability. California's Pacific Gas & Electric Co. (PG&E) is currently undergrounding 10,000 miles of its overhead power lines, which has the potential to reduce the risk of wildfire by 98%.[59]

Although undergrounding is an attractive option, the process is costly, and repairs to damaged lines take more time with steeper maintenance costs compared to an overhead line. In the case of California and PG&E's program, burying lines costs from $1.85 million to $6.1 million per mile, compared to $63 4,000 to $760,000 per mile for building new overhead transmission lines.[60] Nationwide estimates for the cost of undergrounding power lines are closer to $1 million per mile.[61]

Photo: Cass County Solar Farm; Kiewit Corporation



RECOMMENDATIONS TO RAISE THE GRADE

- Adopt a federal energy policy for meeting current and future technology change, carbon reduction, renewables and distributed generation, state and market-based factors, and rate affordability.
- Require energy providers to adopt the most stringent consensus-based codes and standards for all overhead T&D lines, structures, and substations to ensure safety and increase reliability.
- Develop a robust national transformer inventory to ensure grid operators can replace transformers quickly and cost-effectively following disasters.
- Improve grid and pipeline reliability by increasing frequency and effectiveness of critical asset inspections and focusing on robust risk mitigation.
- Mitigate capacity shortfalls by accompanying major energy projects with sufficient storage infrastructure.
- Develop a national hardening plan that considers investment in production/generation and delivery (T&D, pipelines) to enable rapid restoration of energy systems after natural and/or man-made disasters.
- Design energy infrastructure, including life-cycle cost analysis and construction of additional transmission grid infrastructure, to efficiently deliver power from generation sources to regions with greatest demand.
- Adjust electricity rates to keep pace with capital expenditures and resilience initiatives.
- Assign state coordinators to help utilities navigate the federal grant process and identify appropriate programs that align with their long-term strategic goals.

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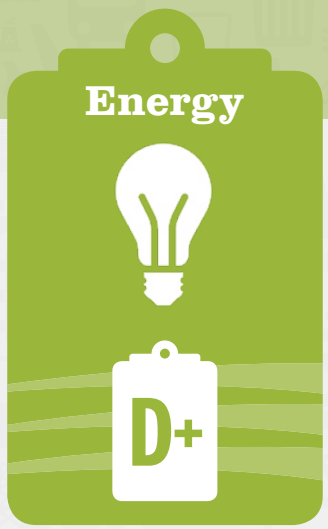

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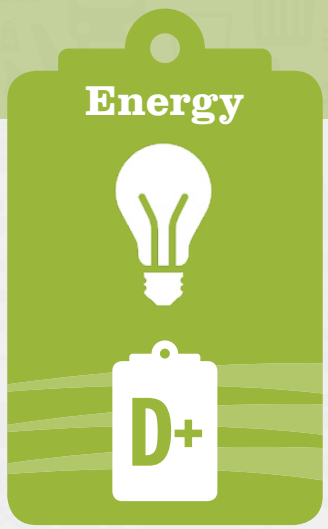

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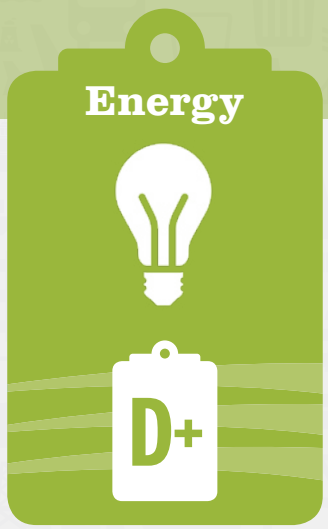

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Photo: Marcin Balcerzak

HAZARDOUS WASTE

EXECUTIVE SUMMARY

The nation's hazardous waste infrastructure is required to manage approximately 36 million tons generated each year. While concerns remain about long-term capacity and resilience, overall hazardous waste infrastructure has significantly improved in recent years due to major investments under the Infrastructure Investment and Jobs Act (IIJA). Those investments included $3.5 billion for the Superfund program and $1.5 billion for the Brownfields program, resulting in accelerated cleanup of contaminated properties, enhanced protection of public health and the environment, and economic benefits.

However, as individual per- and polyfluoroalkyl substances (PFAS) have recently been designated as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), or Superfund program,[1] addressing PFAS contamination will put significant pressure on hazardous waste infrastructure, increasing future requirements for site investigations and remediation, treatment capacity, and the development of new treatment technologies.

BACKGROUND

Two primary laws govern hazardous waste management and disposal in the U.S.: the Resource Conservation and Recovery Act (RCRA) and the CERCLA, or Superfund program. RCRA regulates the management of hazardous waste as it is generated and governs the generation and proper transport, storage, treatment, and disposal of hazardous waste. RCRA also drives the cleanup of RCRA facilities if hazardous substances have been released into the environment. Meanwhile, CERCLA governs the cleanup of abandoned hazardous waste sites, holds responsible parties accountable, and gives the Environmental Protection Agency (EPA) the funds necessary to clean up contaminated sites where there is no viable responsible party. The EPA's Brownfields program was established under CERCLA and authorizes funds for the cleanup and redevelopment of industrial and commercial properties that are unused or underused due to environmental contamination.

Photo: EPA

CAPACITY AND CONDITION

The amount of hazardous materials both generated and managed has remained relatively stable over the past decade. EPA finds that 34.8 million tons of hazardous materials were generated in 2011, increasing to 35.9 million tons in 2021.[2] In 2011, 1,395 regulated hazardous waste management facilities handled 38.5 million tons of hazardous waste, compared to just 882 facilities managing 37.6 million tons of hazardous waste in 2021. Of those 37.6 million tons of managed hazardous waste, 1.6 million tons were recovered or recycled.[3]

Moving forward, infrastructure will be increasingly stressed through deadlines for closure of out-of-compliance coal combustion residual surface impoundments, as well as further accumulation of disaster debris from wildfires, floods, and other extreme weather events.[6]

In 2019, EPA's National Capacity Assessment Report[4] indicated adequate capacity nationwide for treating and disposing of hazardous waste through the year 2044. However, the report predates the designation of several PFAS compounds as hazardous substances, a development that will increase the need for site investigations and remediation, treatment capacity, and creation of new treatment technologies. In addition, the lowering of health-based risk screening levels for lead in soil from 400 parts per million (ppm) to 200 ppm (and to 100 ppm in communities where there are multiple potential sources of lead contamination) will increase demands on cleaning up and managing sites with lead contamination. Therefore, the impacts of PFAS and more stringent cleanup of lead contamination is expected to increase the number of sites requiring cleanup, generate additional quantities of contaminated materials requiring management, and trigger further investigation and remediation work at sites where the environmental work had been considered completed.

However, EPA's economic evaluation of new PFAS rulings concluded that the impacts will not be significant primarily because PFAS contamination will generally be associated with other hazardous wastes that already require management. Industry-based assessments are ongoing, and the full impact of the recent rulings are not clear at this time.[5]

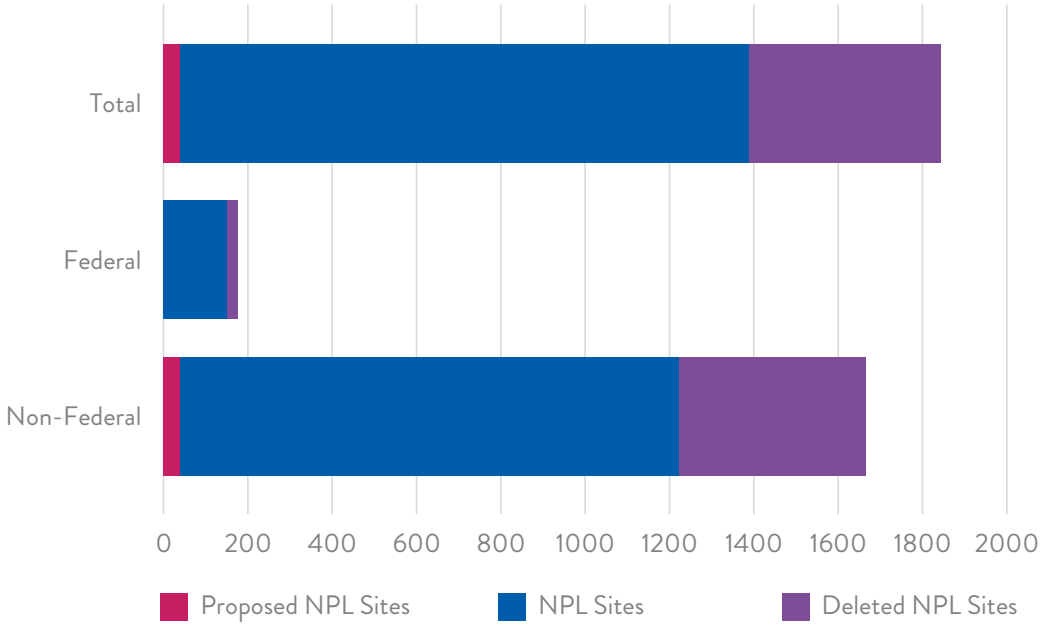
Moving forward, infrastructure will be increasingly stressed through deadlines for closure of out-of-compliance coal combustion residual surface impoundments, as well as further accumulation of disaster debris from wildfires, floods, and other extreme weather events.[6] Greater use of in-situ treatment and of remediation approaches that optimize natural systems may partially offset the regulatory and climate-related trends increasing hazardous waste generation, but it will be several years before we understand how these competing trends will "balance out."

Finally, management of hazardous materials from depleted electric vehicle lithium-ion batteries and solar panels will be required, creating the need for effective reconditioning of these items. For example, reusing retired lithium-ion batteries in energy storage systems has the potential to reduce disposal costs and help stabilize and strengthen the nation's energy grid.[7,8]

Superfund

The EPA's Superfund program has led to more responsible management practices and a significant reduction in careless disposal of hazardous materials since its passage in 1980. Superfund sites are included on EPA's National Priorities List (NPL). The NPL is routinely updated as sites are cleaned up and removed from the list, and other sites are discovered, evaluated, and added. As of September 2024, there were 1,183 non-federal Superfund sites and 157 federal sites, totaling 1,340 NPL sites and an additional 42 sites proposed for the NPL. Since the program was first created, 458 Superfund sites have been cleaned up and removed from the NPL.[9] At the end of 2023, 692 current and former Superfund sites were in reuse, supporting 10,261 businesses, employing more than 237,000 people, and generating more than $18.8 billion in employment income.[10]

Status of the National Priorities List (as of December 2024)



Source: US EPA, National Capacity Assessment Report under CERCLA Section 104(c)(9), December, 2019

Abandoned mine sites, which make up about 10% of the NPL, represent some of the most extensive and costly cleanups, with the top 25 most expensive cleanups estimated at $50 to $583 million.[11] In addition, there are over 22,000 known mines and mine features.[12] ("Mine features" include historic mining infrastructure, old adits and quarries, and piles of rock and mineral that were left behind after mining operations ceased.) The IIJA includes $11.3 billion in funding for reclaiming abandoned mine lands, treating acid mine drainage, and restoring water supplies damaged by mining.

Brownfields

Brownfield sites are properties that were previously developed for industrial or commercial use, where those past uses have resulted in contamination from hazardous substances. There are an estimated 450,000 brownfield sites across the country, which differ from Superfund sites in the degree and nature of the contamination and ability to redevelop the property. Brownfields redevelopment has resulted in significant economic and environmental benefits, with an estimated economic benefit ratio of 21:1 for every federal dollar spent.[13]

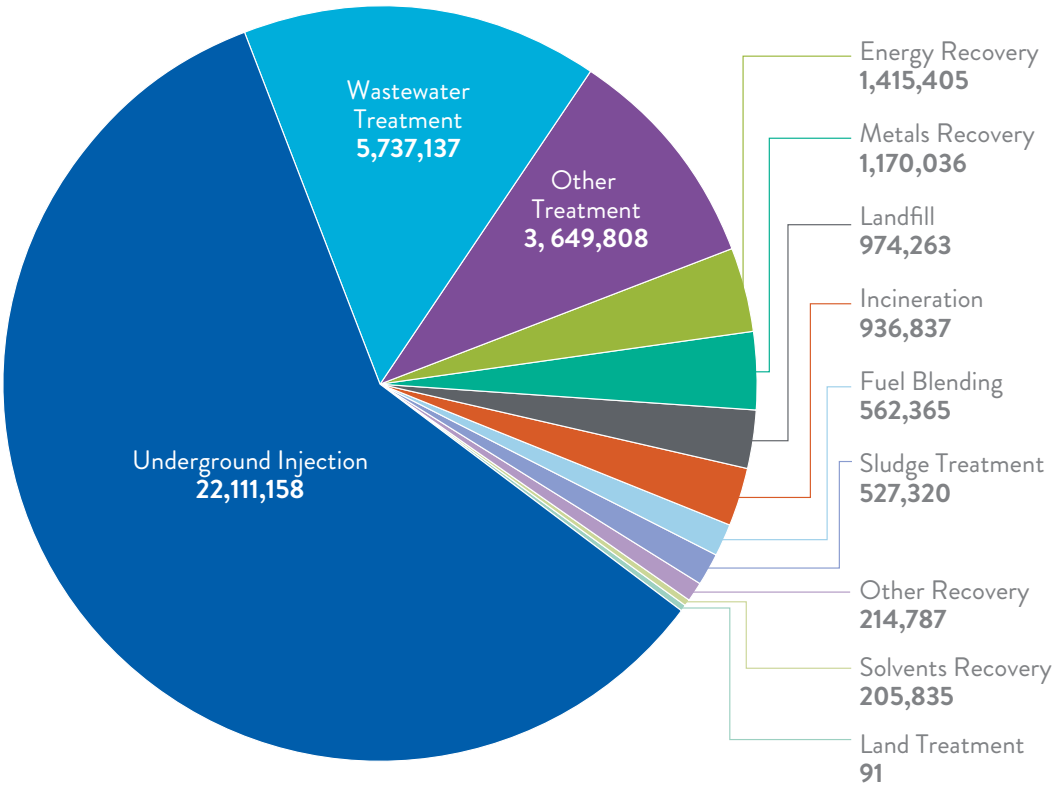
Since 2006, approximately 220,000 brownfield sites have been cleaned up, facilitating the creation of more than 270,000 jobs, with 3.7 million acres ready for reuse.[14] The supplemental investment in the Brownfields program through the IIJA expanded the number of projects and funds over 350 programs supporting the planning, construction, and operation of various public infrastructure projects.

Resource Conservation and Recovery Act

RCRA supports permitting, inspection and enforcement, program management, and corrective action to prevent pollution and facilitate cleanup of environmental problems caused by waste mismanagement. The RCRA hazardous waste program is administered almost entirely by the states (except for Alaska and Iowa) and is supported through federal grants.

Currently, 19,235 facilities are large quantity generators (LQGs) of hazardous waste. (LQGs generate 1,000 kg [2,200 lbs] or more of nonacute hazardous waste or more than 1 kg [2.2 lbs] of acutely hazardous waste per calendar month.) In 2021, those LQGs generated 35.9 million tons of hazardous waste, including eight facilities that each generated over 1 million tons of hazardous waste.[15]

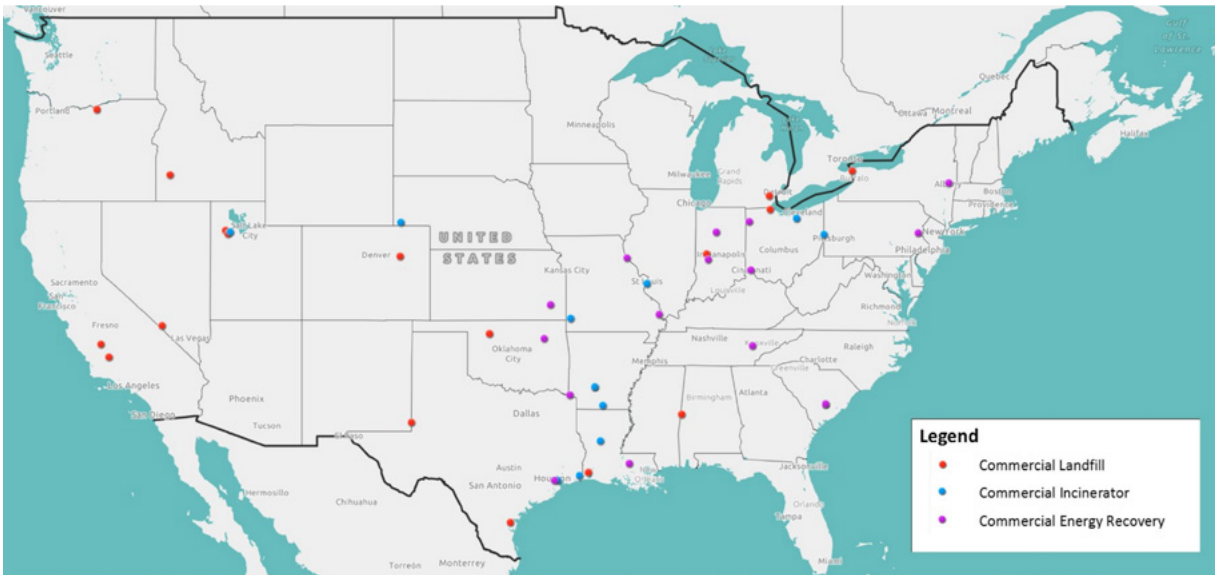
Hazardous Waste Management Methods/Tons Managed



Source: U.S. Environmental Protection Agency

Waste generation is concentrated in certain "hot spots" across the country. About 80% of all generated hazardous waste is produced by three industry sectors: chemical manufacturing, petroleum and coal products manufacturing, and waste treatment and disposal facilities. More than half the nation's hazardous waste is generated in the state of Texas.

Commercial Hazardous Waste Energy Recovery, Incineration, and Landfill Facilities



Source: U.S. Department of Energy

Our nation's ability to effectively manage its hazardous and solid waste in the future is impacted by the weakness of our recycling system under RCRA.[16] Of the 37.5 million tons of hazardous waste generated each year, only 1.6 million tons were recovered or recycled in 2021[17]; comparatively, the EPA estimates that about 32% of non-hazardous waste generated in the U.S. is currently recycled or composted.[18]

Currently, 3,924 facilities have been identified as releasing hazardous waste or hazardous constituents from a RCRA-regulated facility or have applied for treatment, storage, and disposal facility RCRA permit.

Department of Energy Environmental Management Program

The Department of Energy's Environmental Management (DOE EM) program is charged with cleaning up 107 hazardous waste sites nationwide, including some of the world's most dangerous radioactive sites that once supported defense production programs and government-sponsored nuclear energy research. Since 1989, the DOE has completed its cleanup mission at 92 of the 107 primary nuclear weapons and nuclear research sites.

US Department of Energy Active Cleanup Sites

Source: U.S. Department of Energy Office of Environmental Management

FUNDING AND FUTURE NEED

Before the passage of the IIJA, the Superfund budget had been flat for a decade at around $1.1 billion annually. Insufficient funding for the program led to a growing backlog of sites not being cleaned up. The $3.5 billion invested in Superfund through the IIJA was used to clear the backlog of 49 sites where cleanup had been on hold while also accelerating work on new Superfund sites.

In the future, the Superfund program will rely primarily on Superfund excise taxes for its funding. However, Superfund excise taxes expired more than 25 years ago. Since the taxes expired, the program has been funded through general revenues and settlement agreements with parties responsible for the pollution. The 2022 Inflation Reduction Act (IRA) reinstated a Petroleum and Oil Superfund Tax, and the IIJA reinstated the Chemicals Superfund Tax and the Hazardous Substances Tax, the latter sunsetting in 2031. Combined with contributions from general revenues, this represents a substantial increase over pre-IIJA funding levels. EPA projects that these excise taxes will bring in $2.17 billion in tax receipts to fund the cleanup program in Fiscal Year 2025 alone.19 However, there may be "start-up" issues with the initial implementation of the new taxes as revenue thus far trail projections. In FY 2024, the chemical tax collected

$472 million on a $1.7 billion estimate, and the petroleum tax generated $732 million, below the projected $858 million.20 If Superfund tax receipts continue to fall short of projections, additional general revenue or tax regime updates will be needed to sustain the program's effectiveness.

The Brownfields program also benefited from the IIJA, with supplemental funding of $1.5 billion. Prior to the IIJA, Brownfields grant funding to the states remained stagnant at just under $50 million annually for two decades. Over that period, the number of grant applicants more than doubled, resulting in more grants but smaller in size. With more sites, the states' resources were overstretched, and their ability to deliver robust brownfield development programs was compromised. With IIJA funding, the amount granted to states increased to $110 million per year, with that level of financing sustained over FY22–26. Due to this increase, states have added program capacity leading to significantly more economic, social, and environmental benefits for their residents. EPA estimates that $20 is leveraged for each $1 awarded through brownfields assessment, cleanup, and planning grants.[19] Given the return on brownfield investments,[20] the level of funding achieved through the IIJA should be sustained beyond FY26.

The RCRA program is managed by the states but is mainly funded through federal grants, with a 25% state-matching requirement. Unlike the Superfund and Brownfields programs, the RCRA program did not receive supplemental funding through the IIJA. A 2023 study by the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) estimated the total national cost of the RCRA Subtitle C program for FY22 at $194 million.[21] The federal grant allocation for FY22 was $98.2 million, which has been stagnant since 1995, meaning that the program funding has been effectively cut in half due to inflation. Therefore, states have been forced to cover the funding shortfall, which totaled $63 million in FY22 alone, by "overmatching" at 48% of federal grant funding. That has strained the state RCRA management programs in processing permits, inspections, enforcement, responding to new rulemakings, and providing technical assistance, hiring, and training.[22]

For the remaining 15 active cleanup sites under the DOE EM program, the estimated life-cycle cost of cleanup is over $525 billion, with a cleanup completion date projected around 2080. A total of 11 sites have ongoing cleanup operations with a life-cycle cost of at least $1 billion each, with the Hanford Site in Richland, WA, representing the most expensive estimated cleanup at $312 billion.[23] Annual funding for the DOE EM cleanup program has been consistently around $7.4 billion, below the estimated needs.

OPERATION AND MAINTENANCE

EPA indicates that there is adequate capacity nationwide for the treatment and disposal of hazardous waste through the year 2044[24]; however, the estimate does not take into account several factors:

- The incineration of hazardous waste has trended upward for the past two decades,[25] with 937,000 tons of hazardous waste incinerated in 2021,[26] but commercially available incinerator capacity has decreased.
- Several large privately owned incinerators have recently closed, and that waste is now being sent to commercial incinerators.

In 2021, the American Trucking Association estimated a record shortage of over 80,000 qualified drivers. The shortage was most acute for the waste transport industry, where specialized permits, handling, equipment and training are required.[27]

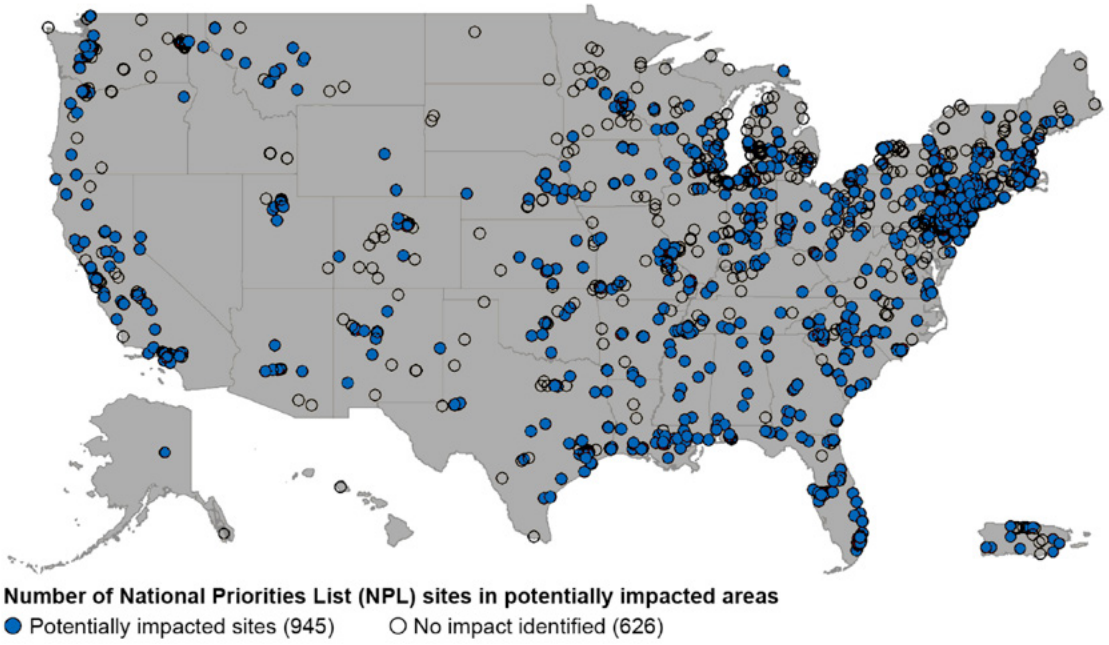
As a result of these factors, a large number of LQGs are exceeding RCRA compliance requirements for how long hazardous waste is permitted to be stored on-site.[28] In response, EPA took the unusual step in 2021 of issuing regulatory exemptions to address these capacity-related compliance issues.[29]

PUBLIC SAFETY AND RESILIENCE

The resilience of the nation's hazardous waste infrastructure is a growing concern. The core purpose of the nation's hazardous waste infrastructure is public safety—preventing the release of and exposure to dangerous and toxic substances. While the existing infrastructure is generally fit for that purpose, the resilience of the infrastructure is less certain. Since certain PFAS compounds have been designated as hazardous substances under CERCLA, addressing this type of public and environmental safety concern will put significant pressure on hazardous waste infrastructure with implications on future requirements for site investigations and remediation, treatment capacity, and the development of new treatment technologies.[30]

Currently, 945 (about 60%) of all non-federal NPL sites are in areas that may be affected by flooding, storm surge, wildfires, or sea level rise related to climate change effects.[31] However, EPA recently issued a directive incorporating climate resilience as a core factor in selecting and designing a Superfund cleanup.

Superfund Sites Potentially Impacted by Extreme Weather



Source: SUPERFUND: EPA Should Take Additional Actions to Manage Risks from Climate Change Effects, US General Accountability Office, GAO-21-555T, May 2021

INNOVATION

Remediation technologies continue to improve, and more effective site characterization and cleanup strategies are used to emphasize adaptive management and optimization of treatment systems. For example, EPA's 2023 Superfund Remedy Report indicates a shift toward greater reliance on in situ and natural systems-based remediation approaches. In situ source treatment increased from 20% to 34%, and monitored natural attenuation (MNA) for groundwater increased from 20% to 31% compared to the previous three years (2015–2017).[32] Meanwhile, EPA's PFAS Strategic Road Map[33] identifies research as a central focus of EPA's strategy, enabling greater collaboration between industry, government, and academia in developing new treatment technologies to address PFAS contamination, resulting in more rapid implementation of promising treatment innovations.

RECOMMENDATIONS TO RAISE THE GRADE

- Maintain current funding levels for the Superfund and Brownfields programs.
- Monitor and maintain the Superfund chemical tax and petroleum tax to ensure the program is adequately funded for the long term.
- Direct robust funding to the state RCRA programs to ensure resources are available to protect the public and environment through permitting, inspections, and corrective action.
- Expand hazardous waste incinerator capacity to meet growing demands.
- Invest in building capacity and resources for hazardous waste transportation.
- Accelerate and increase investment in PFAS research aimed at characterization, treatment, and analysis, and apply that research to inform a protective and scientifically sound regulatory framework for managing PFAS in the environment.
- Strengthen the nation's existing recycling system through investments and innovations in consumer education, collection systems, sorting technologies, and biochemical degradation of plastics and other areas to move forward in the direction where products reaching the end of their use are recycled and productively reused.
- Develop more reliable hazardous remediation cost estimating tools so the nation can effectively plan and budget for future hazardous waste management and infrastructure costs.
- Resolve long-standing technology and implementation problems for long-term stabilization of high-level radioactive wastes.
- Establish a geologic repository for permanent storage of radioactive waste.

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Inland Waterways

C-

GRADE COMPARISON

2025: C-

2021: D+

Photo: Aerial view of barges docked at the shore of the Mississippi River; dvande

INLAND WATERWAYS

EXECUTIVE SUMMARY

The U.S. inland waterways span the Mississippi River and its tributaries, to the Great Lakes, the Columbia–Snake River system of the Pacific Northwest, the Sacramento and San Joaquin Rivers on the West Coast, as well as the Gulf and Atlantic Intracoastal Waterways. The system is the hidden backbone of the nation's freight network, which serves both our industrial and agricultural sectors. Inland waterways also provide flood mitigation and drought relief through dams that are responsible for providing municipal and industrial water supply for 136 multifunction reservoirs.[1] Operated and managed by the U.S. Army Corps of Engineers (USACE), in coordination with the Maritime Administration (MARAD), the system encompasses 12,000 miles of inland navigation and 11,000 intracoastal channels.[2] Inland waterways play a vital role in the global supply chain by moving $158 billion of goods annually, facilitating the transport of one-third of the nation's gross domestic product (GDP).[3] Inland waterways allow commodities to move cost-effectively, reducing the strain on congested roadways and rail systems, and with fewer greenhouse gas emissions.[4] Federal funding has increased in recent years, but a $7.5 billion backlog for construction projects remains, causing ongoing lock closures.[5]

BACKGROUND

The U.S. has two major navigable river systems: the Mississippi and Columbia–Snake Rivers. The former comprises the Mississippi, Arkansas, Illinois, Ohio, Missouri, and Tennessee Rivers, and Gulf Intracoastal Waterway, whereas the latter includes the Columbia and Snake Rivers.[6] Congress authorizes and funds the USACE to oversee the planning and construction of water resource projects and maintenance of navigation improvements and other infrastructure.[7] **The complete inland waterway system contains 25,000 miles of navigable waterways and channels, including 237 lock chambers at 192 sites and 1,072 coastal, Great Lakes, and inland harbors that directly serve 45 states and territories.[8]**

Fuel-Taxed Inland Waterways Systems

Source: U.S. Army Corps of Engineers

CAPACITY AND CONDITION

As part of the inland waterways system, dams and navigation locks enable shallow draft operations on many major rivers, manage the river's flow, and preserve navigation.[9] A critical carrier of commodities, approximately 465 million tons valued at over $158 billion, move on the waterways system annually. The system facilitates the transportation of diverse commodities across many sectors, including agriculture, construction, manufacturing, and energy, and represent one-third of U.S. GDP.[10] In 2022 alone, a combined 210 million metric tons of agricultural exports and imports were transported via the network.[11] Alleviating pressure from the nation's roadways and freight rail system, one barge efficiently and cost-effectively carries the equivalent of 70 tractor trailers.[12] More than 4% of the nation's freight tonnage uses a waterway.[13]

However, the age and capacity of the lock and dam infrastructure inhibit commercial navigation,[14] with 80% of the lock and dam infrastructure on the inland waterways system exceeding its 50-year design life in 2024.[15] When a lock or dam reaches a state of poor repair, traffic on the inland waterways is disrupted to allow for scheduled maintenance or unscheduled repairs.[16] Although scheduled delays impose a financial loss to shippers and consumers, an even greater cost occurs from unscheduled delays caused by maintenance issues. It can interrupt business operations for entire supply chains for weeks or months. **In 2020, locks experienced 9,147 periods of unavailability, of which 6,361 were scheduled shutdowns and 2,786 were not planned, resulting in an average delay of 172.2 minutes.[17]**

Since 2022, decreased rainfall and drought conditions upstream have led to low water levels on the Lower Mississippi River,[18] which in turn hampered the flow of freight. Droughts upstream limit the ability of USACE to release headwaters and store waters in tributaries to mitigate the low flow conditions downstream, meaning what affects upstream areas ultimately impacts downstream waterways. In 2023, low water coincided with peak shipping season for U.S. corn and soybeans, the nation's largest export crops. At that time, 69% of the transport on the Lower Mississippi below Lock and Dam 27 near Granite City, Illinois, were soybeans and 30% corn.[19] As a result, models showed that Brazil's global export market share would have risen from 51% to 68%, with the U.S. world market share declining from 38% to 28%. The case underlies the need to invest in the U.S. inland waterways' capacity to remain a global trade competitor.

FUNDING AND FUTURE NEED

Major rehabilitation and new construction projects for inland waterways are funded through federal general funds and revenue from the Inland Waterways Trust Fund (IWTF). The IWTF receives revenues from a tax (a.k.a. the inland waterway user fee) on commercial barge fuel throughout federally designated waterways.[20] The fund pays some construction costs as well as significant rehabilitation on those waterways. In addition, individual projects can receive funding through supplemental federal appropriations, which provide additional funding during a fiscal year; in modern practice, this is typically in response to urgent and unanticipated needs such as natural disasters and urgent military operations.[21]

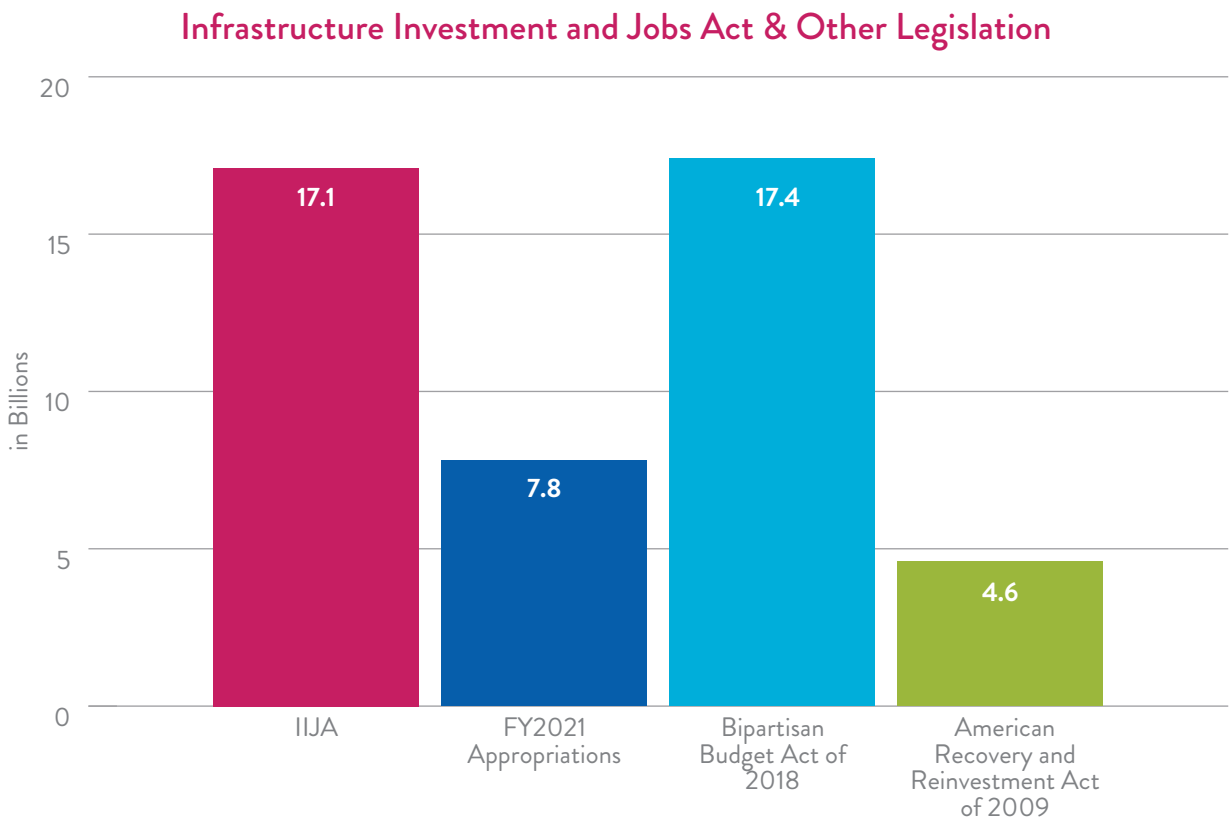
During 2021–2022, critical federal laws positively impacted investment in the nation's water resources infrastructure. The Infrastructure Investment and Jobs Act of 2021 (IIJA) provided $17.1 billion in supplemental appropriations to various USACE accounts, with 68% going to USACE's "Construction" account, amounting to $11.62 billion.[22]

Every two years, Congress passes the Water Resources Development Act (WRDA), a comprehensive legislative package that provides for the conservation and development of water and related resources.[23] Congress has kept this biennial schedule approving WRDA on a bipartisan basis since 2014.[24] WRDA 2022 revisited how much federal funding for inland waterways projects should come from the government's general fund versus the IWTF. Initially, federal funding for such projects required 50% general funds and 50% IWTF funds. In 2024, Congress changed this formula to 75% general funds and 25% IWTF funds. With a greater reliance on general funds, IWTF funding can in turn support more projects.[25]

However, challenges remain in the form of sustained funding. First, the IIJA and WRDA authorized funding levels are tied to the appropriations process and can be impacted by various spending amounts approved by Congress. In addition, according to the Inland Waterways Users Board and since the passage of IIJA, the USACE determined that, based on the funding received, program-wide cost overruns will make IIJA funding insufficient to complete any of the seven priority projects. IIJA funding was based on original project cost estimates that did not reflect current inflation and market conditions, labor shortages, and other impacts from the COVID-19 pandemic.[26]

Stiff trade competition with Brazil is one example of why the U.S. needs the inland waterway system to be modernized. The top two producers in the world soybean market, the U.S. and Brazil, compete for the same overseas markets.[18] For both countries, the competitiveness of their soybean exports depends on low transportation costs to critical markets, primarily China and Europe.

Brazil's decades-long efforts have improved its transportation cost competitiveness, and it has been the top exporter of soybeans since 2013.[19] Therefore, if portions of the inland waterways system close due to outages, it will impede the export of goods or require those goods to be transferred to other modes, which is less efficient and more costly, thus reducing profitability.



Source: U.S. Army Corps of Engineers

OPERATION AND MAINTENANCE

The upkeep of the inland waterways—such as lock repairs and dredging—is funded through annual appropriations. Dredging removes sediments and debris from the bottom of lakes, rivers, harbors, and other water bodies and is essential to maintain or increase the depth of navigation channels, anchorages, or berthing areas, which is necessary for the safe passage of boats and ships.[27] In addition to annual appropriations, the IIJA provided $4 billion to the USACE Operation and Maintenance account and $808 million to its Mississippi River and Tributaries account.[28]

With the deferred maintenance backlog standing at $7.5 billion, funding shortfalls exist, posing the potential for unnecessary delays in planned and unplanned maintenance activities. Access to sufficient financing, regardless of timing in the fiscal year, is crucial to mediate unexpected emergencies caused by low water events like those seen in 2022 and 2023.[29] Delays and closures caused by the age and capacity of the lock and dam infrastructure result in an average delay of 172 minutes (nearly 3 hours), affecting 47% of vessels.[30] Challenges also persist in rising and declining water levels due to extreme weather events and workforce shortages delaying project construction.[31]

Photo: Coast Guard USACE monitor construction on Calcas

PUBLIC SAFETY

Transportation using the nation's inland waterways has the lowest injury and fatality rates in comparison with other freight transportation modes. There are 96 rail and 1,145 tractor-truck injuries for every one barge injury. Similarly, for one barge transportation fatality, there are 26 fatalities related to rail and 120 deaths related to trucks.[32] According to the Bureau of Transportation Statistics, in 2022, there were five fatalities caused by freight vessels in comparison to 626 deaths by freight rail.[33] From a technology standpoint, modernization of the national maritime systems is needed to monitor the status of aids to navigation and ports, to predict and assess risk, identify and respond to evolving cyber threats, and intercept noncompliant vessels. The U.S. Department of Homeland Security's Science and Technology Office commissioned a study[34] in 2021 to better understand how commercial port operators deploy their Informational Technology and Operational Technology systems, the resiliency of these systems and what improvements can be made to reduce vulnerabilities in U.S. ports, evaluate the effectiveness of current protections and mitigations, and harden the maritime port infrastructure against cyber intrusions and disruptions.

RESILIENCE AND INNOVATION

Changing climates across the U.S. are contributing to less predictable water levels and impacting the efficiency of the inland waterway system. In 2023, drought affected virtually the entire midwestern U.S., and rainfall in the eastern states was below regular averages.[35] Water levels on the Mississippi and Ohio rivers fell at an alarming rate. Near the city of Cairo, the level of the Ohio River dropped six feet in one week, and there was a further decline of four feet before the end of the month.[36] On the Mississippi, the water receded three feet in the St. Louis area and about six feet around Memphis. In response, barges must carry less cargo to reduce their drafts, and barge tows must be reduced in number and length. Because of the low water levels, some parts of the waterway system were not navigable by barges, leading to higher transportation costs, because barges and vessels may be loaded to less than capacity because of low water.[37] The record-low water levels in the Mississippi River disrupted the transportation of agricultural goods, costing about $1 billion in losses.[38] Vessel operators, the Coast Guard, and the USACE partnered to avoid more damaging disruptions on the system and kept cargo moving, although at a slower pace with smaller loads.

To monitor the water levels on the inland waterways, USACE uses a geographic information system (GIS). Their GIS allows them to record, analyze, and visualize data about the river and the forces that affect its flow. However, no universal system yet exists for reliably tracking the commodity movements and delays of the inland waterway system in real time. Federal funding for new and existing federal navigation project designations of high-, medium-, and low-use waterways as well as private investment decisions hinge on tonnage reporting. The USACE Geospatial Open Data Portal provides shared and trusted USACE geospatial data, services, and applications for use by partner agencies and the public. Both academic and private sectors are also advancing in-tracking shipping vessel data.[39] Innovations can be critical for more efficient product delivery and traffic control, including real-time vessel tracking and location prediction using Automatic Identification System (AIS) data or vessel traffic data.[40] Supported by University of Arkansas researchers, recent advancements have been made using traffic cameras and machine learning techniques to identify vessel types.[41]

In addition, interest grows in using hydrogen energy as fuel for vessels operating on inland waterways, primarily due to its potential for significantly reducing emissions and providing a cleaner alternative to traditional diesel fuel. In August 2023, a new fuel utilizing hydrogen energy began powering barges in the Mississippi River. The alternative fuel is part of an effort among many local organizations, including the Port of South Louisiana and GNO Inc., to reduce the regional maritime industry's carbon footprint. The H2TheFuture project is a larger plan to create a clean hydrogen energy cluster in south Louisiana.[42]

RECOMMENDATIONS TO RAISE THE GRADE

- Sustain IIJA-authorized funding for the U.S. Army Corps of Engineers to address operations, maintenance, and backlog needs, emphasizing the system's resilience to mitigate changing climates.
- Ensure federal funding at authorized appropriations is disbursed for inland waterways projects.
- Continue enactment of the Water Resources Development Act biennially.
- Safeguard and fully use the Inland Waterways Trust Fund in the annual appropriations process.
- Foster greater coordination, communication, and collaboration with USACE and the private sector for tracking inland waterway traffic.

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Photo: Barge; U.S. Department of Agriculture

Levees

D+

GRADE COMPARISON

2025: D+

2021: D

Photo: Water surges onto the road as natures fury reveals the aftermath of a levee failure; Leli

LEVEES

EXECUTIVE SUMMARY

Twenty-three million Americans nationwide live and work behind a levee. The nation's levees guard against flood risk to critical infrastructure systems and protect $2 trillion worth of property, seven million buildings, and five million acres of farmland. The National Levee Database contains over 24,000 miles of levees across the U.S., but nearly two-thirds have not been assessed for risks posed to the communities behind them. More than half of the nation's levees are operated and maintained at the state and local level. While a national effort to enhance levee safety continues to take shape, including the development of draft National Levee Safety Guidelines, improvements to the National Levee Database, and development of best practices for levee management, more must be done to support states in regulating levees. There are currently limited funding streams for levees and levee safety, as programs like the National Levee Safety Program and Levee Rehabilitation Grant Program have received little federal funding in recent years. The states are also responsible for promoting consistent but flexible best practices for levee operation and management as well as improving and expanding access to funding sources for levee rehabilitation and repair.

BACKGROUND

In the late 19th and early 20th centuries, periodic flooding in the nation's major river basins led Congress to pass the Flood Control Act of 1917, which authorized the construction of new levee systems and required communities to share in construction costs and assume responsibility for levee maintenance.[1] Further reauthorizations of the Flood Control Act established greater federal interest in the design and construction of levees. More than half of the nation's levees are owned and operated by state and local governments, but more than one-third of the nation's levees have unknown ownership. Across all 50 states, there are 7,000 levee systems spanning a total of 24,000 miles listed in the National Levee Database. However, the total number of levee systems may be higher, with some estimates indicating as many as 100,000 miles of non-federal levees. Approximately one-third of the nation's levees have been assessed for risk to populations in relation to a levee's condition. Of those levees assessed for risk, 84% are rated as low or very low risk, and about 3% are rated as high or very high.

CAPACITY AND CONDITION

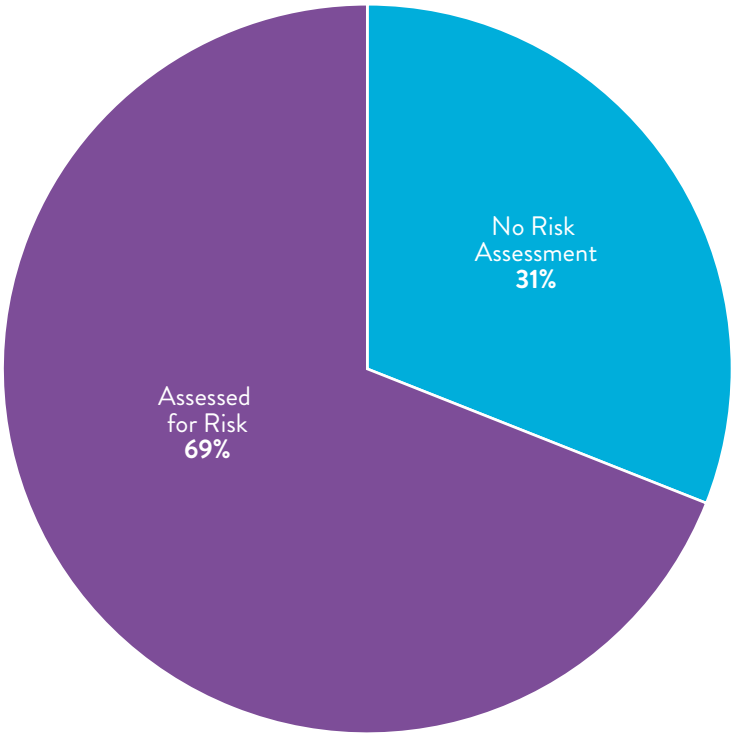
In every state, including the District of Columbia, Guam, and Puerto Rico, communities depend on levees to protect against flood risk. Earthen embankments make up more than 97% of the nation's levees, whereas approximately 2.5% of levees are concrete, rock, and steel flood walls. The average age of the nation's levees is 61 years old, meaning that many are not built up to modern codes and standards.[2]

Since the National Levee Safety Program was first authorized in 2007, the U.S. Army Corps of Engineers (USACE) has cataloged more than 24,000 miles of levees in the National Levee Database.[3] As of 2021, USACE has worked closely with agencies such as the Federal Emergency Management Agency (FEMA) to determine a more accurate accounting of the nation's levees, including identifying structures and entities previously misidentified as levees. Because of this, the database is updated continually as new information becomes available, resulting in fluctuating figures. While it is the most comprehensive data set available on the totality of the nation's levees, it still may not fully represent the total number of levee systems in the U.S. One estimate indicates that there may be as many as 100,000 miles of non-federal levees nationwide; however, as estimates continue to vary, it has led to uncertainty regarding the nation's overall levee systems.[4]

There are nearly 7,000 total levee systems listed in the National Levee Database. USACE regularly assesses the risk posed by levee systems in their portfolio, about 23% of the nation's total levees, by relating a levee's condition to the total potential consequences to the population living or working behind the levee. As of November 2024, USACE has completed risk assessments on 97% of the levees in its portfolio.[5] USACE also has authority to conduct one-time reviews of all other levees under the National Levee Safety Program, which includes an assessment of risk. While many states have contributed data to the National Levee Database, there has been limited progress in the development of state levee safety programs since the creation of the National Levee Safety Program in 2007, posing challenges to consistent oversight of non-federal levees outside of USACE's portfolio.[6] However, of the total levee systems nationwide, only about 31% have received a risk assessment. Of the non-USACE levees inspected, nearly 84% were rated as low or very low risk, 13% were rated as moderate risk, and just over 3% were assessed as high or very high risk.[7]

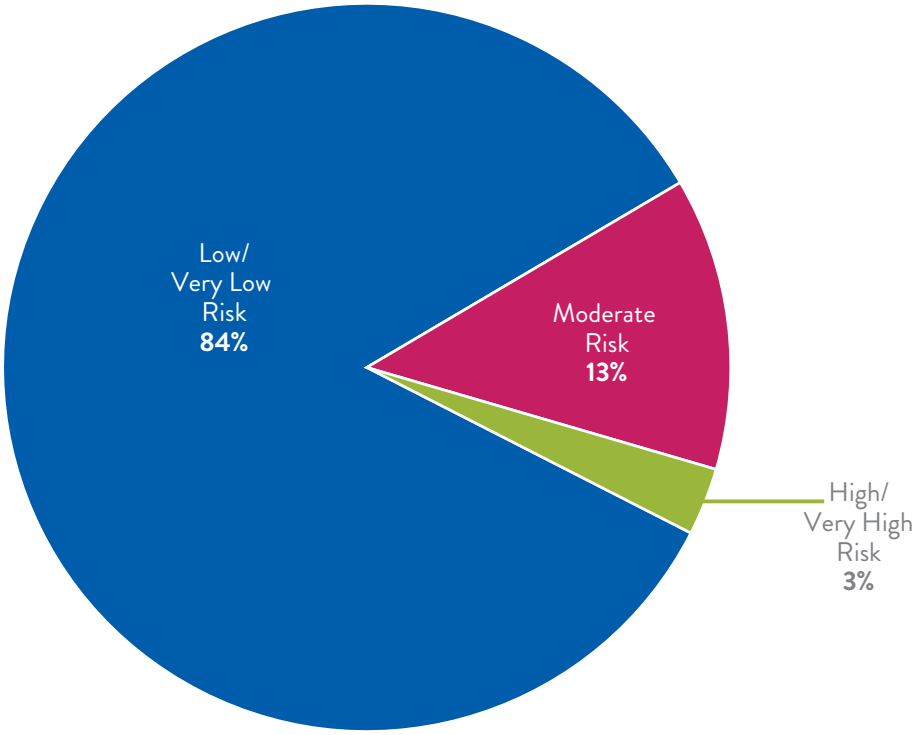
Photo: Aerial view of old US Route 66 bridge over chain of rocks canal, Pontoon Beach, Illinois; Kent Raney

Nationwide Levee Risk Assessments



Source: National Levee Database, U.S. Army Corps of Engineers

Levee Risk Assessments Nationwide



Source: National Levee Database, U.S. Army Corps of Engineers

More than 1,100 levee systems nationwide are accredited as part of FEMA's National Flood Insurance Program, more than double the amount certified in 2018.[8] Of these, 610 levee systems are within USACE's portfolio, more than twice as many as in 2018. A FEMA-accredited levee is certified by a registered professional engineer; meets the National Flood Insurance Program minimum design, operation, and maintenance requirements; and is expected to provide a reduction of flood risk from a 1% annual-chance flood (100-year flood). Approximately 27% of these accredited levees within USACE's portfolio are moderate, high, or very high risk. Forty-five levees within USACE's portfolio rated as high or very high risk have either been fully or provisionally accredited.

FUNDING AND FUTURE NEED

In 2018, USACE estimated a $21 billion cost to improve and maintain the moderate-, high-, and very high-risk levees in their portfolio. However, the amount did not account for levee systems outside USACE's portfolio, meaning the actual cost is much higher. Given the increasingly severe effects of extreme weather events, aging of the nation's levees, and lack of substantial investment in levee safety and improvements, it is likely that cost has grown significantly since 2021, when ASCE's overall estimate to bring the nation's levees into a state of good repair totaled $70 billion.

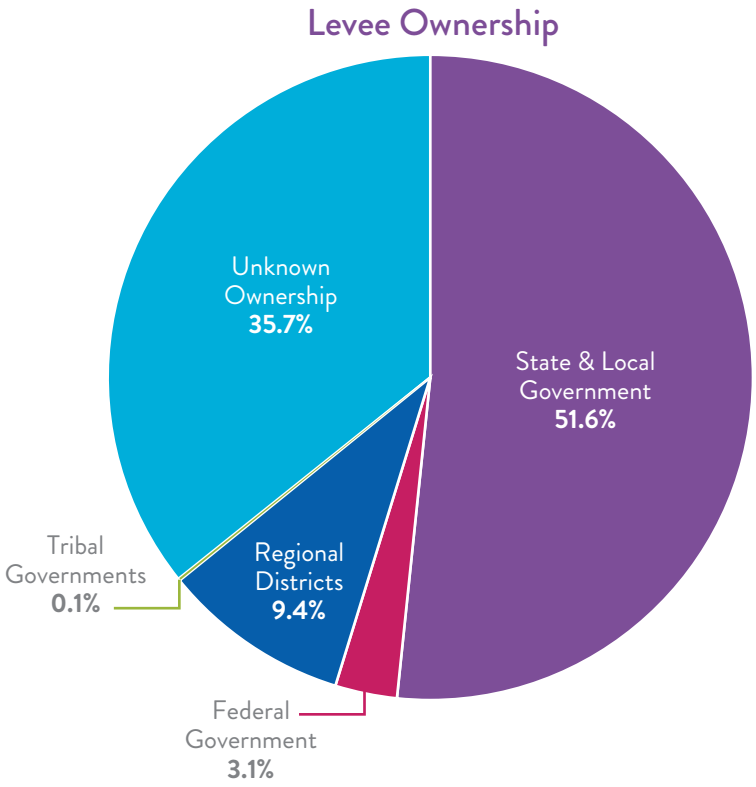
Programs like the National Levee Safety Program and the USACE Levee Rehabilitation Program provide support to states to assist in building levee safety capacity and improvements to existing levees. The Rehabilitation Program provides federal repair funds to levees operated and maintained by a nonfederal levee sponsor damaged by floods or coastal storms.

The Water Resources Development Act (WRDA) of 2022 reauthorized the National Levee Safety Program through 2028. The program is designed to provide a framework of best practices by developing levee safety guidelines, supporting states in setting up their levee safety programs, and completing the National Levee Database. Since the program's reauthorization, USACE has produced several draft brochures and educational materials to guide levee management for levee owners and to assist states in developing their levee safety programs.

Although USACE has made progress in implementing the National Levee Safety Program, it has not been met with commensurate federal funding. In 2020, Congress appropriated $15 million to support continued program development. The program's 2022 reauthorization also extended its funding authorization of $54 million annually. However, aside from the $29.5 million total for continued growth of the National Levee Database since fiscal year 2021, Congress has not provided any additional appropriation for the National Levee Safety Program.

OPERATION AND MAINTENANCE

USACE's levee portfolio consists of over 2,000 total levees and spans more than 12,000 miles nationwide. Management of these levees falls to various federal, state, and local entities, as well as many private entities. Of the 12,000 miles of levees in the USACE portfolio, 26% (about 3,200 miles) are operated and maintained fully or partially by USACE. Nearly 52% of the total levees in the USACE portfolio are operated and maintained in whole or partially by state and local governments, more than 9% by regional districts overseen by one or multiple state governments, and just over 3% are federally owned.[9] Beyond USACE's portfolio, more than one-third of the nation's levees have unidentified ownership, which means that critical information about their proper maintenance—and whether a levee is being used for its intended purpose—is unknown.



Source: U.S. Army Corps of Engineers

The National Levee Safety Program was partly designed to help alleviate such challenges. Standing up state levee safety programs can help provide technical assistance to levee owners and operators, support regular inspection and monitoring, and better communicate flood risk to communities. National Levee Safety Guidelines, a draft of which was published by USACE in April of 2024, will provide states with a standard set of best practices for levee operation and management and achieve consistent nationwide reliability of levees and community resilience in areas behind levees.[10] The 2024 draft guidelines were the first-ever produced and promote best practices for consistent levee safety and reliability. The guidelines cover topics such as strategies to reduce flooding impacts, consideration of the effects of climate change, and addressing the needs of underserved communities impacted by levees.

PUBLIC SAFETY

The nation's levees protect communities against flood risk. In the U.S., at least 23 million people live behind levees across nearly 2,400 communities in all 50 states.

A recent study found that the percentage of disadvantaged communities living in leveed areas is 41% higher compared to their proportion in non-leveed areas, indicating that these communities are disproportionately concentrated behind levees.[11] Furthermore, these communities often lack adequate flood mitigation infrastructure, such as stormwater systems, and frequently suffer from a lack of critical resources such as flood insurance, emergency savings, and access to transportation for evacuation, which are needed to respond to flooding events.[12]

All levees are vulnerable to being breached. Even well-maintained levees can breach, and water can seep through and underneath them; these effects are hard to detect but can weaken the levee's stability. These residual risks are always present and can stem from flooding that exceeds levee design that leads to overtopping, erosion, and structural failures, in addition to seepage.[13] Frequent extreme weather events put many communities at

an increased risk of flooding and levee breaches, including those previously not in high flood-risk areas. Unfortunately, levee systems are often neglected, in many cases due to cost–benefit determinations that prioritize structures protecting higher-value assets.

In 2023, levee breaches in Pajaro, CA, displaced thousands of residents. The breaches resulted in significant damage or complete destruction of 200 homes, while the surrounding county suffered agricultural losses of more than $450 million.[14] It was later found that the levee, built in 1949 (more than 10 years older than the national average age of levees), was never prioritized for repair or rehabilitation, even though the levee experienced inadequate flood protection as early as the 1960s, which resulted in flooding multiple times over nearly eight decades.[15] Local officials in Pajaro had warned about the levee's danger for years. But home and business values in the area did not rise to the level required for repair under the federal government's cost–benefit formula.[16]

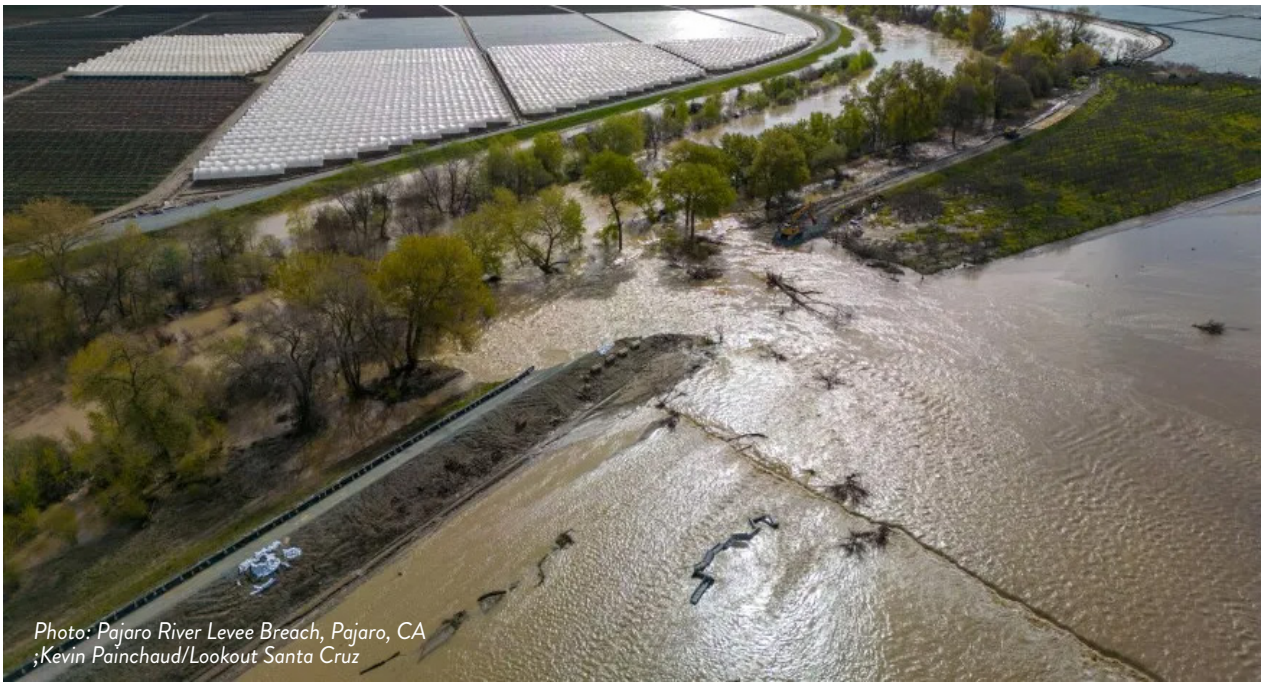


Photo: Pajaro River Levee Breach, Pajaro, CA ;Kevin Painchaud/Lookout Santa Cruz

RESILIENCE AND INNOVATION

Levee performance and condition can be affected by a number of factors, including extreme weather, funding for safety and maintenance, and age. As climate change increases the frequency and severity of rain events, the added strain on levees is likely to raise the total cost of levee rehabilitation projects. In 2023, a proposed USACE levee rehabilitation project in Colorado Springs, CO, was projected to cost more than $1 billion.[17] Local governments rarely have the resources necessary to maintain a levee system properly. It may not be until a flood event that the levee owner recognizes maintenance must be a priority.

Many levees that are locally managed were built decades ago, and the knowledge of the construction materials may be limited without costly and potentially invasive investigations. No national standard for levee construction exists, and many of the nation's levees (some decades old) were designed and built using different processes and standards.[18] At least 641 of the levee systems in USACE's portfolio (nearly 32%) average 60 years old or older, including at least 163 built before 1950.[19] Levees of this age were constructed using data that does not account for the increasingly frequent and intense rain events that these structures have been required to withstand since the 1960s.

In 2022, Congress took action to improve the resilience of the nation's levees. In addition to reauthorizing the National Levee Safety Program, WRDA 2022 amended USACE's Levee Rehabilitation Program to bring flood-

risk reduction and climate resiliency improvement activities under the definition of rehabilitation, thus allowing these types of projects to become eligible for program funding. It also increased the maximum amount of funds a project may receive through the program from $10 million to $25 million and gave priority to levee projects in underserved communities.

Congress also has prioritized improved data collection on the frequency and intensity of rainfall by passing the Providing Research and Estimates of Changes in Precipitation (PRECIP) Act in 2022. This law will improve how the National Oceanic and Atmospheric Administration (NOAA) estimates probable maximum precipitation (PMP) to better account for rainfall patterns. Limited or incomplete data regarding PMP and the effects of extreme weather have posed consistent challenges and impediments to levee and levee safety investment.[20] The changes to data collection practices expected to result from the PRECIP Act may also indirectly support a possible boost in funding for levee safety investments.

Passage of the PRECIP Act followed efforts to update the National Weather Service's precipitation frequency standard, ATLAS 14. The forthcoming ATLAS 15 is expected to be completed by 2027. Once complete, it will account for historical trends in precipitation frequency and incorporate the effects of extreme weather into future modeling. Ultimately, this will lead to the collection of more accurate data on rainfall events to improve future levee design and construction projects.

In recent years, several innovative technologies and methods have emerged that may help to maintain structural integrity and improve the performance of the nation's levees. The innovations leverage advancements in materials science, data analytics, and sensing and monitoring technologies to provide more effective and proactive levee management. For example, self-healing concrete incorporates materials that contain healing agents like bacteria or polymers that activate when cracks form and automatically repair minor cracks, thus preventing them from becoming a more severe issue. In addition, the increased use of technology such as uncrewed aerial vehicles (drones) equipped with high-resolution cameras and sensors can cover large areas quickly and use thermal energy to detect erosion and other signs of distress. Furthermore, robotic systems are currently being developed for levee inspection and maintenance. Systems can navigate challenging terrains and perform tasks such as soil sampling, surface repairs, and deployment of monitoring equipment.

In recent years, several innovative technologies and methods have emerged that may help to maintain structural integrity and improve the performance of the nation's levees.

Another commonly applied approach is interferometric synthetic aperture radar (InSAR), which has been used to monitor levees for nearly two decades. InSAR technology is capable of detecting ground movements with millimeter accuracy, can cover large areas along levees to better indicate areas of erosion, provide continuous monitoring to help assess the overall structural integrity of levees, and can identify stress points and areas of potential failure to allow for more timely maintenance. In the past, InSAR was used to monitor levee systems in the lower Mississippi River area and the California Delta.

Nature-based solutions (NbS) have also become an increasingly popular approach to improving infrastructure resilience. They can be used for various purposes, including flood-risk reduction and stabilizing shorelines. NbS provides multiple benefits such as reducing risks to existing infrastructure systems while increasing their functional lifespan, incorporating natural recovery potential into infrastructure systems, and reducing the harm done to natural ecosystems by the built environment. For example, setback levees push levee embankments away from the river, providing extra space to increase flood protection, reduce erosion, and support healthier riverine and coastal systems.[21]

RECOMMENDATIONS TO RAISE THE GRADE

- Fully fund the National Levee Safety Program to help states set up state levee safety programs, finalize and promulgate National Levee Safety Guidelines, and strengthen the National Levee Database.
- Reform cost–benefit analysis thresholds to ensure that underserved communities supported by levees are not at greater risk of flooding from levee breaches or prioritized for levee development if needed.
- Encourage efforts at all levels of government to achieve risk assessments for levees.
- Increase resources, education, and outreach efforts to those communities that live and work behind levees to communicate to the public the risks and consequences of levee failure.
- Complete the development of NOAA's ATLAS 15 precipitation frequency standard, and fund and implement the modernization of maximum probable precipitation estimates prescribed by the PRECIP Act to produce more accurate data on current and future rainfall events.

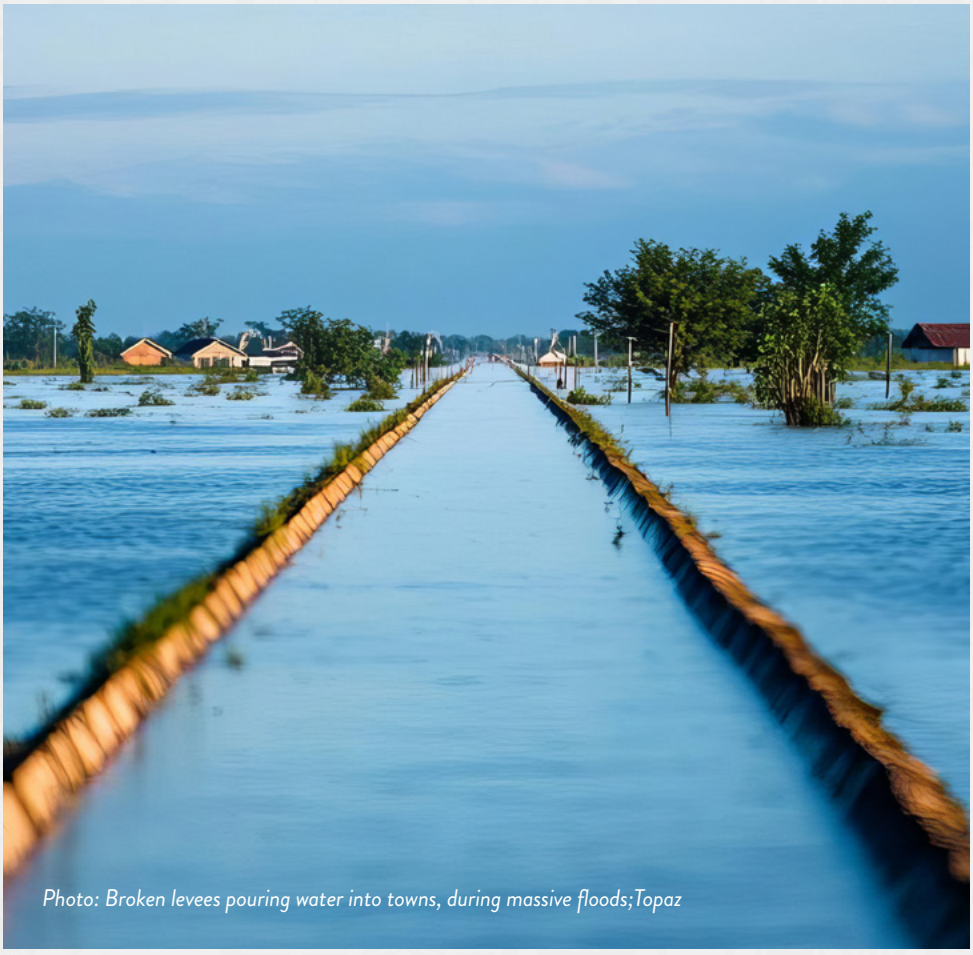


Photo: Broken levees pouring water into towns, during massive floods;Topaz

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Ports

B

GRADE COMPARISON

2025: B

2021: B-

Photo: Port of Seattle

PORTS

EXECUTIVE SUMMARY

Ports are an essential component of the U.S. economy, supporting $2.89 trillion in GDP.[1] The ports sector continues to adjust to the disruptions brought about by the COVID-19 pandemic, which caused an initial decline in containerized imports followed by a surge due to an increase in consumer-driven economic activity. Ports facilitate the movement of goods and connect American manufacturers and households with international trade. U.S. ports support more than 21.8 million jobs, including maritime industry professionals and suppliers.[2] Recent federal investments nearly doubled annual funding levels for programs such as the Port Infrastructure Development Program to $450 million per fiscal year, allowing America's ports to more robustly assess, balance, and address their waterside and landside needs. Meanwhile, ports are increasingly contending with the current and future impacts of extreme weather events, which present unique challenges to their coastal facilities that are susceptible to sea level rise.

BACKGROUND

Situated along the coasts and rivers as well as the Great Lakes–St. Lawrence Seaway System, the country's more than 300 ports facilitate the movement of goods as varied as agricultural products, electronics, and chemicals throughout the country and to and from trading partners around the world. Operated by states, counties, municipalities, and private entities, ports are complex facilities that integrate water, rail, road, and utility infrastructure. Maritime commerce dates back centuries, and port infrastructure is often a mix of old and new components. While facilitating the movement of goods daily, ports are pressed to modernize their infrastructure to meet current needs and face future challenges.

CAPACITY AND CONDITION

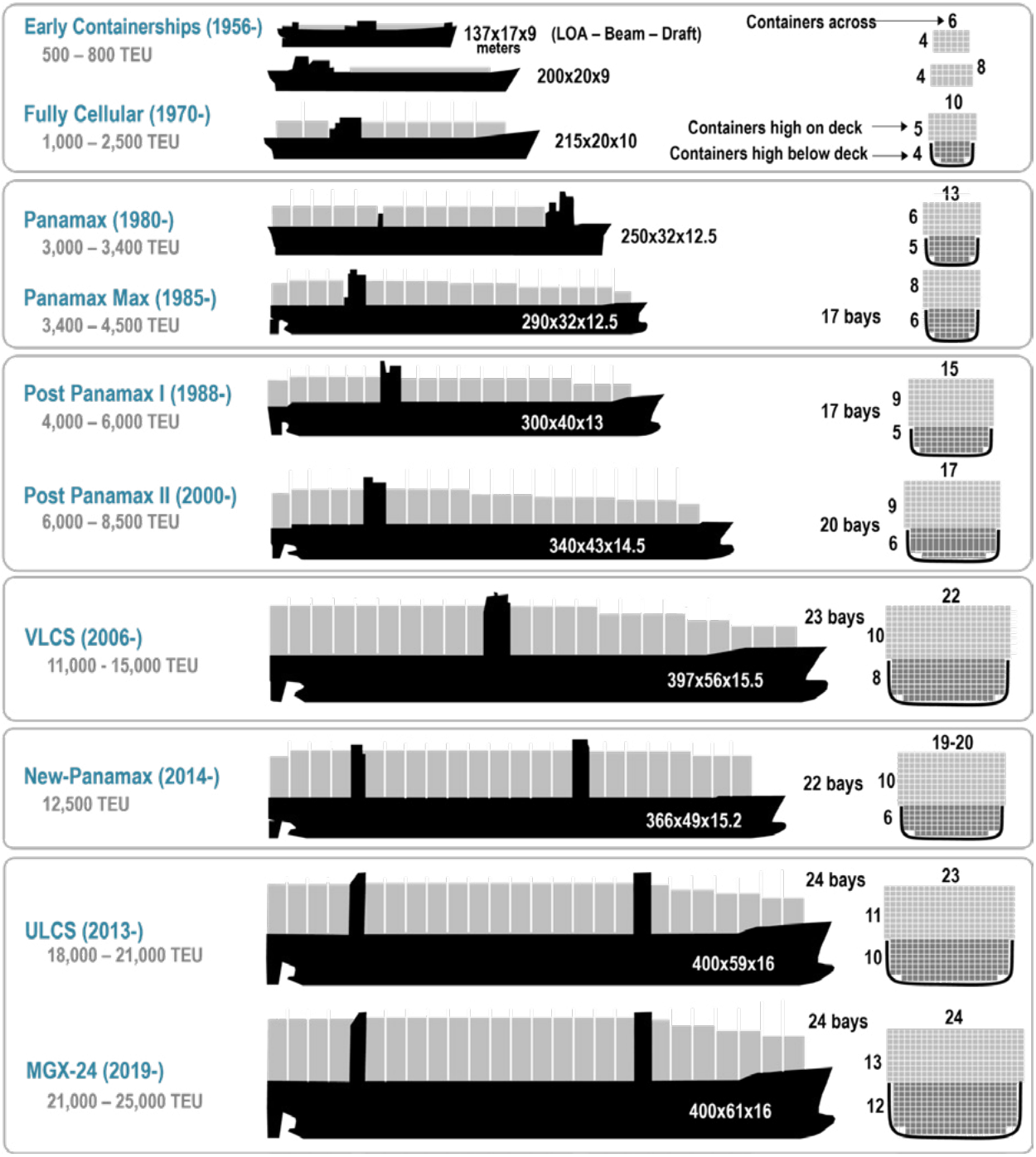
The nation's ports handled 41.5% (or $2.1 trillion) of U.S. international trade by value in 2023.[3] Furthermore, approximately 743 million tons of cargo, or 15%, of domestic freight is carried by water and must move through the nation's ports.[4]

The pandemic disrupted shipping operations domestically and globally, but U.S. ports demonstrated nimbleness amid the uncertainty. Although maritime container imports declined during the first half of 2020, they increased in the second half of the year owing to a sharp rise in imports principally from China.[5] Spending on household supplies surged as many people found themselves working from home. Container shipping firms, which had canceled scheduled sailings and consolidated shipping routes during the first half of 2020, raced to restore capacity to pre-pandemic levels as economic activity and consumer demand increased.[6]

Annually, the number of twenty-foot equivalent units (TEUs) handled by the leading ports in the U.S. (Tacoma, Seattle, Savannah, Virginia, Oakland, New York–New Jersey, Los Angeles, Long Beach, Houston, and Charleston) grew in the years before the pandemic and has continued to increase in the years since.[7]

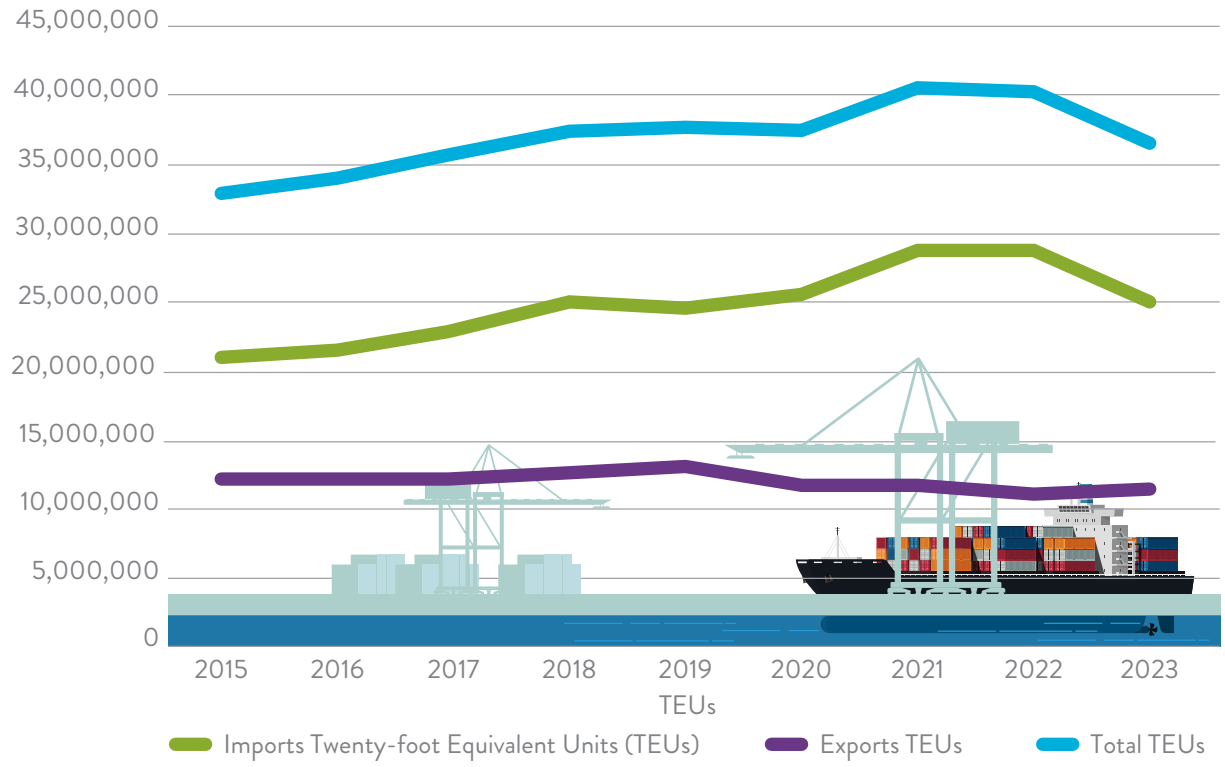
The total volume of containerized import and export cargo at U.S. ports was 32.9 million TEUs in 2015, a quantity which grew to 35.7 million TEUs in 2017 and 40.1 million TEUs in 2022.[8]

Evolution of Containerships



Source: Rodrigue, J-P (2024) The Geography of Transport Systems, Sixth Edition, New York: Routledge

Containerized Cargo at U.S. Ports (in TEUs)



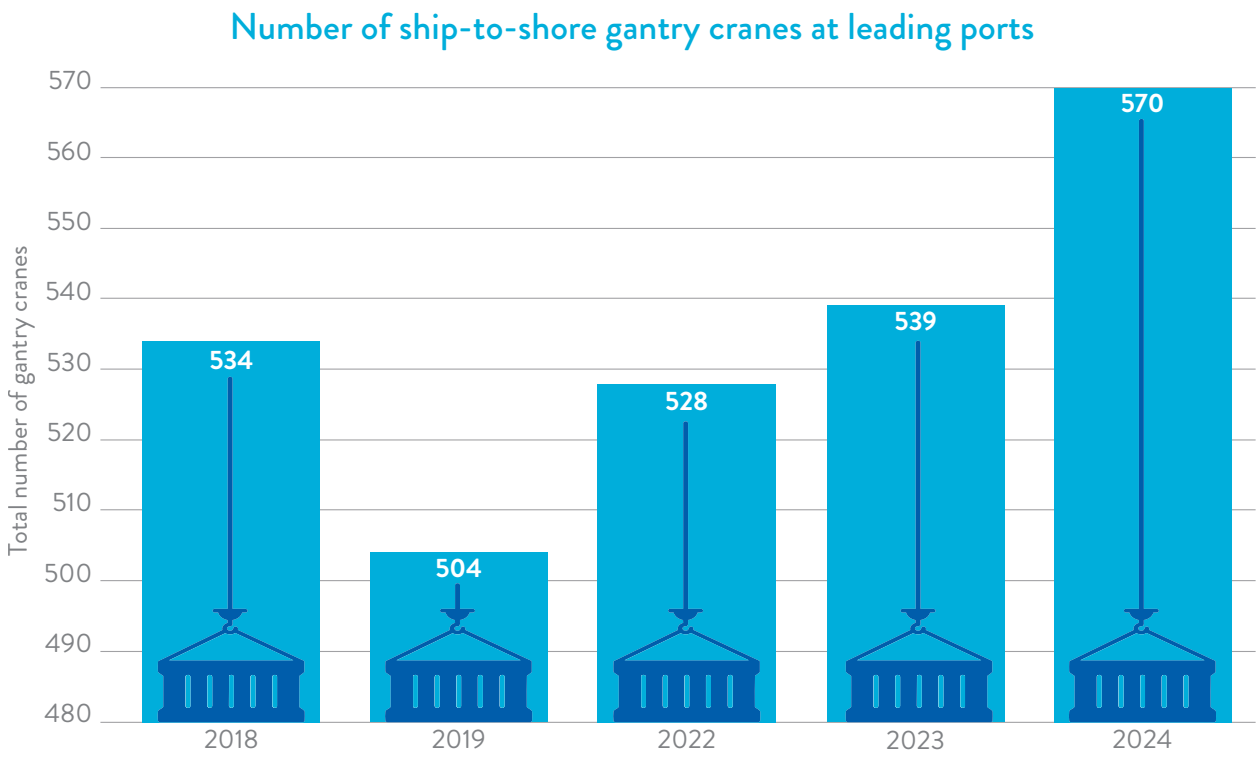
Source: Maritime Administration analysis of data from S&P Global PIERS

Although TEU throughput often fluctuates across the various seasons, ports sometimes need to accommodate unexpected shipments in the event of disruptions. For example, the collapse of the Francis Scott Key Bridge that temporarily closed the Port of Baltimore in March 2024 caused vessels bound for Baltimore to reroute to other East Coast ports.

Port investment decisions are driven by the need to accommodate ever-larger vessels, upgrade aging facilities, and decarbonize their infrastructure. Some ports, such as PhilaPort in Philadelphia and Honolulu Harbor in Hawaii, have piers dating back to the early 20th century. These aging assets and limited water frontage can affect the ability of ports to construct suitable modern facilities. In addition, channel depth determines the size of vessels that can call at a port. Ports throughout the country have been engaged with federal and non-federal projects to deepen channels and widen harbors to safely accommodate large ships and compete with one another.

Ship-to-shore (STS) gantry cranes serve a vital role in moving containers. The number and size of STS cranes at a port affect the number and size of vessels that a terminal can service. The top 25 container ports operated 570 STS cranes in 2024, up from 539 STS cranes in 2023.[9] Of these STS cranes, 248 are classified as super post-Panamax, which are the most capable because they are large enough to load and unload super post-Panamax ships, the latest and largest container ships. Several port facilities plan to purchase cranes at new and existing container terminals.

Photo: Port of Seattle



Source: Bureau of Transportation Statistics

The ease with which a port can facilitate the movement of goods depends largely on its ability to connect with other modes of transportation. Nearly all major ports have National Highway System connectors and on-dock or nearby intermodal container transfer facility (ICTF) rail connections.[10] Of the top 25 container ports, 18 have on-dock rail, and all have nearby rail transfer facilities.[11] On-dock rail eliminates the need for drayage trucks to ferry shipping containers to and from the marine terminal and ICTFs, reducing port congestion and emissions and improving efficiency.[12]

FUNDING AND FUTURE NEED

Federal, state, local, and private sector funding support port infrastructure. Waterside infrastructure needs, such as maintenance dredging, are paid for through the federal Harbor Maintenance Trust Fund (HMTF). The HMTF collects revenue through a 0.125% user fee on the value of the cargo shipped. Although intended specifically for maintenance dredging, the fund has also been used for other port infrastructure purposes. The Water Resources Development Act (WRDA) of 2020 included full utilization of the $10 billion balance of the HMTF by allowing $500 million to be appropriated in Fiscal Year 2021, with an increase of $100 million annually until 2030.[13]

Recent federal legislation has included provisions to improve ports and their equipment. In 2021, the Infrastructure Investment and Jobs Act (IIJA) invested $17 billion in ports and inland waterways, supporting programs such as the Maritime Administration's (MARAD) Port Infrastructure Development Program (PIDP) and the Federal Highway Administration's (FHWA) Reduction of Truck Emissions at Port Facilities Program. The IIJA provided $450 million annually over five years for the PIDP. Prior to 2021, the program averaged $245 million annually.[14] In addition to the PIDP, MARAD administers programs for marine highways and small shipyards. **Since the IIJA's enactment, the Department of Transportation (DOT), the U.S. Army Corps of Engineers (USACE), and the Environmental Protection Agency (EPA) have announced more**

than 1,060 port and waterways projects.[15] The EPA's Clean Ports Program, which funds zero-emission port equipment and technology, was provided $3 billion through the Inflation Reduction Act in 2022.[16] In the fall of 2024, the EPA awarded $3 billion through the Clean Ports Program, while MARAD awarded $580 million through the PIDP.

ASCE's *Bridging the Gap* report indicates water transportation needs from 2024 to 2033 are about $45 billion, of which nearly $38 billion is specific to ports.[17] According to a survey conducted by the American Association of Port Authorities, public port authorities and their private tenants have about $163 billion in capital investments planned through 2025.[18] Ports have planned a variety of landside and waterside infrastructure improvements, and port property tenants have planned their own investments in terminal facilities, warehousing, and security. However, infrastructure owners need better data to inform long-term investment decisions for inland and river ports.[19]

Another anticipated need at ports is radiation portal monitors, which scan incoming containers for radioactive materials. The SAFE Port Act of 2006 required all containerized cargo entering the U.S. to be screened for radiation, and the monitors have been fixtures at container ports since. However, nationwide, those scanners are reaching the end of their useful lives, and ports must install upgraded equipment.

OPERATION AND MAINTENANCE

U.S. port governance is unique because there is no national port authority.[20] Rather, authority is dispersed through federal, state, and local levels of government. Some ports are privately owned and operated, whereas government authorities manage others. Port authorities are government entities that either own or administer the land, facilities, and adjacent bodies of water where cargo is transferred between modes. Port authorities manage the infrastructure within ports, including docks, terminals, and storage facilities. At the federal level, the USACE is responsible for deepening and maintaining federal shipping channels to keep them safe and navigable.

In addition to traditional maritime infrastructure, such as piers and channels, ports must maintain the network of systems connected to their facilities. For example, in addition to focusing on projects such as harbor deepening and wharf repairs, the Port of Long Beach maintains a diverse investment portfolio that includes sewer and stormwater maintenance as well as rail infrastructure.

Photo: Georgia Ports Authority

Asset management is fundamental to effectively operate and maintain all infrastructure, including ports. Some ports have assessed vulnerabilities and risks to their infrastructure. For example, Port Tampa Bay is conducting a vulnerability analysis, which evaluates the port's critical assets, the vulnerability of those assets, and preliminary adaptation strategies to enhance the port's resilience. Initial findings of the analysis have led the port to pursue adaptation projects aimed at reducing flooding and constructing a redundant underground electrical feeder. Although Port Tampa Bay lost power for two days after Hurricane Milton made landfall on October 9, 2024, the facility did not experience widespread flooding and the docks were not significantly damaged. The port reopened channels and resumed vessel operations October 12.[21]

Challenges in finding qualified workers—and the need to train workers on operating and maintaining modernized cargo handling equipment—are an element of ports' operational needs. The Ports of Los Angeles and Long Beach have partnered to construct the Goods Movement Training Campus, which will provide a centralized facility to attract and retain dockworkers, truck drivers, warehouse employees, and other logistics workers. The Steamship Trade Association of Baltimore purchased a crane simulator to expedite training programs for workers without slowing cargo movement.

Challenges in finding qualified workers—and the need to train workers on operating and maintaining modernized cargo handling equipment—are an element of ports' operational needs.

PUBLIC SAFETY AND RESILIENCE

Prompted by environmental concerns and regulatory pressures, ports have demonstrated efforts to address the effects of climate change. Sea level rise along the U.S. coastline is projected to increase between 10 and 12 inches in the next 30 years.[22] Rising sea levels can damage port infrastructure and disrupt commerce, leading ports to consider solutions such as raising structures and electrical equipment and building protective barriers. The Hawaii Department of Transportation manages the state's harbors and conducts light detection and ranging (LiDAR) scans to see which piers would be susceptible to overtopping.

While coastal ports grapple with rising sea levels, inland ports have faced challenges with low water levels, hampering freight movement along the Mississippi and Ohio Rivers. In 2022, the Mississippi River carried 57% of the 164.1 million tons that moved between the states on the Upper Mississippi System and Louisiana.[23] Because of low water levels, the movement of river-borne freight was affected, because barges had to carry less cargo to reduce their drafts and barge tows needed to be reduced in number and length. At points in 2022 and 2023, parts of the waterway system were unnavigable by barges, delaying the movement of goods.[24]

Air draft, the vertical clearance between the water's surface and a restriction such as a bridge, can bar vessels from entering a port. In recent years, ports have constructed new bridges (such as the Long Beach International Gateway Bridge in California, completed in 2020) or elevated existing bridges (such as the Bayonne Bridge near the Port of New York and New Jersey, completed in 2019) to alleviate this restriction.[25] At the federal level, the National Oceanic and Atmospheric Administration (NOAA) maintains the Physical Oceanographic Real-Time System (PORTS), which provides data to vessel agents and ship pilots to help ensure vessels can safely transit under bridges. This system has been installed in 38 ports, and four more have been approved over the next two years.[26]

Ports are critical in the aftermath of disasters because they facilitate the delivery of supplies. Integrating ports into a holistic disaster recovery plan—developed with all stakeholders and based on shared data—is vital to helping a community recover quickly. Moreover, in the event of major disruptions, such as the Francis Scott Key Bridge collapse, adaptation plans should be implemented so logistics and commerce can continue.

INNOVATION

Many recent examples of port innovation stem from efforts to cut emissions. The maritime sector requires vast amounts of energy for vessel propulsion, ground transport, cargo handling equipment, and electricity generation. Some ports have embraced innovation, such as the electrification of equipment, to comply with air quality mandates and reduce emissions. The Ports of Los Angeles and Long Beach use shore power, which allows vessels to connect to the electrical grid while berthed instead of relying on their engines for power. Shutting down their engines reduces air pollution, improving air quality in the port area and surrounding communities.

Photo: Electric cranes at the Port of San Diego; Port of San Diego.

Wind is another potential power source. In May 2023, the Port of Long Beach released plans for Pier Wind, a facility that would support the assembly of floating offshore wind turbines.[27] Once assembled, the turbines would be towed by sea to wind farms off the coasts of Central and Northern California, where they would generate power for the grid. Ports on the East Coast are building facilities to support the offshore wind business in the Northeast and mid-Atlantic regions.

As the maritime industry considers options other than traditional fossil fuels, alternative fuels for oceangoing vessels are under development. Ports provide the infrastructure for fueling and bunkering operations, meaning they can play a crucial role in adopting cleaner fuels. Hydrogen, green methanol, ammonia, renewable natural gas (RNG), and liquefied natural gas (LNG) have the potential to decarbonize the maritime sector.

The Ports of Los Angeles and Long Beach use shore power, which allows vessels to connect to the electrical grid while berthed instead of relying on their engines for power. Shutting down their engines reduces air pollution, improving air quality in the port area and surrounding communities.

Photo: Ship bunkering at Jacksonville, Fla.; Jacksonville Port Authority

Brought on by pandemic-induced consumer demand, the number of container ships waiting to enter U.S. ports has surged.[28] To address this backlog, the Ports of Los Angeles and Long Beach participated in an innovative vessel queuing system to improve the efficiency of cargo movement, reduce congestion, and minimize negative air quality impacts.

The beneficial reuse of dredged material has been another area of innovation. Dredged material can be used to create or restore habitats, and ports often realize cost savings associated with not hauling sediment long distances. Various projects ranging from Green Bay, WI, and Oakland Harbor to wildlife refuges in Louisiana have made use of dredged material.

Automation is an emerging factor in the ports sector as well. Although it is expensive and has drawn concern from labor representatives, automation can increase efficiency and physically transport freight.[29]

RECOMMENDATIONS TO RAISE THE GRADE

- Sustain federal and state funding for ports to address outdated infrastructure and the maintenance backlog and invest in alternative energy options.
- Encourage innovation and adopt new technologies to reduce wait times, improve efficiency, increase resilience and security, and reduce negative environmental impacts.
- Improve freight and landside connections, such as through on-dock rail and rail transfer facilities, to boost the efficiency of freight movement and reduce congestion.
- Include ports in comprehensive disaster planning and establish redundancies so commercial operations can proceed in the wake of a disaster or failure.
- Encourage port owners and operators to use asset management to best allocate available funding and identify critical repairs. In addition, by establishing data collection systems, ports can better assess asset conditions and infrastructure needs.
- Ensure ports of varying sizes can compete in both existing and new competitive grant programs.
- Spend down the balance of the Harbor Maintenance Trust Fund on maintenance dredging needs while supporting approved port investments.

DEFINITIONS:

Twenty-foot equivalent units: The most prevalent container transported in the maritime sector is 40 feet long. However, the capacity of container ships is measured in twenty-foot equivalent units (TEUs), which are equal to 8 feet wide, 8.5 or 9.5 feet high, and 20 feet long.

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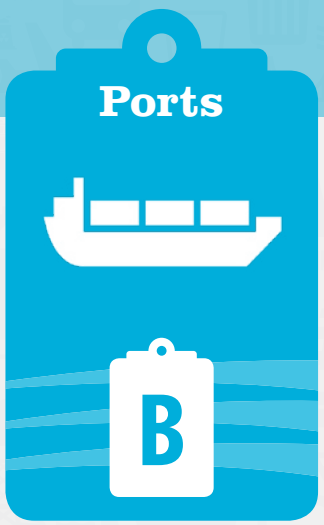

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Public Parks

C-

GRADE COMPARISON

2025: C-

2021: D+

Photo: Acadia National Park; Forest Putnam

PUBLIC PARKS

EXECUTIVE SUMMARY

Parks, forests, and other public spaces in America improve the mental and physical health of those who visit, create jobs, and support the overall well-being of communities. Parks promote higher property values, sometimes increasing real estate prices by 8%–10% for nearby homes,[1] help improve drinking water sources, moderate heat islands, and make significant contributions to stormwater management. Although park systems have recently received significant investment from the federal government, deferred maintenance has continued to rise. Meanwhile, parks continue to face challenges posed by workforce shortages as they simultaneously experience record visitation numbers.

Recently, the federal government has prioritized investments in public lands through the American Rescue Plan Act (ARPA), the Infrastructure Investment and Jobs Act (IIJA), and the Great American Outdoors Act (GAOA). These investments are expanding access, updating aged systems, and growing park inventory. Advances in technology have improved asset management and allowed park authorities to better consider overall life-cycle cost estimates for park assets.

BACKGROUND

Our nation's parks are owned and operated by a variety of government entities ranging from federal agencies like the National Park Service (NPS) and the U.S. Army Corps of Engineers (USACE), to states, regional authorities, counties, cities, and townships. These parks are vital for the economic prosperity of communities across the country. As national park tourism continues to grow, so do the economic outputs. In 2023, 325 million visitors to national parks spent an estimated $26.4 billion in local gateway regions, supporting 415,000 jobs, and generating $55.6 billion in gross output to the economy.[2] In the prior year, visitors spent an estimated $23.9 billion in gateway regions, supporting 378,000 jobs and generating $50.3 billion in total economic output.[3]

National Park Service Yearly Visitation

Year	Amount Spent	Jobs Supported	Gross Economic Output
2023	$26.4 B	415,000	$55.6 B
2022	$23.9 B	378,000	$50.3 B

Recreational sites in the USACE portfolio continue to grow, with visitors spending $13.6 billion in regions near USACE-managed lands/waterways in 2023, an increase from $11 billion in 2019.[4] The most significant economic impact comes from local public parks and recreation

agencies, which generated more than $201 billion in economic activity and supported almost 1.1 million jobs in 2021, compared to $166 billion in economic activity in 2017.[5] Outdoor recreation accounts for 2.2% of the overall U.S. gross domestic product (GDP), more significant than vehicle manufacturing or air transportation. In comparison, only 0.2% of the federal budget is allocated to outdoor recreation; to match outdoor recreation's contribution to GDP, federal spending would have to increase 13.5 times.[6]

CAPACITY AND CONDITION

Since more state and national parks have been established to accommodate increased visitation, overall capacity has remained relatively level. However, increased visitation has added additional stress to park infrastructure such as roads, bridges, and buildings. On average, park and recreation agencies across the country provide one park for every 2,386 residents, with 10.6 acres of parkland per 1,000 residents.[7] Park acreage per resident varies tremendously. For instance, among the 15 cities with the most parkland per 1,000 residents (including federal, state, county, metro, and city parks), Anchorage, AK, leads with more than 3,000 acres, followed by Chesapeake, VA, with 230 acres, and Nashville, TN, in 15th place with 35 acres.[8]

The NPS currently manages 429 recreation areas, including parks, national forests, national monuments, and national wildlife preservation areas, as well as over 75,000 constructed assets ranging from visitor centers and utility systems to roads, bridges, and trails. Altogether, these recreation areas cover over 85 million acres, about the area of California,[9] and welcomed 325 million visitors in 2023.[10] In 2020, visitation declined dramatically to 237 million due to the COVID-19 pandemic but has steadily increased since then. While visitation to national parks declined during 2020, local parks saw large increases in visitation. A recent Federal Lands Transportation Program report lists 57% of paved roads in national parks in good condition, 30% in fair condition, and 13% as poor. The same report listed 66% of bridges in fair condition, 31% in good condition, and 3% in poor condition.[11] In comparison, 39% of major roads in the U.S. are listed as in poor condition, and 49% of bridges are in fair condition.[12]

Federally operated parks range from the 13-million-acre Wrangell-St. Elias National Park and Preserve in Alaska to the 0.02-acre Thaddeus Kosciuszko National Memorial in Pennsylvania. Altogether, facilities maintained by the NPS include over 5,500 miles of paved roads, 17,000 miles of trails, and 25,000 buildings. Despite the vast total national parkland acreage, the most popular national parks have had to limit visitation due to visitor demand outpacing resources.[13] Prominent and famous national parks are seeing record numbers of visitors, while lesser-known parks have experienced decreased visitation. This discrepancy leads to increased stress on resources that could be mitigated by encouraging exploration of lesser-known destinations.

Top 15 cities with most parkland per 1,000 residents

CITY	ACRES PER 1,000
Anchorage, AK	3,022
Chesapeake, VA	229
Scottsdale, AZ	128
Fremont, CA	93
Jacksonville, FL	85.6
Honolulu, HI	65
New Orleans, LA	64
North Las Vegas, NV	59
Virginia Beach, VA	56
Santa Clarita, CA	48
El Paso, TX	43
Albuquerque, NM	38
Kansas City, MO	36
Oklahoma City, OK	36
Nashville, TN	35

Source: Trust for Public Lands, 2024 Acreage and Park System Highlights

The USACE trails the NPS in total annual visitors, receiving 268 million visits in 2023.[14] The 4,746 USACE-operated recreational areas cover 4 million acres of land and an additional 5 million acres of water, with 41,000 miles of shoreline and almost 8,000 miles of trails. Over 90% of USACE recreation areas are within 50 miles of a major metropolitan center.[15]

State parks received 867 million visitors in 2023, an increase of approximately 60 million from 2017.[16] The number of state parks has increased by 15%, or just over 1,300 parks, since 2021; totaling 9,817 state-operated parks in 2023 covering over 20 million acres of land.[17] A survey conducted by the National Association of State Park Directors (NASPD) reported the condition of state park roads as 4.8 out of 10 and water infrastructure as 5 out of 10.[18] The rating has been consistent since the last survey in 2021. The same survey found that over half of state park directors believe park facilities are unable to accommodate the significant increase in visitation in recent years. With increased park visitation, park facilities have experienced additional use, which has led to a faster decline in quality. State parks also struggle to contend with challenges introduced by extreme weather, which require workers to spend more time responding to these events than keeping up with routine maintenance.

At the local level, park accessibility varies significantly. Data from the Trust for Public Land (TPL) indicates that 100 million people, including 28 million children, do not have easy walking access to parks.[19, 20] Local parks serving primarily low-income households are, on average, four times smaller than parks that serve higher-income households.[21] Among the 100 most populated cities in the U.S., the percentage of the population able to access a park within a 10-minute walk ranges from almost 100% to just 25%, with the median rate for all cities and towns in the U.S. being 55%.[22]

Photo: Yellowstone National Park; Gina Beim

FUNDING AND FUTURE NEED

Federal programs targeted toward public parks in addition to the standard NPS budget have attempted to keep pace with overall needs, yet deferred maintenance continues to increase and funding from certain government programs will expire in the coming years. The NPS was funded at $3.32 billion in Fiscal Year 2024, a 4% cut compared to FY23 appropriations. In addition to this discretionary budget, the NPS mandatory appropriations for FY24 is estimated to be $1.2 billion, a 2% decrease from FY23.[23]

Road and bridge improvements within the NPS are partially supported through funding from the U.S. Department of Transportation and fees from sources such as fossil fuel mining rights. Annual appropriations, combined with grant funding, form the majority of funds for repair, rehabilitation, operations, and maintenance.

The 2021 IIJA increased funding for the NPS under the Federal Lands Transportation Program by 22% to over $1.73 billion over 5 years, expiring in 2026. These funds are used to repair and upgrade transportation infrastructure. The IIJA also made billions of dollars in discretionary and formula grant programs available to be used for resiliency projects, bridge replacements, and wildlife crossings, in addition to other projects.

The 2020 GAOA significantly changed how funding is handled for conservation and provides complete and permanent funding to the Land and Water Conservation Fund (LWCF) of $900 million annually.[24] Established by Congress in 1964 to protect natural areas, water, and cultural heritage, the LWCF is fully funded by earnings from offshore oil and gas leasing. These funds supply grants for states and local communities and assist the federal government in acquiring lands and waters to extend and provide access to national parks.[25] In 2023 the NPS received $461 million from the LWCF for land acquisition.[26] LWCF state grants are now being used to extend public access to parks and establish parks in underserved communities.

To address deferred maintenance in national parks, the GAOA created a National Parks and Public Land Legacy Restoration Fund to direct up to $9.5 billion over the 5-year lifespan of the law. This funding comes from unobligated federal mineral revenues, such as royalties from onshore and offshore oil, gas, and renewable energy development on public lands. Owing to the size of the NPS network, the cost of deferred maintenance in national parks has steadily increased in recent years to $23.3 billion at the end of FY23,[27] up from $15.3 billion in 2020 (adjusted to 2023 dollars). The increase is primarily because the NPS incorporated the cost associated with best practices design and construction management into their estimation to provide a more accurate sense of the total backlog.[28] This update will better track total life-cycle costs, leading to a more efficient use of resources.

Federal programs targeted toward public parks in addition to the standard NPS budget have attempted to keep pace with overall needs, yet deferred maintenance continues to increase and funding from certain government programs will expire in the coming years.

States have implemented innovative funding mechanisms for their parks. Some states have dedicated funding sources for recreation by using a portion of lottery proceeds, redirecting sales taxes on sporting goods, or dipping into real estate tax revenues. These funding tools have had varying levels of success. Revenues from federal excise taxes on shooting, hunting, fishing, and boating equipment provided almost $1.4 billion dollars to state parks in 2024.[29,30] Despite these funding mechanisms, state park deferred maintenance has increased since 2021 when state park directors reported a nationwide total deferred maintenance amount of $6.5 billion (in 2024 dollars), which increased to a total of $15.9 billion in 2024, or an average of $354 million per state.[31]

City parks have seen increased levels of investment over the past three years. In 2022, the 100 most populous cities directed $9.7 billion to their parks. In 2023, the same cities invested $11.2 billion after adjusting for inflation.[32] The Trust for Public Land notes that about 90% of spending on city parks comes from local governments. These funding increases help to meet a deferred maintenance backlog for municipal parks estimated in 2022 to total $65 billion nationwide.[33] It should be noted that data regarding city park maintenance backlogs are extremely limited, and the figure above only represents the top 100 most populous cities.

ARPA has been a critical funding source for city and county parks. States, cities, and counties across the country have used funding from ARPA to improve access to local parks. The largest disbursement of funds for public space improvements went to the City of Los Angeles, which received $59 million in funding to renovate and improve parks, green spaces, and recreational facilities servicing low-income neighborhoods.[34] Funds from the U.S. Department of Transportation's Rebuilding American Infrastructure with Sustainability and Equity (RAISE) program, have also improved state and local parks. Cleveland Metroparks was recently awarded $19.5 million from the RAISE program to extend trail systems, creating connectivity and access for residents.

OPERATION AND MAINTENANCE

National, state, regional, and municipal parks currently deal with significant workforce challenges that affect the ability of parks to maintain and improve conditions. Many states have increased staffing over the last 5–10 years, but staffing has been unable to keep pace with increased visitation rates and compensation remains relatively low, leading to high attrition rates.[35] National parks are facing a similar challenge, with the park service having to cut 16% of their full-time staff due to budget constraints.[36] The 2022 Inflation Reduction Act (IRA) allocated $500 million to the NPS in an effort to alleviate some of those budget constraints, yet hiring remains slow. As of May 2024, the NPS has dedicated about $21 million toward hiring, meaning the majority of the available funding, which is set to expire in 2030, might not get used at the current pace. To assist with attrition concerns, the NPS has created the Facilities Workforce Career Academy (FWCA) to provide skills-based training to current and prospective NPS employees. This program helps the NPS meet a need for skilled workers and provides career growth opportunities to current NPS employees.

The two accounts within the NPS budget that address regular and deferred maintenance have seen a 17% increase in inflation-adjusted dollars between 2013 and 2023.[37] About 84% of 2023 NPS spending went to the Operation of National Park Systems (ONPS) account to support day-to-day activities, programs, and services.[38] The next largest account, construction, received 7% of available funding for repair, replacement, and improvement of existing facilities, as well as new construction.

The NPS also engages in partnerships with outside organizations, who assume some asset maintenance responsibilities. The NPS also leases assets to other parties, and in exchange, the lessee rehabilitates or maintains the asset. Many NPS units engage volunteer groups to perform maintenance duties; if the NPS could increase its volunteers to 600,000 by 2028, it would result in 40 million hours of volunteer labor valued at $802.6 million over 10 years.

Photo: Grand Teton National Park; Gina Beim

Like national parks, state and local parks also rely on volunteers ("friends of," "conservancy for") organizations to supplement maintenance tasks such as the removal of invasive species. Regional park agencies ("Metroparks") and municipalities tend to maintain the state department of transportation-rated roads and bridges within their properties, in addition to smaller nonrated bridges. They do not inspect buildings, pavement, dams, storm sewers, and other infrastructure assets. On average, state park and recreation agencies dedicate 46% of their operating budget to park management and maintenance.[39]

Photo: Zion National Park; Karen Donohue

PUBLIC SAFETY AND RESILIENCE

In addition to being beneficial for public mental and physical health, parks are a vital tool for a community's resilience. Parks are being used to manage stormwater overflow during extreme weather events and are protecting communities from dangerous flooding. Efforts are being made in some flood-prone areas to return the landscape to its original state and thereby act as a buffer between bodies of water and communities. Parks in this way contribute to the sustainability of communities and mitigate the effects of climate change.

State park directors continue to note concerns over the impact of xtreme weather on park systems. Increased coastal flooding, algae blooms, and invasive species are affecting park access and conditions.

Eighty-four percent of U.S. adults support their local parks and recreation agencies undertaking or continuing projects on environmental provisions or natural disaster prevention.[42] Green and open spaces, including floodplains, floodways, and estuaries, are now embraced as part of a total parks program.

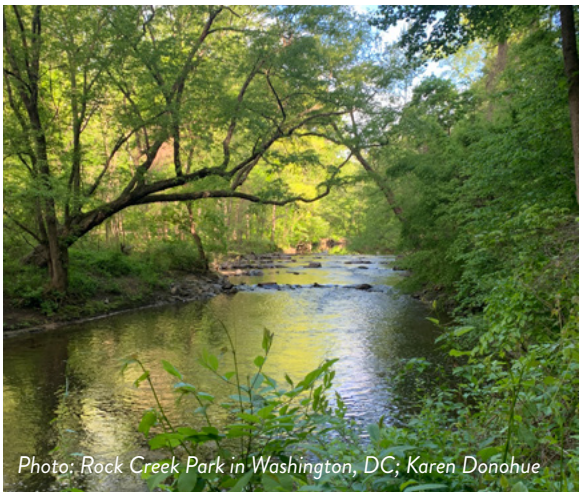


Photo: Rock Creek Park in Washington, DC; Karen Donohue

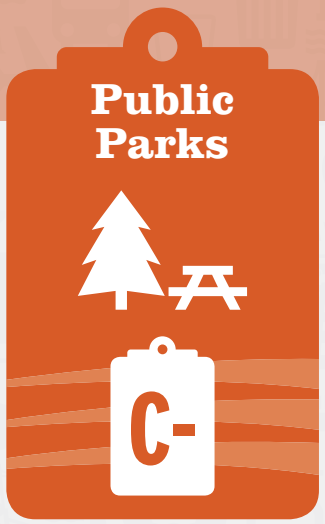
The East Side Coastal Resiliency Project in New York City aims to enhance parks while creating a 2.4-mile-long flexible flood barrier. This $1.5 billion project will provide flood protection and improve open spaces for more than 120,000 New Yorkers.[40] The ResilienCity Park Project in Hoboken, NJ, which was partially funded by the IIJA, is another project designed to serve its community, by transforming a former industrial site into a public park. The park will include a multipurpose athletic field, a basketball court, and other public spaces that double as a stormwater detention basin. Below ground stormwater infrastructure will also be added to allow the park to detain up to 2 million gallons of stormwater that would otherwise flood city streets.[41]

Photo: New York City; Carl Newton

When considering safety in public parks, adequate lighting is routinely cited by community members as critical. However, park services must weigh the impacts of increased illumination on local ecosystems with community needs. Los Angeles has instituted a program called Summer Night Lights (SNL), which adds lighting, keeps parks open later, and brings in community social workers to prevent gang-related violence. At the eight parks where SNL was introduced in 2008, gang violence had reportedly dropped to its lowest level since 1967.[44] In addition to increased lighting, parks are using more security cameras to enhance safety. Security cameras are increasingly viable as manufacturing costs have dropped and many are now solar powered.

INNOVATION

Parks are increasingly used for multiple functions. State and local parks are partnering with other agencies, nonprofit organizations, and private entities to find innovative ways to make green spaces accessible and desirable to every community member. The National Recreation and Parks Association has identified five state park systems in Colorado, Michigan, Minnesota, South Dakota, and Georgia, and one national park, Sleeping Bear Dunes National Lakeshore in Michigan, that have programs to loan off-road, tracked, powered wheelchairs to persons with disabilities.Some state parks are working with geographic information system (GIS) mapping technology to efficiently track all projects underway within the park system, including park, facility, and infrastructure needs. The GIS databases assist with asset management, task and revenue tracking, and provide information for data-driven decision-making on future development and infrastructure repairs based on metrics like return on investment and infrastructure condition. GIS also allows park management agencies to map park trails quickly and efficiently. The Ohio Department of Natural Resources highlighted this using GIS to accurately map its 5,000 miles of hiking trails across 75 state parks.[45] The National Recreation and Parks Association has noted increased use of GIS in combination with the creation of digital twin maps, three-dimensional models, used to accurately represent the physical environment.



RECOMMENDATIONS TO RAISE THE GRADE

- Maintain recent federal funding included in the GAOA and IIJA and enhance federal programs in the National Park Service to better match increasing visitation, growing number of parks and park land, and increasing deferred maintenance costs.
- Identify and secure new avenues of funding available to state parks and local governments, allowing agencies to be more competitive for skilled/experienced employees in the job market.
- Enact federal legislation to permit federal agencies, including the U.S. Army Corps of Engineers, to retain user fees in the park system for use at parks and recreation facilities.
- Encourage the use of GIS and other technologies to assist with asset management and enhance park user experience.
- Increase funding at all levels of government for park projects that enhance resilience, reduce stormwater pollution, and protect drinking water sources.
- Encourage local, state, and federal parks to partner with other government agencies and outside entities to assist with asset maintenance and maximize park uses and benefits for local communities.
- Increase park accessibility for all ages, abilities, and income levels, including a focus on walkability and transit access to parks.
- Promote public awareness of lesser visited national parks to alleviate stress on the most popular parks, while also encouraging visits to state and local facilities.

Photo: Yosemite National Park; Karen Donohue

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Photo: Brightline; Eric Czerniejewski

RAIL

EXECUTIVE SUMMARY

The U.S. rail network consists of approximately 140,000 miles of track and serves freight and passenger services. Freight rail supports the movement of 1.5 billion tons of goods annually.[1] Amtrak reported 28.6 million passengers in 2023, up from 22 million in 2022. Ridership on the Northeast Corridor shows fast growth, with passenger services on the national network increasing in frequency, speed, and scope.[2] The Infrastructure Investment and Jobs Act (IIJA) authorized $66 billion for rail projects from Fiscal Year 2022 to 2026, making vital improvements such as intercity passenger rail service expansion, Amtrak corridor development, and road–rail crossing grade separation possible.[3] Train safety incidents show a promising long-term trend, down 23% in the 23 years from 2000 to 2023, but recent incidents like 2023's derailment in East Palestine, Ohio, raise concerns and is just one of 10,577 incidents that year.[4,5] Recent programs and actions implemented by the U.S. Department of Transportation (DOT) can improve the rail network, which calls for a balance between modern advancements in the sector, such as precision-scheduled railroading, and sufficient staffing to ensure public safety.

BACKGROUND

Rail transportation was first conceived in the early 19th century as more efficient and expedient than water navigation to move people and goods. The network expanded throughout the century, going from only a few miles between end points to the initial transcontinental rail line in mid-century and several other lines spanning the national footprint by 1900. Rail experienced considerable growth in the early 20th century, followed by a downturn in the 1970s.

The 21st century represents a renaissance in the rail industry with the use of new technologies and the reemergence of passenger rail transportation. Although rail infrastructure continues to experience its share of challenges, it remains reliable, safe, and fuel efficient.[6]

CAPACITY AND CONDITION

Freight rail companies own and maintain their own infrastructure, while U.S. passenger rail consists of Amtrak and commuter rail systems that transport riders from suburban communities to dense urban centers.

Freight Rail

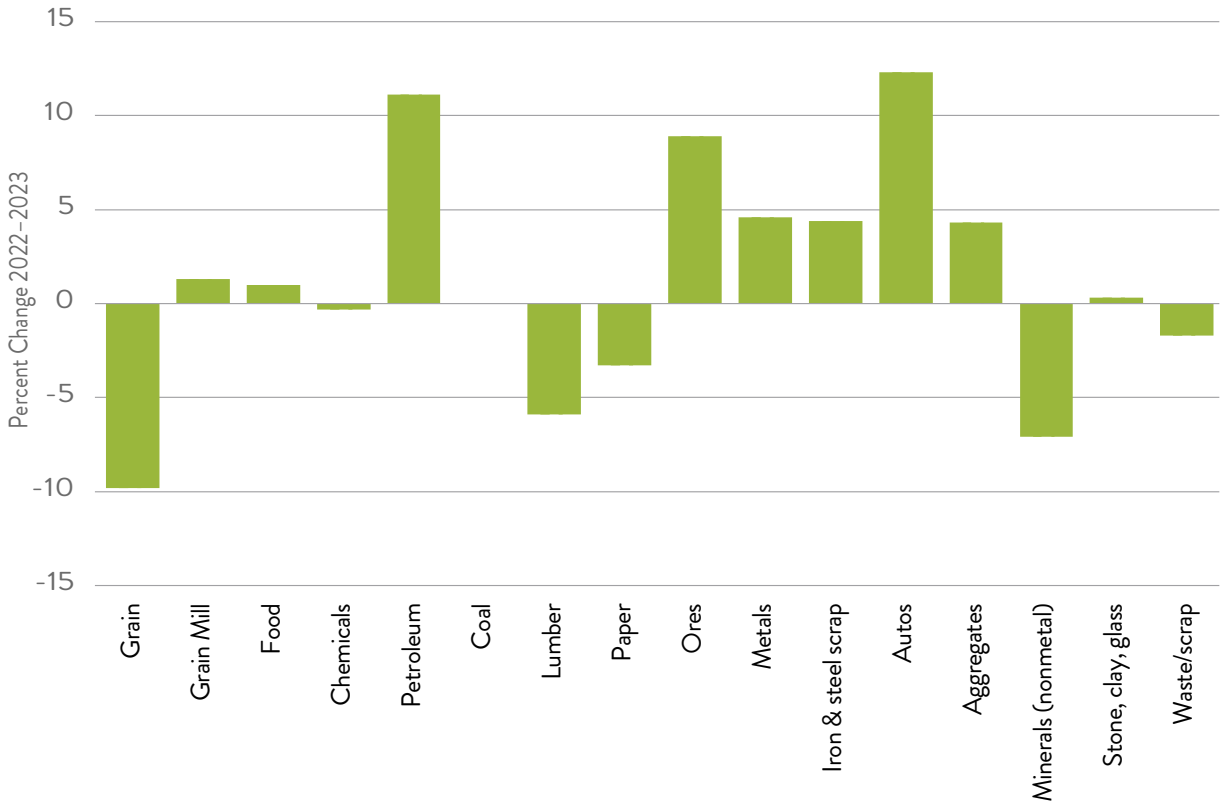
Freight rail moves 1.5 billion tons of goods, a figure that has been increasing over the last two decades. **In 2022, the average train car hauled 4,089 tons compared to 2,923 tons in 2000.** Freight rail transports agricultural products, chemicals, coal, crude oil, intermodal goods, and motor vehicles, among other essential items.[7]

Hundreds of private rail companies own and maintain the national freight network and are classified based on annual revenue. There are six large Class I railroads and 615 total Class II and Class III short line railroads in the U.S.[8] Together, these companies serve 49 states and Washington, DC.

Type	Definition as of 2023 (revenue numbers updated annually by STB and reflect inflation)	Mileage	Number of Systems
Class I	Revenue of at least $1 billion	Approximately 92,000 miles (accounts for 67% of freight rail mileage)[9]	6
Class II	Revenue of at least $47.3 million	47,500 route miles of Class II/Class III[10]	615[11]
Class III	Revenue less than $47.3 million[12]		

Freight rail traffic decreased during the early days of the COVID-19 pandemic but rebounded sharply in the months and years after. Although supply chain choke points existed, rail infrastructure performed adequately during this era of increased traffic.[13] Between 2022 and 2023, rail traffic increased slightly by 0.7% or 81,504 carloads. For October 2024, freight rail volume managed a 3.5% increase year-over-year. Though uncertainty exists, capacity on the freight rail network is currently sufficient.[14,15]

Carloads by Commodity, 2023



Source: American Association of Railroads Policy and Economics Departments (via Progressive Railroading, February 2024)

Carload Traffic for 2023

Traffic	Units	vs 2022 (%)
Total Carloads	11,701,875	0.7
Total Intermodal Units	12,667,354	-4.9
Total Traffic	24,369,229	-2.3

Source: Association of American Railroads, Week 52, 2023—Ending December 30, 2023

Railroads do not provide aggregated information on the condition of their infrastructure or ongoing maintenance priorities. Weight restrictions can be a proxy metric for rail infrastructure, as they can indicate the structural integrity of railroad tracks and the overall state of repair. Most railcars weigh up to 280,000 pounds, whereas heavy-axle freight cars weigh as much as 315,500 pounds.[16] Four of the largest freight rail networks in the U.S. indicate that most company rail lines support 286,000 pounds for 4-axle cars from 39 ft and longer.[17]

Class II and III railroads provide connections or serve as feeder lines to the larger Class I railroads. They might serve specific markets or regions, are often vital to transferring goods between modes, and serve as a "last mile" connection. Many of the Class II and III railroads in the U.S. have inherited track in need of maintenance and upgrades that were deferred by legacy owners. According to the American Short Line and Regional Railroad Association, **it is estimated that of the 86,000 miles of track and 31,000 bridges in operation, only 41,500 track miles (48%) and 17,000 bridges (53%) can sustain 286,000 lb. rail car traffic—the current industry standard across Class I operators.**[18]

Today, short line railroads invest at least 25% of their annual revenue in upgrading their track and other infrastructure, but challenges remain. For instance, Class II and III railroads are more dependent on individual industries or commodities than Class I railroads. A key example is coal. As coal demand has diminished, short line rails have sought alternative cargo to replace it.[19]

Passenger Rail

Passenger rail in the U.S. consists of Amtrak and commuter rail systems for passengers who rely on heavy rail to get from suburbs to major city centers. In Fiscal Year 2023, Amtrak reported more than 28.6 million riders—an increase of 25% from FY22 (22.9 million).[20]

Amtrak service can be divided into three categories:

- **The Northeast Corridor (NEC):** As the passenger rail corridor between Boston and Washington, D.C., the NEC is the only passenger rail corridor owned by Amtrak; other routes operate almost exclusively on privately owned freight railroad tracks. Before the pandemic, 39% of all Amtrak trips were on the NEC.
- **State-supported routes**: Routes under 750 miles that receive financial assistance from the state(s) where they are located; 47% of all Amtrak trips before the pandemic.
- **Long-distance routes**: Segments of track over 750 miles; 14% of all Amtrak trips before the pandemic.[21,22]

Service expansion and projects are underway as Amtrak looks to double ridership to 66 million by 2040. Capital improvements will support additional service stops, upgrade lines for improved rail performance, and update facilities. Projects include the Gateway Program, which will address ongoing congestion along a 10-mile stretch of Amtrak rail between New York and New Jersey, and the Chicago Hub Improvement Program (CHIP), which will implement key infrastructure improvements in this critical access point for long-distance travel.[23] The new Fredrick Douglass Tunnel Program will also address the NEC's biggest bottleneck, replacing the 1.4-mile Baltimore and Potomac Tunnel, which experiences persistent age-related issues.[24]

FUNDING AND FUTURE NEED

Freight rail companies in the U.S. invest an average of 18.4% ($23 billion) of their revenue on capital expenditures annually.[25] Class I railroads do not report an unfunded need or deferred maintenance. Short line railroads specifically invest 25% of their annual revenue in Operation and Maintenance.[26]

Several federal programs support financing for freight rail. In 2020, the Railroad Track Maintenance Tax Credit was permanently extended. The program, or 45G as it is frequently called, provides short line and regional railroads with a tax credit for maintenance up to $3,500 per mile.[27] Other programs were strengthened through the IIJA. The Consolidated Rail Infrastructure & Safety Improvements (CRISI) Grant Program offers funds to improve safety, efficiency, and reliability of rail networks; over $2 billion was made available in FY24.[28] Low-interest loans are also made available through the Railroad Rehabilitation and Improvement Financing (RRIF) program with $35 billion in direct loans and loan guarantees; as of 2023, Amtrak has two active RRIF loans totaling over $3 billion.[29,30] IIJA also authorized $245 million over 5 years for a new Railroad Crossing Elimination Program to invest in grade separation projects nationwide.[31]

Amtrak operates with support from the federal government's general fund. Before COVID, Amtrak was moving toward supporting itself through ticket sales and other sources of revenue, although capital expenses would still need to be paid for by the federal government. In FY19, Amtrak's revenue was $3.5 billion with expenses totaling $4.9 billion, a difference of $1.4 billion.[32] Incoming revenue significantly declined in FY2020 due to the pandemic with a 50% drop in riders and revenue down over 30% from the previous year.[33] The federal government responded by increasing federal subsidies over base funding by $3.7 billion in FY20 and FY21.

Most of Amtrak's capital needs are on the NEC. In July 2021, the organization issued CONNECT 2035, a comprehensive 15-year plan that outlines needed revitalizations along the corridor. Over 150 projects have been identified in CONNECT 2035, new and revitalized stations, the Gateway Program rebuilding the connection between New York City and New Jersey, bridge replacements, and storm hardening efforts. The plan costs $117 billion, with a $100 billion funding gap identified.[34] The NEC Commission revised its 15-year plan by releasing its Connect 2037 (C37) plan in November 2023. The update would address projects with a total cost of $135 billion in 2023 dollars or $175 billion when considering inflation. About 40% of this amount would be covered by existing or expected funds leaving a funding gap of $100 billion. Over one-third of the funding for C37 will be provided by the Federal-State Partnership for Intercity Passenger Rail grant program. The report cites 171 projects to get underway within the next 5 years, 2024–2028; however, only 74 projects have funding available to start, and only 21 are fully funded.[35]

In addition to studying the NEC specifically, the organization issued Amtrak Connects US in 2021, which proposes nationwide service expansion, including 39 new and 25 enhanced routes, eventually serving 20 million new passengers annually. The Amtrak Connects US program is projected to cost $75 billion over 15 years.[36]

Photo: Matt Kirby

Amtrak Proposed Expansion

Source: Amtrak, Connects US, April 2021

Robust funding from 2021's IIJA is a significant resource for rail improvements and expansion. The IIJA provides passenger and freight infrastructure with $66 billion over 5 years. Most of that funding goes to passenger rail service, including $22 billion directly to Amtrak as well as an additional $44 billion through competitive grants available for both freight and passenger rail.[37] In total, **$58 billion is available for passenger rail**, which, according to Amtrak, is the equivalent of the total federal funding for Amtrak to date over the organization's entire lifespan.[38]

In addition to the recent influx of federal funds, Amtrak's revenue is rebounding from considerable losses due to the pandemic. The agency's revenue was $3.4 billion in FY23, an increase of 20% from FY22 and 97% of pre-pandemic annual revenue.[39]

Robust funding from IIJA is a significant resource for rail improvements and expansion. The IIJA provides passenger and freight infrastructure with $66 billion over 5 years.

Photo: Matt Kirby

Amtrak Enacted Federal Funding FY2019–24

Year	Base	COVID-19 Relief/IIJA	Total
2019	$1,941,600,000		$1,941,600,000
2020	$2,000,000,000	$2,700,000,000	$4,700,000,000
2021	$2,000,000,000	$1,018,000,000	$3,018,000,000
2022	$2,331,371,000	$4,400,000,000	$6,731,371,000
2023	$2,453,000,000	$4,400,000,000	$6,853,000,000
2024	$2,427,763,000	$4,400,000,000	$6,827,763,000

Source: Amtrak. General and Legislative Annual Report & Fiscal Years 2023 & 2025 Grant Requests

OPERATION AND MAINTENANCE

Competing interests between freight and passenger rail unfortunately continues to pose ongoing operational challenges. For 2023, Amtrak reports issues with on-time performance (OTP), showing an overall 74.4% OTP for customers. Federal law requires freight railroad dispatching to prioritize Amtrak trains over freight, but the agency contends this is often ignored and results in lower OTP.[40] Freight and passenger rail can benefit from partnerships to improve track sharing and avoid delays such as the Chicago Region Environmental and Transportation Efficiency Program.

Class I Rail Employment

Source: Surface Transportation Board

While freight traffic is decreasing, there are some indicators that service delays are increasing. A survey commissioned by the American Chemistry Council (ACC) on its members' experience with the freight and rail system found that "companies that ship by rail are increasingly reporting that railroad delays and service challenges are worse. Since the fourth quarter of 2021, nearly all companies (93%) reported conditions were either getting worse (46%) or were about the same (48%). A small number (7%) of companies reported that rail transportation-related delays/service challenges have improved overall. Many rail users reported longer transit times (90%), missed switches (66%), increased demurrage charges (59%), reduced service days (64%), and higher rates (59%)."[41] In September 2024, ACC cited continued challenges in moving products by rail largely due to excessive costs, lack of service reliability, and insufficient network resiliency.[420]

Amtrak is expanding its maintenance capacity nationwide. New maintenance facilities are planned or under construction in Seattle, Washington, DC, New York, Boston, and Philadelphia, and are largely due to IIJA funds[43] Track maintenance is also underway including $240 million deployed in summer 2024 for infrastructure upgrades along the Northeast Corridor.[44] Amtrak is also making strides to increase staffing, which is necessary to carry out its goals, hiring more than 4,800 positions in FY23, with 21,600 total workers. Amtrak also aims to bolster workforce education through its Training Center and Workforce Development initiative with a new, consolidated training center and expanding training through activities such as the Mechanical Craft Workforce Development Apprenticeship Training Program.[45]

PUBLIC SAFETY

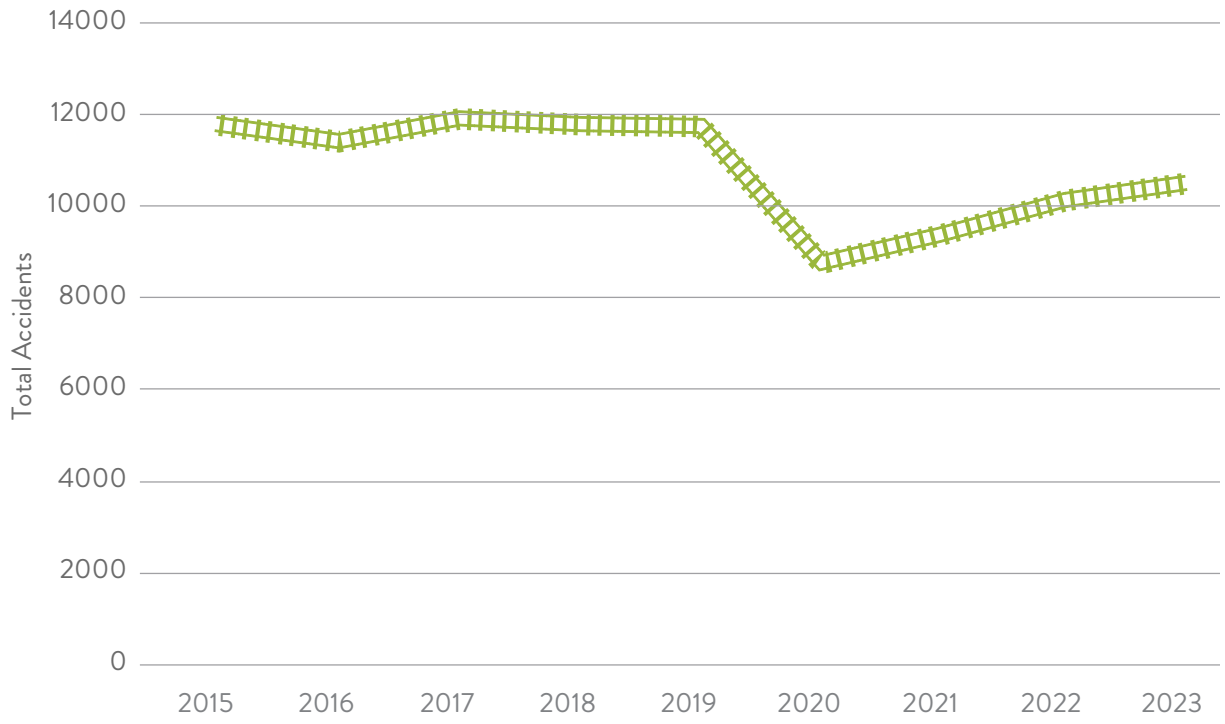
Freight railroads have experienced improved safety over the last two decades, although an uptick of incidents has been reported in recent years. For Class I railroad employees, fatality and injury rates for freight rail employees have dropped 63% since 2000, reaching an all-time low in 2023. However, more incidents and fatalities have been reported recently. According to Federal Railroad Administration (FRA) safety data, railroad deaths totaled 970 in 2023, an 7% increase from 2022's 904 and much higher than nearly a decade ago. Overall incidents were 10,578 in 2023, also larger than immediately preceding years. Trespassing is the top cause of rail-related deaths with a high number of incidents also occurring at highway-rail grade crossings.[46,47]

Rail Accident/Incident Overview 2015-2023

	2015	2016	2017	2018	2019	2020	2021	2022	2023
Number of railroads included	820	829	839	835	847	839	837	844	837
TOTAL ACCIDENTS/ INCIDENTS	11,851	11,482	11,990	11,874	11,800	8,807	9,453	10,207	10,578
Total fatalities	749	761	817	793	849	729	849	904	970

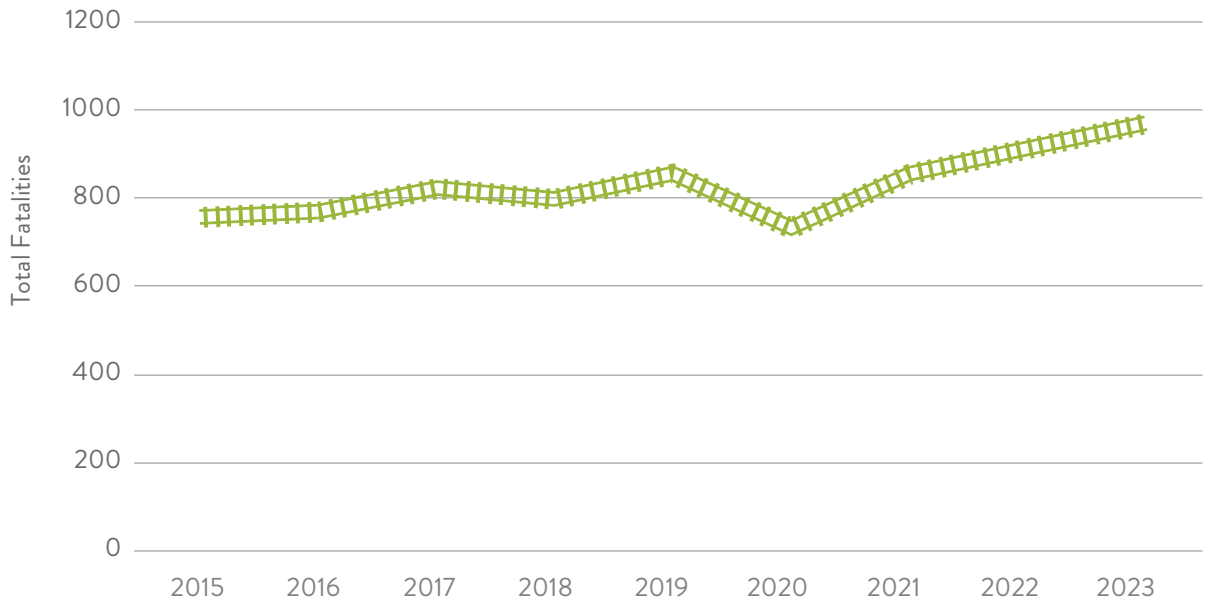
Source: Federal Railroad Administration

Rail Accident/Incident Overview 2015–2023



Source: Federal Rail Administration

Rail Fatalities Overview 2015 - 2023



Source: Federal Rail Administration

At the center of rail safety was a high-profile train derailment in East Palestine, OH, on February 3, 2023.[48] The derailment was caused by an overheated wheel bearing on a 149-car train passing through Ohio and carrying hazardous material.[49] According to the National Transportation Safety Board, 38 cars derailed, 11 of which were carrying hazardous material. Residents reported a myriad of health issues after hazardous chemicals were released into the soil, air, and water, including sore throats, coughing, and nausea, and thousands of nearby animals died.[50]

Overheated wheel bearings are frequently the cause of derailments. To counter these impacts, freight rail lines have "hot-bearing detectors" installed along tracks to provide alerts regarding overheating. NTSB found that the tracks had properly functioning detectors, but because they were spaced 20-plus miles apart, by the time employees received the alert showing that the bearing was heating up it was too late to respond. The derailed train also included DOT-111, cars which the NTSB had recommended be phased out due to risks presented in transporting flammable chemicals.[51]

In another high-profile public safety failure, the NTSB found that poor track conditions contributed to a fatal Amtrak train derailment near Joplin, MT, in September 2021. NTSB recommended increased track inspections and continued deployment of autonomous track monitoring systems to prevent future tragedies.[52]

In response to these and other rail incidents, the FRA finalized its latest regulation in April 2024 requiring a minimum size of train crews. With exception to some Class II and III railroads, freight trains must now be crewed by at least two workers.[53]

RESILIENCE AND INNOVATION

Rail lines face considerable threats from extreme weather, making resilience a key priority for future projects. In 2024 alone, Hurricane Helene damaged to rail lines in the Southeast, while rising waters caused the collapse of a rail bridge over the Big Sioux River between South Dakota and Iowa, and excessive heat along the Northeast Corridor delayed Amtrak trains due to fires and speed restrictions.[54,55]

It is estimated that for every $1 invested on project upgrades, another $4 in cost savings is achieved, which would otherwise have had to address network failures.[56] In 2024, Amtrak established design guidelines and identified current resilience certifications to incorporate climate considerations in asset development. Amtrak's development of a national network climate vulnerability assessment and

strategic plan is also underway. Based on a similar study for the Northeast Corridor in 2022, the assessment will incorporate future climate conditions to inform network plans and financing of capital improvements.[57] In addition, Amtrak's CONNECT NEC 2037 includes 215 miles of track renewal and signal replacement between Connecticut, Massachusetts, and Rhode Island, which will help protect the network against extreme weather.

Class I rail companies continue to implement strategies aimed at increasing efficiency and performance. Precision-scheduled railroading (PSR) has been increasingly adopted, improving efficiency through the simplification of routes, use of technology, train lengthening, eliminating unnecessary stops, and cutting costs. However, PSR is not without controversy, as it typically decreases the number of engineers on each train, while simultaneously increasing the length of trains. The GAO found that PSR has reduced overall staff among the largest freight railroads by 28% from 2011 to 2021.[58] However, FRA's new regulation directing minimum staff may result in added employees across the industry.

In addition, freight railroads have been implementing automated track inspection equipment that includes sensors. This provides more data for a lower cost than manual inspections and can provide additional insights into necessary improvements. However, these are not yet widely approved for FRA-required track inspection, nor is the data shared outside of the railroads.[59]

Although adding more train cars is not new, recent technologies, like positive train control and enhanced rail analytics, have helped companies expand train lines.[60]However, concerns exist related to grade crossing and difficulty in train controls for unexpected stopping. To reduce carbon emissions, freight companies are updating vehicles with more fuel-efficient locomotives, using railcars with lighter-weight steel, testing low-carbon fuels, and applying electric and hybrid vehicles and automation at rail yards and related facilities.[61] Companies are increasingly using active and remote monitoring on track bed and rail head conditions through LiDAR and related sensors. The ability of LiDAR to collect spatial data at centimeter levels offers companies the ability to improve safety and movement of goods across its infrastructure.[62]

For passenger rail, updated trains and infrastructure will improve performance and rider experience. Amtrak aims to reach 100% net-zero emissions by 2045. A significant share of Amtrak's fleet already features zero-emission vehicles, including 108 electric Northeast Regional and Acela locomotives.[63] As part of its capital improvement plan, Amtrak will implement infrastructure updates such as redesigned interlockings, new tracks, and modernized signals to accommodate higher speed rail as a part of the Susquehanna River Bridge Replacement.[64] For long-distance trips, Amtrak has renewed its delay notification system and improved accessibility through expanded ADA-compliant facilities.[65]

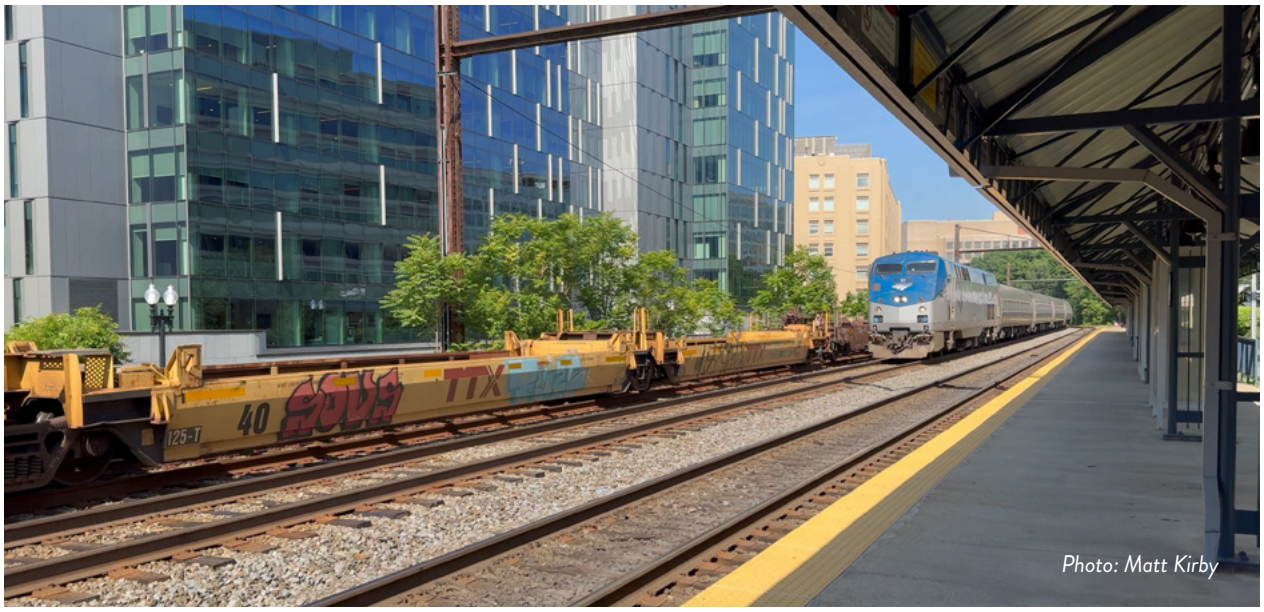


Photo: Matt Kirby

RECOMMENDATIONS TO RAISE THE GRADE

- Support improvements to the multimodal freight network, enhance safety, provide capacity improvements, and improve economic competitiveness, as outlined by the National Freight Strategic Plan (NFSP). To implement the NFSP, a robust National Asset Management system should be created to support identifying, prioritizing, and sourcing funding for capital investment projects.
- Implement safety technologies on additional wayside monitoring infrastructure to detect defects in rolling stock.
- Modernize rail tank cars, including transitioning from DOT-111 to DOT-117 and related infrastructure, and equipment upgrades to improve safety and reduce risk to the public.
- Enact renewed federal legislation addressing railway–highway crossings, hazardous materials, rail car inspections and maintenance, and emergency response.
- Support a financial and regulatory environment that grows private rail investment and innovative financing options.
- Enact public-private rail programs to enhance both freight and passenger service for more efficient operations.
- Encourage passenger rail infrastructure investment in high-population centers, particularly focused in the NEC, which will relieve system stress on other modes.
- Ensure passenger and freight projects supported by IIJA are implemented.
- Facilitate resilience of the current and future rail network by leveraging long-term partnerships with federal, state, and local agencies; freight railroads; and neighboring communities.

Photo: Kiewit Corporation

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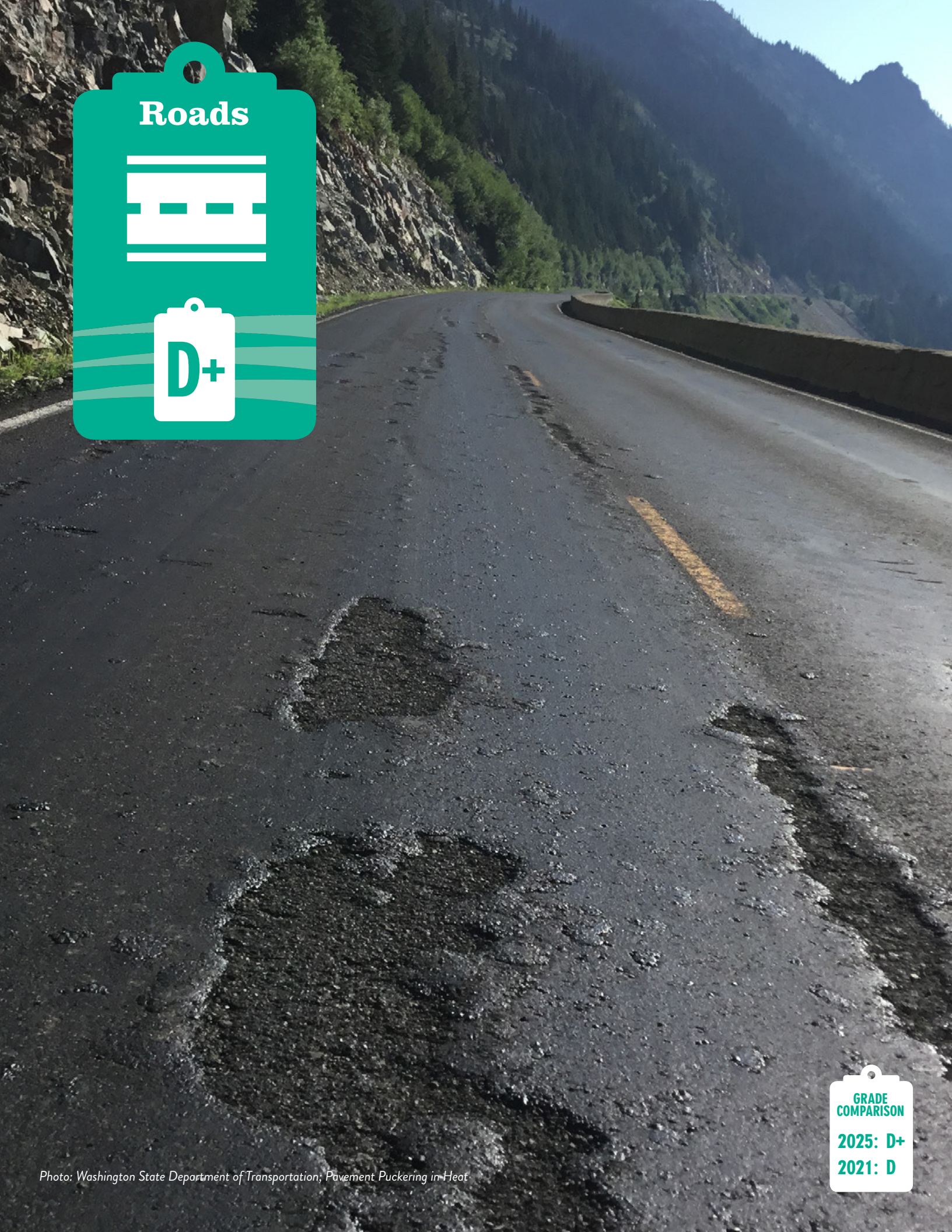


Photo: Washington State Department of Transportation; Pavement Puckering in Heat

ROADS

EXECUTIVE SUMMARY

Roads connect communities and play a vital role in the nation's economy. Although Americans' travel patterns have shifted in the years following the COVID-19 pandemic, vehicle miles traveled (VMT) have rebounded. Some 39% of major roads in the U.S. are in poor or mediocre condition, an improvement from the 43% recorded in 2020.[1] Driving on deteriorated and congested roads still costs the average driver over $1,400 per year in vehicle operating costs and lost time. While once again declining, the number of people dying on America's roads remains high, totaling 40,990 in 2023. Furthermore, the impacts of extreme weather events present challenges for maintaining existing roads and planning future projects. Recent investments, including more than $591 billion since late 2021 from the Infrastructure Investment and Jobs Act (IIJA), are a positive step.[2] The nation's roadways still face a $684 billion funding gap over the next 10 years. Sustained and robust infrastructure investment is needed to maintain and improve the roadway network for the future.

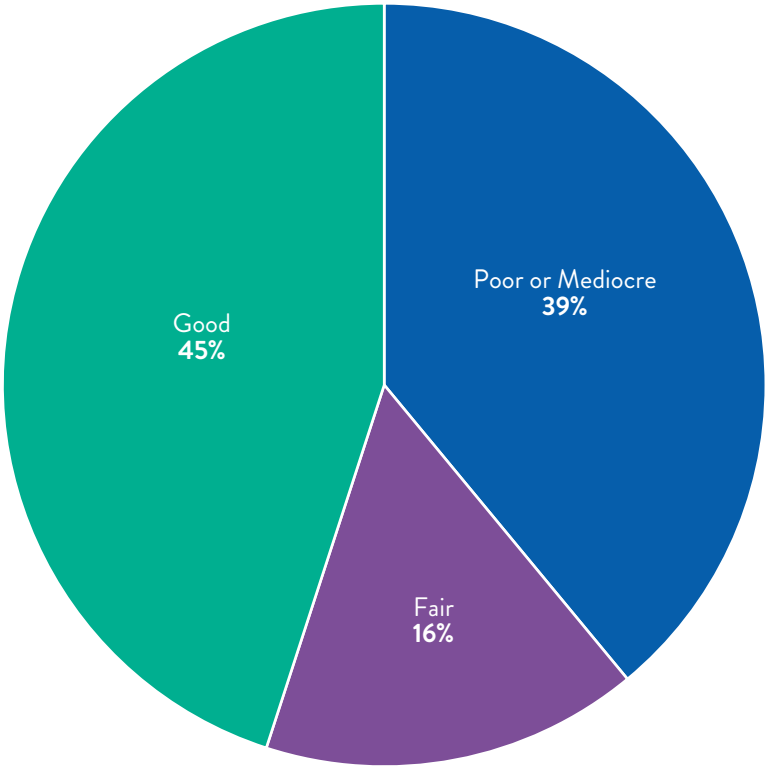
BACKGROUND

America's more than 4.1 million miles of public roadways form a vital network, facilitating the movement of people and goods. This interconnected system consists of roads, sidewalks, dedicated lanes for transit vehicles, and bike lanes. The road network is maintained by government agencies and private sector entities, who handle responsibilities ranging from snow removal and traffic management to traveler information services and signage.

CAPACITY AND CONDITION

The nation's roads have had to accommodate increased vehicle travel and a growing population in recent years. Roads with the highest speeds and the highest volumes of traffic are generally prioritized for funding and therefore are typically in the best condition. Based on miles, the share of pavements on roads eligible for federal funding with good ride quality improved between 2008 and 2018, rising from 40.7% to 47.2%. However, the share of federal-aid highway pavements with poor ride quality also grew during this period, increasing from 15.8% to 22.6%.[3] Deteriorated roads result in additional operating costs in the form of vehicle repairs and tire wear. Additional vehicle operating costs totaled $725 per motorist in 2023.[4]

Pavement Condition, 2023

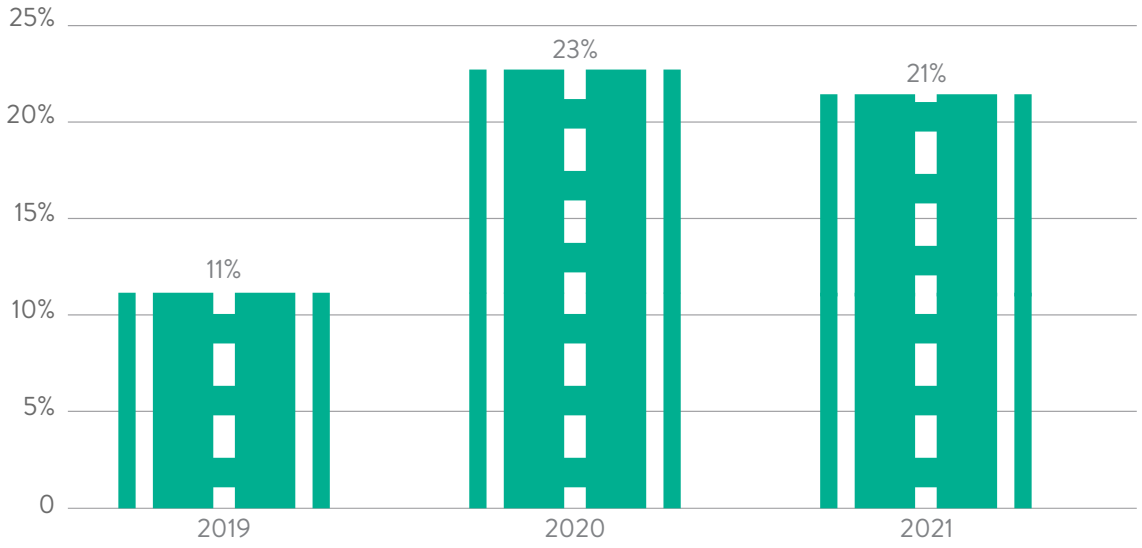


Source: TRIP analysis of Federal Highway Administration data

The pandemic brought with it an increase in teleworking and affected how people used or did not use roads. Hybrid jobs (employees worked from home at least one day per week) increased from 4.1% in 2020 to 5.7% in 2021.[5]

The number of vehicle trips to and from work declined from 53.1 million in 2017 to 41.3 million in 2022, a 28% drop.[6] Yet "commute VMT" remained at a little less than one-third of total VMT between these years.[7]

Percentage of Fully Remote Jobs



Source: U.S. Census Bureau

In addition to an increase in working from home, travel shifted across other modes. Americans opted for modes such as biking, which allowed them to socially distance. The Bureau of Transportation Statistics indicates national expenditures on bicycles and related accessories increased in the years following the pandemic's start, and total bikeshare ridership on six of the largest systems increased 42% from March 2020 to March 2023.

Over the last few years, the pattern of road use has changed due to increased remote work and other factors. The Federal Highway Administration (FHWA) has found that morning and evening peak periods include not only commutes but also shopping trips, school drop-off and pick-up runs, and other nonwork trips.[8] School trips in particular have experienced a shift. In 2022, 53.2% of U.S. students were dropped off at school or drove themselves rather than take the bus, bicycle, or walk.[9] This figure represents an increase from 46.4% in 2009.

After dipping drastically due to the pandemic, VMT has rebounded to nearly 2019 levels, reaching 3.19 trillion miles in the U.S. in 2023, a slight increase from 2022.[10]

The typical U.S. driver lost 43 hours to traffic congestion and $771 worth of time in 2024, up from 42 hours and $733 in 2023.[11] These amounts of time lost are equivalent to spending one work week per year sitting in traffic. Congestion negatively affects people headed to their destinations and goods on their way to market. While congestion has traditionally been reported, travel time reliability has increasingly measured roadway network performance. A reliable network allows for consistent travel times during peak period trips; drivers can accurately plan for extra time. Significant challenges occur when the network is unreliable, delaying people and products.

Freight transportation also affects the roadway system. One consideration with trucks, and vehicles in general, is their weight's impact on pavement. Vehicle weight, from sedans to minivans, has increased over the past 40 years, and electric vehicles are heavier still due to their batteries.[12] Trucking accounts for the largest share of freight movement, and freight moved by truck is expected to increase 91% by value and 53% by weight between 2022 and 2050.[13]

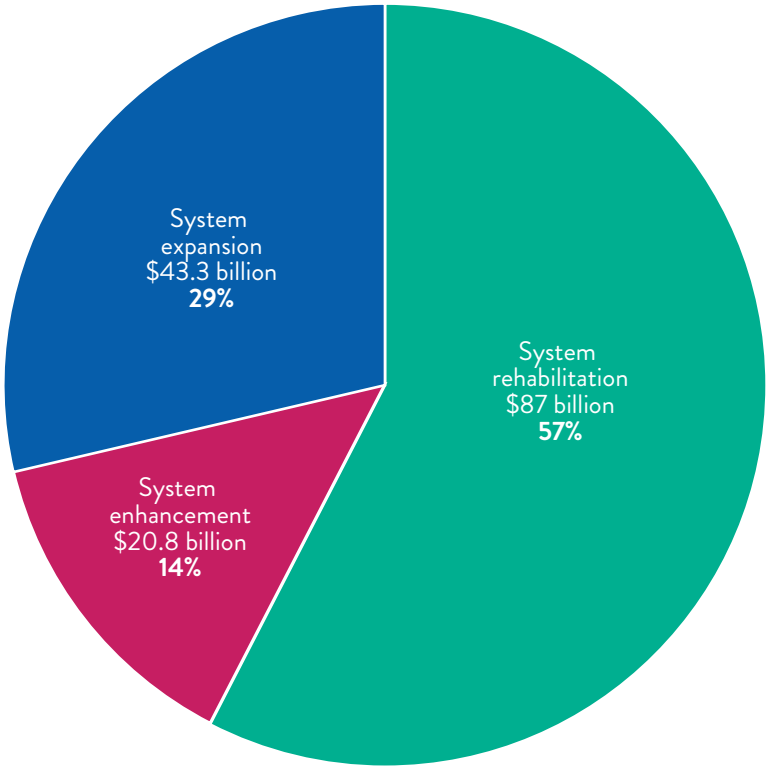
FUNDING AND FUTURE NEED

The IIJA contained a five-year reauthorization of federal surface transportation programs for Fiscal Years 2022 through 2026, including $273.2 billion over five years in formula funding for states through the federal-aid highway program.[14] The IIJA represented a nearly 50% increase in highway funding from the previous surface transportation reauthorization.[15] Since the law's enactment, construction work has started on 207,000 miles of roadways.[16]

Because of years of underfunded roadway maintenance, the transportation system has staggering needs. According to ASCE's *Bridging the Gap* report, surface transportation needs from 2024 to 2033 total about $3.5 trillion, of which $2.2 trillion represents the nation's roadway system.[17] If funding levels included in the IIJA become the new baseline for annual investment, the nation's roadways will have a funding gap of $684 billion over the next 10 years. As of 2018, FHWA estimated $1.1 trillion was needed to address a backlog of highway and bridge investments over 20 years.[18] To fund all potential highway capital investments from 2018 to 2038, some $151.1 billion in average annual investments would be needed, with $87 billion directed toward system rehabilitation, $20.8 billion to system enhancement, and $43.3 billion to system expansion.[19]

Transportation funding in the U.S. has generally followed a "user pay" principle, meaning people who use a service, such as a road, should bear its costs. Federal road investment relies on the Highway Trust Fund, a user fee–funded source supported by motor fuel tax revenue. The federal motor fuel tax rate of 18.4 cents per gallon for gasoline and 24.4 cents per gallon for diesel has not been raised since 1993. The U.S.'s federal fuel tax rate is lower than other industrialized countries. For example, Germany's excise tax on gas is $2.76 per liter, and France's is $2.81 per liter.[20] The growth in construction costs and the fuel efficiency of vehicles means that the purchasing power of the federal gas tax has declined 80% since 1993.[21] Between 2013 and 2024, 34 states have approved or adjusted motor fuel tax increases.[22] States have also explored mechanisms such as electric vehicle (EV) registration fees, EV charging station taxes or fees, and road usage charge (RUC) programs.

Funds Needed for Highway Capital Investments



Source: U.S. Department of Transportation, Federal Highway Administration, "25th Edition of Status of Nation's Highways, Bridges and Transit: Conditions and Performance Report to Congress," 2024

Voters have demonstrated support for transportation funding measures at the state level and the IIJA represents a substantial investment, but reliable federal funding is still needed to maintain and modernize the transportation system. Investment needs are outpacing available revenue owing to declining fuel tax receipts, aging infrastructure, and in some cases, budget cuts. At the same time, many states are struggling to update their revenue sources to keep pace with inflation and mitigate the impacts of revenue losses caused by electric and fuel-efficient vehicles.[23]

Since 1993, the purchasing power of the federal gas tax has declined 80%.

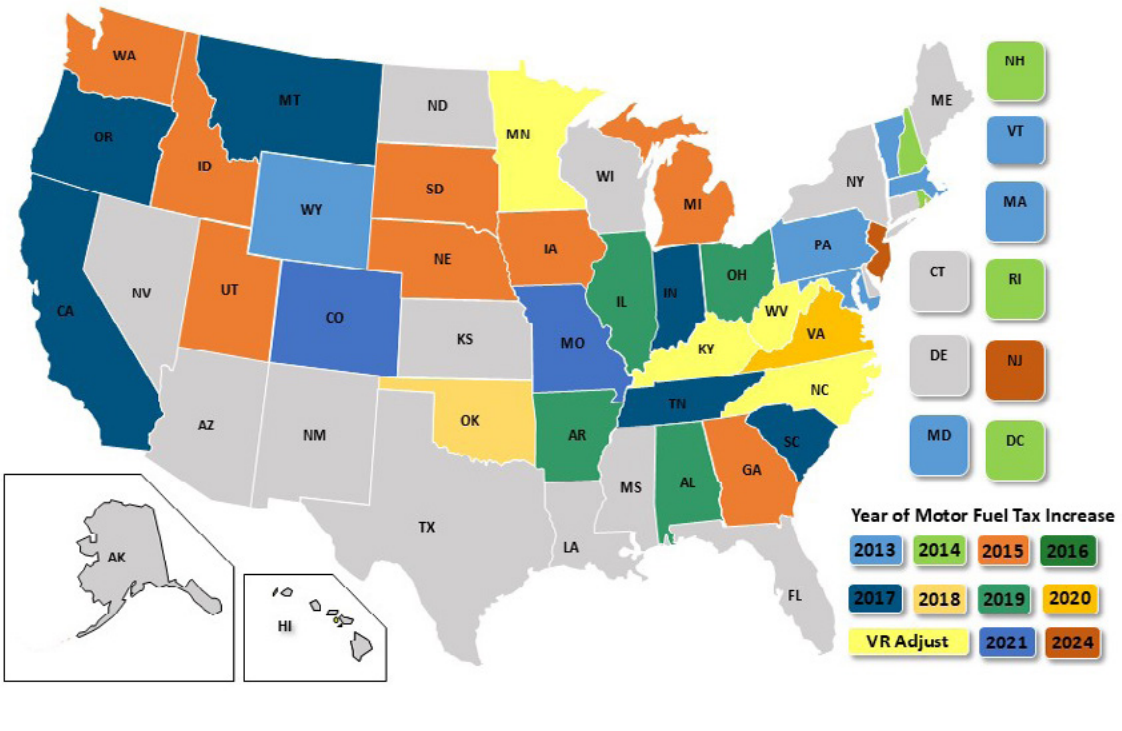
OPERATION AND MAINTENANCE

Government agencies and private sector entities work together to operate and maintain the nation's transportation system. Each state is required by federal law to develop a risk-based asset management plan for the National Highway System to improve or preserve system condition and performance.[24] Achieving and maintaining a state of good repair on existing roadways is essential. Life-cycle cost analysis, which helps provide awareness of total infrastructure cost, can help transportation professionals and elected officials make well-informed Operation and Maintenance decisions.

America will never be able to build its way out of congestion. Roadway expansion can often fail to meet travelers' expectations for reduced congestion

and improved reliability due to induced demand. For example, the Katy Freeway, which carries Interstate 10 and connects Houston with its western suburbs, was widened to 26 lanes of traffic in the mid-2000s. Although travel times on the route declined right after the project's completion, within a few years, they had exceeded previous levels. Similarly, a $1 billion effort to improve traffic along I-405 in Southern California resulted in slower travel times for drivers.

34 States Approved/Adjusted Motor Fuel Tax Increases, 2013–2024



Source: American Road and Transportation Builders Association's Transportation Investment Advocacy Center

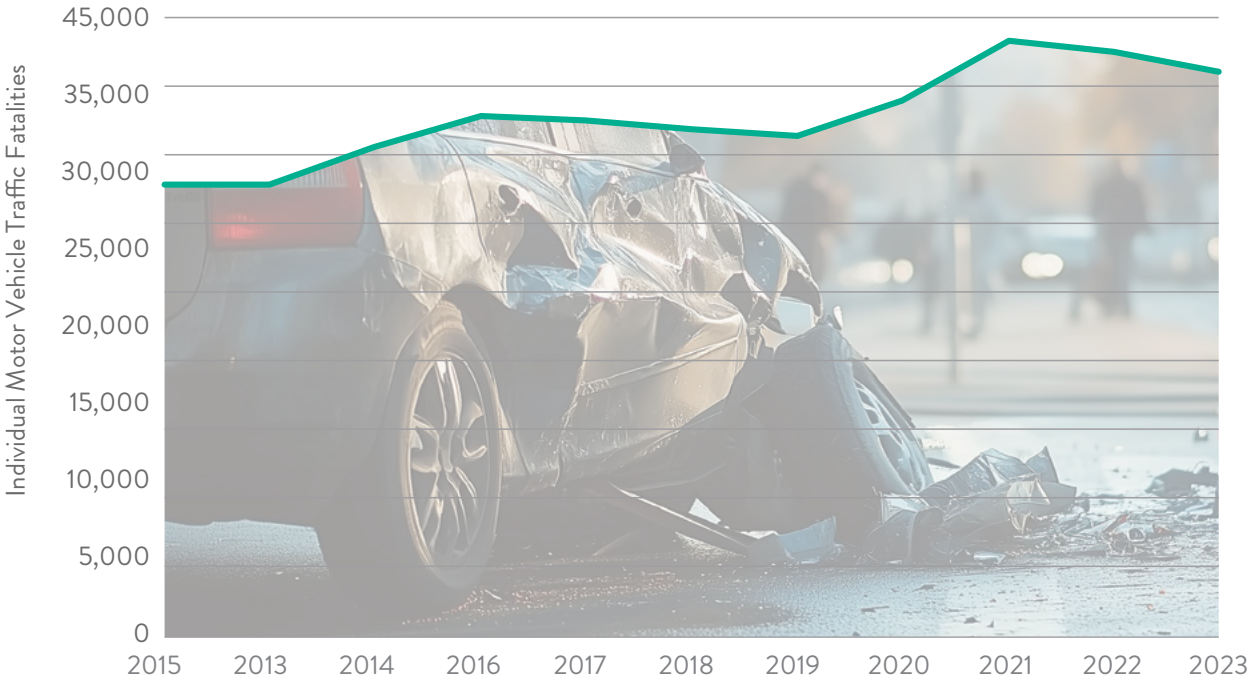
PUBLIC SAFETY

Safety remains a significant issue on the nation's roadways. The National Highway Traffic Safety Administration (NHTSA) estimates 40,990 people died in motor vehicle traffic crashes in 2023, an average of 112 deaths per day. The amount of people dying on America's roadways per year is equal to four airplanes full of passengers crashing every week.

Although there has been a slight drop in traffic deaths in recent years, numbers are still high. NHTSA's research suggests that, throughout lockdowns associated with the pandemic, drivers engaged in more risky behavior, such as speeding and refusing to wear a seat belt.[25] Traffic fatalities in the U.S. tower over those reported by other countries. A study of 31 nations found that the U.S. had the second-highest fatality rate of 12.8 deaths per 100,000 people in 2022, trailing only Colombia.[26]

Traffic safety is a particular concern in rural areas, where only 19% of the U.S. population lives and 47% of all roadway fatalities occur.

Number of Motor Vehicle Fatalities

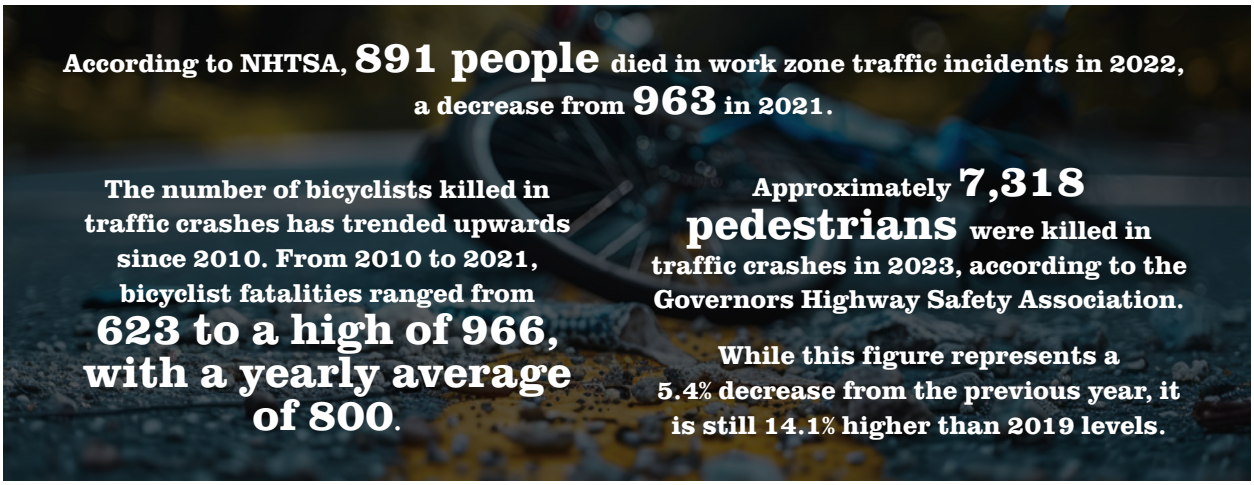


Source: National Highway Traffic Safety Administration

Traffic safety is a particular concern in rural areas, where only 19% of the U.S. population lives and 47% of all roadway fatalities occur. Challenges with rural roads include a lack of safety features, such as rumble strips, ample shoulders, recoverable slopes, lighting, and a lack of quick access to emergency medical care.[27] Rural roads play a critical role in the movement of freight, which also presents safety implications for the individuals who live near them and use them. In 2022, 5,837 trucks were involved in a fatal crash, a 1.8% increase from 2021 and a 41.6% increase since 2012.[28]

In addition to causing deaths and injuries, traffic crashes are expensive. According to a NHTSA report, the total economic cost of motor vehicle crashes in the U.S. in 2019 was $340 billion,[29] or about $1,035 for every person in the country.

Pedestrian, bicyclist, and work zone safety are also important issues, because these users of the transportation system are particularly vulnerable to vehicles.



RESILIENCE AND INNOVATION

Among the most pressing challenges for roads are the impacts of extreme weather, which the transportation sector itself exacerbates. Transportation accounted for the most significant portion (28%) of total U.S. greenhouse gas emissions in 2022.[30] Most of these emissions (80%) came from cars and medium- and heavy-duty trucks. Rising temperatures, fires, flooding, erosion, and severe weather strain the nation's roadways. In addition to planning and building resiliently for the future, state departments of transportation (DOTs) need to ensure their existing infrastructure can support daily operations and facilitate the movement of people evacuating areas affected by extreme weather events. Evacuations are necessary to move people out of harm's way; however, they can stress transportation networks, snarl traffic, and present safety concerns. One particularly fraught example is the evacuation preceding Hurricane Rita, which hit less than a month after Hurricane Katrina and forced an estimated 3.7 million people to evacuate the Houston area. The evacuation resulted in more than 100 deaths.[31] In contrast, the Caldor Fire in the summer of 2021 required an organized evacuation of more than 50,000 residents from California to Nevada and did not result in any fatalities.

Resilience Efforts Across the Country

WASHINGTON

The Washington State DOT (WSDOT) has dealt with extreme heat and wildfires, which impact pavement, curbs, sidewalks, and guardrails. WSDOT adjusted crews' work schedules due to health concerns and have replaced wood posts with metal ones in wildfire-prone areas to be more resilient during future wildfires.

COLORADO

The Colorado Department of Transportation developed a suite of risk and resilience tools to help analyze risks to transportation assets.

DENVER

In 2022, the Transportation Commission of Colorado dropped expansions to Interstate 25 through downtown Denver in favor of greener transportation options.

MINNESOTA

In 2023, the Minnesota Legislature approved a transportation package calling for greenhouse gas emission reduction targets and requiring commissioners to determine if capacity expansion projects conform with those targets.

VERMONT

The Vermont Agency of Transportation (VTrans) developed its Transportation Resilience Planning Tool to identify bridges, culverts, and road embankments vulnerable to flood damage and estimate risks based on vulnerability.

ATLANTA

The Atlanta Regional Commission is developing a Resilience Improvement Plan to identify areas in the transportation system vulnerable to natural hazards, particularly flooding.

BROWARD COUNTY, FLA.

The Broward Metropolitan Planning Organization prioritized roadway segments based on their vulnerability to sea level rise and storm surges when composing its Commitment 2045 Metropolitan Transportation Plan.

Emerging technologies and policies present opportunities to improve traffic flow and safety. Alexandria, VA, a suburb of Washington, DC, ended 2023 with zero traffic fatalities after adopting several strategies, including speed limit reductions, speed cameras in school zones, and "no turn on red" restrictions.[32] Hoboken, NJ, has not had a traffic fatality since January 2017 due to steps such as removing parking spaces near intersections and lowering speed limits. Artificial Intelligence (AI) also has the potential to improve traffic flow, as demonstrated on I-15 in Nevada through a pilot program led by government partners and a mobility company.

State DOTs have made organizational changes to lead innovative activities. Within the DOTs of Colorado, Connecticut, Delaware, Pennsylvania, and Utah, new entities were created to handle issues such as vehicle electrification, innovative finance, climate change, and new technologies.[33] Several state DOTs have taken on roles related to emerging technologies (such as automated and connected vehicles and drones), often as partners in exploring these technologies and their impacts.[34]

Photo: Jamie Street

RECOMMENDATIONS TO RAISE THE GRADE

- Dedicate resources to preserving a state of good repair, because no nation can build its way out of congestion. New capacity should be designed to support multimodal transportation options.
- Optimize the capacity of the existing road network for the movement of people in coordination with the development and deployment of new technologies and intelligent transportation systems that promote an integrated, multimodal transportation network. Travel time reliability, which indicates whether people can accurately plan for travel times, should inform decisions about capacity and should not be used solely to justify roadway expansions.
- Increase funding from government and private sector partners to improve the condition and operations of the transportation system and enhance safety for all users. Transportation funding should involve a continuation of traditional user fees, such as federal and state motor fuel taxes, while transitioning to more sustainable and equitable innovative user fees, such as alternative energy vehicle fees and RUCs.
- Encourage states and localities to develop transportation asset management plans that incorporate asset management efforts with long-term transportation planning and use life-cycle cost analysis. Urge state DOTs to publish their project lists, including the funding sources and prioritization process that led to the projects' programming.
- Incorporate infrastructure design choices that can help save lives, including reducing lane width and implementing low-cost features such as asphalt art, which can heighten the visibility of crosswalks.
- Promote the frequent release of accurate and updated condition data at the federal level.

DEFINITIONS

Pavement ride quality: The indicator for pavement ride quality is the International Roughness Index (IRI), which measures the cumulative deviation from a smooth surface in inches per mile.[35] The FHWA has found that a road surface with an IRI rating below 95 provides good ride quality, a road with an IRI from 95 to 170 provides fair ride quality, and a road with an IRI above 170 provides poor ride quality.

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Photo: Yusheng Deng

SCHOOLS

EXECUTIVE SUMMARY

America's more than 98,000 public PK–12 schools serve 49.4 million students. However, these buildings that America's children rely on are aging. Nationwide, schools average 49 years old, but detailed data on their condition is scarce. Only 10% of total school spending in School Year (SY) 2021–2022 was directed to facility expenses, a total that has been low for decades, and a majority of which is dedicated toward new construction versus maintenance of existing buildings. The annual funding gap to reach a state of good repair for the nation's public schools has grown from $60 billion in 2016 to $85 billion in 2021. Critical needs at school buildings include water upgrades to remove lead and installation of cooling systems amid increasing temperatures. A 2021 study estimated that 13,700 additional schools must add air conditioning, representing more than $40 billion in investment needs. Moving forward, better management of existing assets will be needed along with the most up-to-date building codes and standards. Those upgrades can be accommodated with high-quality public data on school facilities and greater predictable funding dedicated to infrastructure.

BACKGROUND

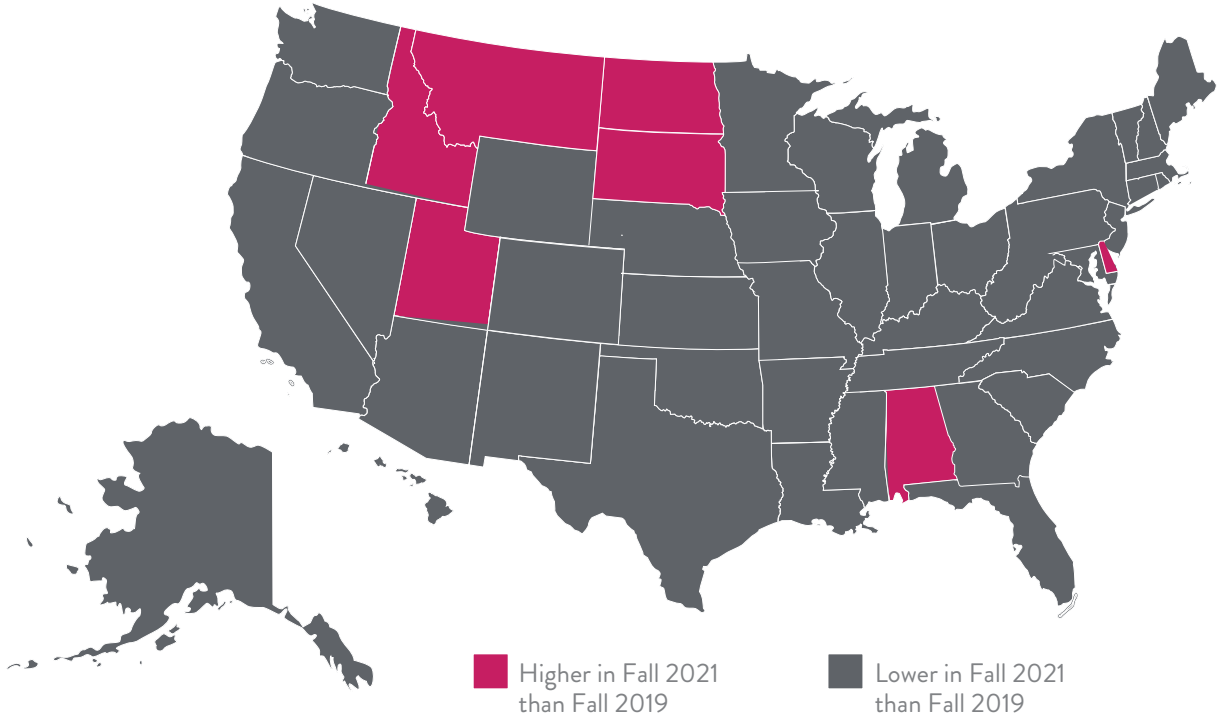
In SY21–22, 49.4 million American students attended more than 98,000 public schools, from prekindergarten through high school, in more than 13,300 school districts.[1] Most school facilities are governed and managed locally, where school boards set capital investment plans and approve budgets. The physical infrastructure of schools is occasionally a topic for oversight and regulation at the state level. The federal government provides relatively minimal regulation and funding for school infrastructure, which is left almost exclusively to local government.

CAPACITY

America's public school facilities can currently accommodate the overall student population and are expected to continue to meet needs over the next decade, given enrollment trends and resident birth rates. Therefore, although school capacity issues exist, they tend to be localized.

In SY21–22, schools saw a 3% enrollment decrease across all public PK–12 pupils from SY19–20, measured before the COVID-19 pandemic disrupted school operations.[2] Some public school children may have moved to private school alternatives during COVID-19, but not in large numbers based on U.S. Department of Education data.[3] The U.S. Department of Education projects that public school enrollment nationally will slowly decline to 46.9 million in SY31–32 from 49.4 million a decade prior.[4]

Change in Public School Enrollment between Fall 2019 to Fall 2021, by State



Source: National Center for Education Statistics

Overall, changes in enrollment vary widely by state, and growth is often in previously less populated areas. North Dakota is one of seven states where public school enrollment grew from Fall 2019 to Fall 2021 (about 3.5%). In one case, responding to a 25% increase in students from 2019 through 2024 (150 to 200 pupils) Medina Public School in North Dakota broke ground on an expansion project that added 5,330 square feet, some of which will be dedicated to students with special needs.[5]

CONDITION

Fewer than half of states collect representative data on their school facilities.[6] Based on public data, the average age of main instructional buildings in America's public school system is 49 years. That means many buildings where American school children spend their days are reaching their 50-year design life, where essential facility systems need comprehensive upgrades or replacements.[7] Throughout the U.S., 38% of public school buildings were constructed before 1970, with another 41% split evenly between the years 1970 and 2000 and between 2000 and 2023. Twenty percent of American public schools report that they do not know the construction year of their main instructional buildings. Despite their age, fewer than half of all public school buildings have undergone significant renovations or replacements since their original construction, and fewer than one-third have undergone improvement since 2010.[8]

Defects are common at schools when considering basic needs like reliable electricity, clean drinking water, and cool safe indoor air. According to a 2020 Government Accountability Office (GAO) report, 41% of school districts needed to update heating, ventilation, and air conditioning (HVAC) systems in at least half of their schools, making HVAC repairs the most common infrastructure need across school systems.[9] Meanwhile, at least 28% of school districts must upgrade interior lighting, roofs, and safety or security systems in half of their overall buildings.[10]

Unfortunately, the prevalence of lead in school piping and supply lines is largely unknown. According to a 2023 study of school drinking water infrastructure, 10 states have announced a testing program but have collected little or no data. Sixteen more states have tested for lead pipes in some school districts but collected data from relatively few. The analysis devised a 200-point scale, awarding points to school districts for drinking water best practices. The District of Columbia ranked first with 148 points. South Dakota and West Virginia tied for last at 0 points. South Dakota was planning to start a voluntary EPA-funded testing program in schools.[11]

Montana passed legislation requiring drinking water assessment at school buildings by the end of 2021. However, across the state's 591 public schools, 149 had not submitted their drinking water assessments by the deadline, primarily owing to a lack of funding for the assessments and high-priority, time-sensitive repairs taking precedence. In Montana, the initial statewide funding for lead drinking water inspections was only $40,000.[12]

Recently, several states have made efforts to better assess school facilities. Michigan's Fiscal Year 2024 budget included $20 million to the state Department of Education to perform building audits using best practices and licensed professionals, including civil engineers. Michigan made the funding flexible enough to support evaluations of essential facility functions and innovative capital projects like feasibility studies of solar energy installations.[13]

Tennessee includes school infrastructure needs as part of an annual report from an independent statewide commission. The evaluation breaks down education facility needs into state of good repair work and school expansions or new construction, informing decision-makers on funding and oversight priorities and setting a best practice that other states could follow.[14]

Photo: Aaron Burden

FUNDING; OPERATION AND MAINTENANCE

School funding for physical infrastructure is primarily driven by local and state governments, with infrequent increases from federal sources during economic recessions, like 2008–2009's recession and the downturn from COVID-19.[15]

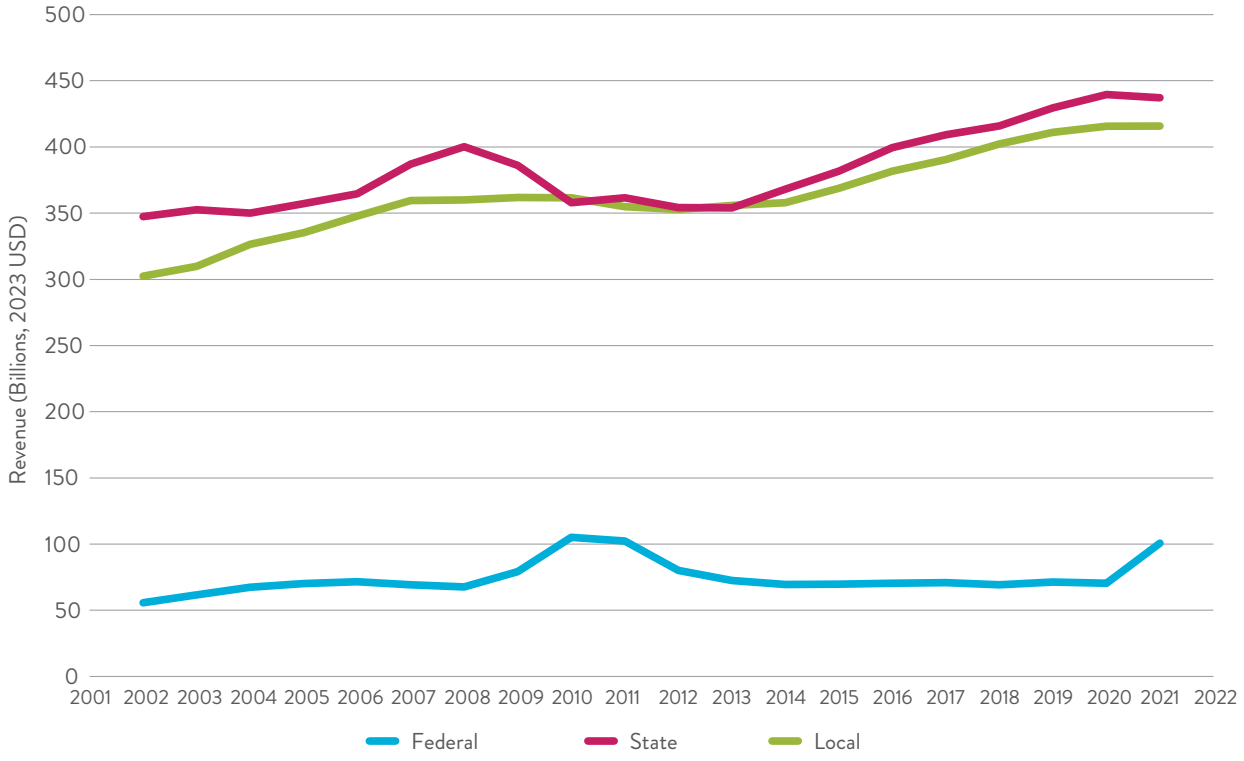
About $813 billion in total spending supported America's public PK–12 schools in SY 2021–22, including $703 billion in operations expenditures and $79 billion in capital costs, with $22 billion in debt service and $9 billion in other programming. Capital costs represent less than 10% of total education spending, and capital budgets skew heavily toward new facilities rather than maintenance of existing infrastructure. Seventy-six percent of capital expenditures ($60 billion) was dedicated toward construction on new sites compared to

7% ($5.7 billion) in land and existing structures expenses. Equipment purchases cover the bulk of the remaining capital budget. Investments at this rate mean the upkeep of buildings is often underfunded and delayed, often to the point where full replacement is needed.[16]

With most of the dedicated annual funds from federal, state, and local government used for school staff payroll and other non-facility operations, support for school facilities is often left to bond or tax measures voted on locally. Voters approved these measures at an average national rate of 76% recently, but approval rates vary greatly by state.[17] In elections held within 2024, every single school bond measure passed in 13 states, but only 56% of those in Ohio and 14% of those in South Dakota cleared the threshold for adoption.[18] Even in states with historically high school bond passage rates, the measures have unpredictable results, adding unpredictability to asset planning.[19] The aforementioned Medina, ND, school expansion was delayed while officials regrouped after losing their first bond measure appeal to voters. In the Kansas City suburbs, Grandview C-4 School District won support from 71% of voters for a 2024 bond issue, partly because the measure did not increase taxes.[20]

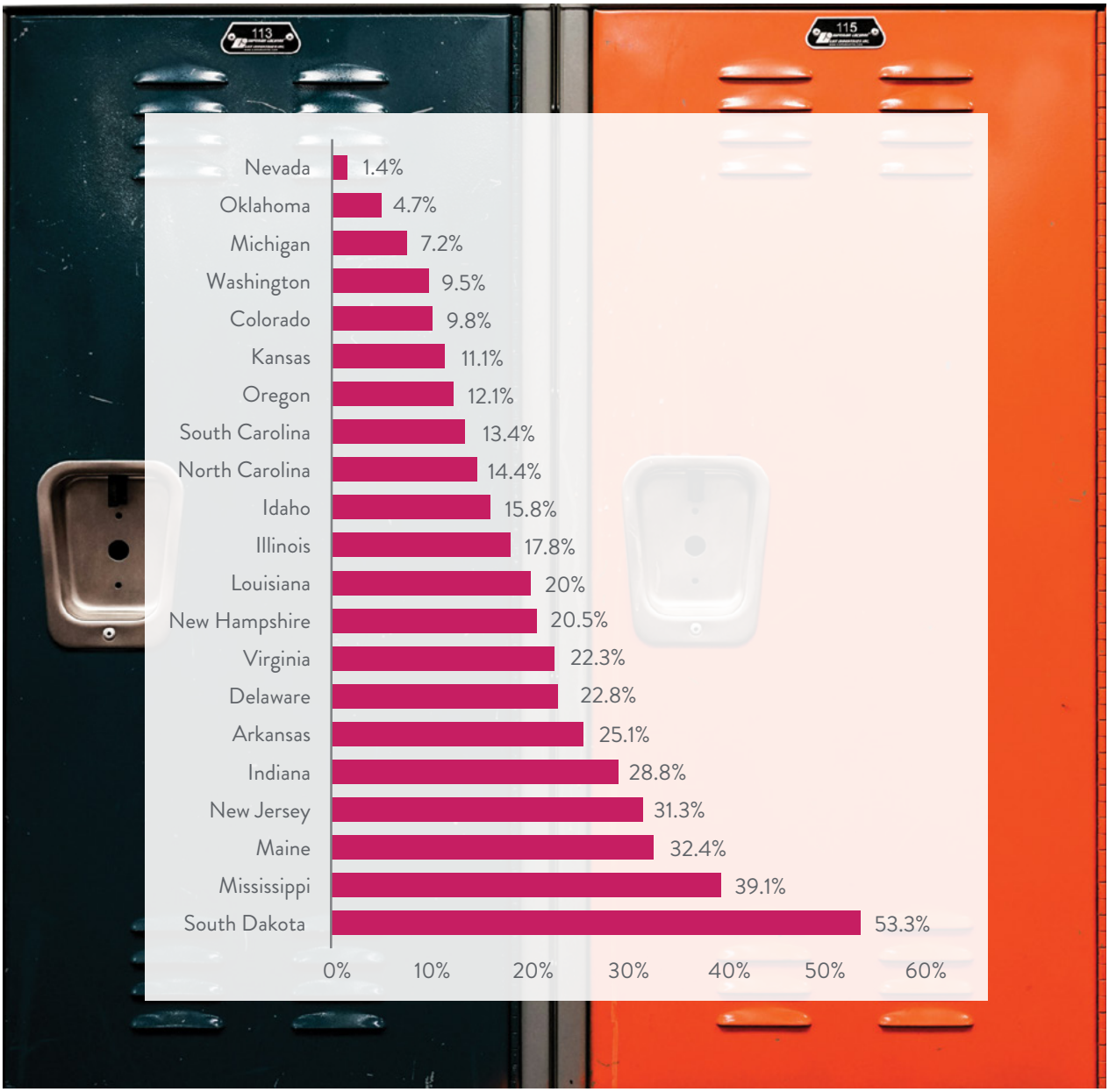
Ahead of SY21–22, the federal government delivered $24.2 billion in COVID-19 federal assistance funds. Federal investments into schools included the Coronavirus Aid, Relief, and Economic Security [CARES] Act of 2020, the Coronavirus Response and Relief Supplemental Appropriations [CRRSA] Act of 2021, and the American Rescue Plan Act of 2021 [APRA]. Despite notable attention to HVAC system upgrade projects, only a tenth of that spending ($2.5 billion) went to capital expenditures. Other spending went to maintain safe operations with consumable goods like face masks and additional hiring. Many districts quickly increased their staffing to reduce learning loss during the pandemic.[21] Some states prioritized facility spending more than others, with South Dakota allocating the most federal money to infrastructure and Nevada the least of the 21 states with publicly available data.[22]

Funding for PK–12 Public Education by Source, School Years starting Fall 2002 through Fall 2021



Source: Congressional Research Service

Share of COVID-19 Aid to Schools Spent on Facilities, SY21–22



Source: Chalkbeat

In Washington, D.C., the public school system began a facilities modernization process in 2000, and 70% of its square footage was modernized by 2021. The effort was successful because best practices for school facility management were written into District law, and annual appropriations funded facility evaluations.[23] The school system's asset management practices span from a high-level planning of facility needs through the management of real estate, maintenance of existing assets, construction of new buildings, and mindful disposal and repurposing of land.[24]

Mindful asset management requires staffing dedicated to that purpose, and relatively few members of the education workforce have a portfolio in physical infrastructure. Of the 8 million Americans employed at K–12 schools in 2022, only 4% (300,000) worked in building and grounds cleaning and maintenance.[25]

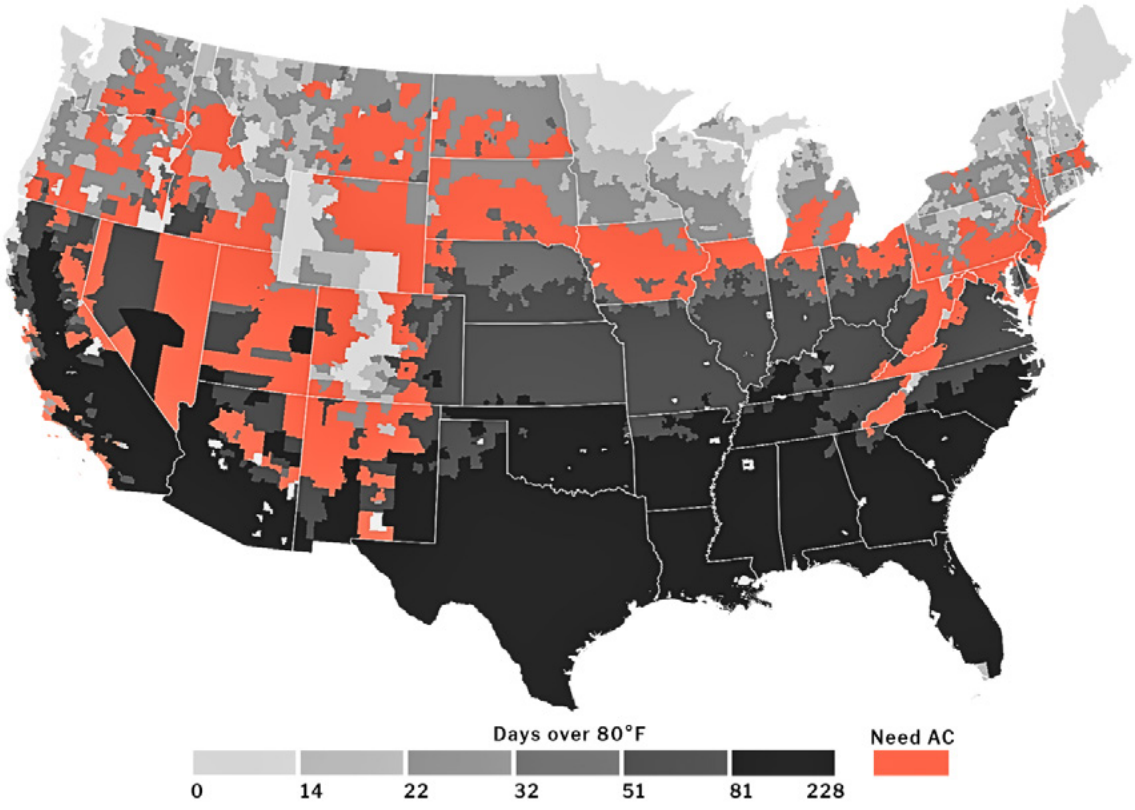
FUTURE NEED

In 2021, the 21st Century Schools Fund found that America's investments in public primary and secondary schools trailed the need for state of good repair by $85 billion annually,[26] a 42% increase from $60 billion (2020 dollars) as estimated in 2016.[27] That total includes capital improvement needs as well as maintenance and facility operations. While those repair needs grow—as do the total number of project numbers and inflation-adjusted cost for each—a list of new facility features is moving from "nice to have" to "necessary," and chief among those "must-haves" is air conditioning.

In the last half-century, daytime temperatures during the first two months and the final two months of America's traditional school calendar are increasing with hotter temperatures extending further north. The Center for Climate Integrity determined that most schools experiencing 80 degrees and higher for at least 32 days of a school year had air conditioning. Using that baseline and 2025 temperatures, the study estimated that 13,700 additional schools will need air conditioning, totaling more than $40 billion in investment needs.[28]

National weather trends show higher air temperatures further north; as a result, air conditioning retrofits are increasingly needed for schools located higher in latitude. Also, the funding resources of local school districts reveal a disparity: northern state schools in high-income communities may already have A/C installed, but their neighboring districts in lower-income areas may not. The Center identified schools in rural, under-resourced communities needing A/C as far north as Washington, Idaho, Montana, and North Dakota.

Need for Cooling Systems at American Public Schools, by County



Source: Center for Climate Integrity, used with permission

PUBLIC SAFETY

Traffic safety is a growing concern at school facilities and campuses, in part because American families now drive their kids to school more than ever before. The use of private vehicles for student pickup and drop-off has grown from less than 20% in 1969 to almost 54% in 2022, with only 10% of students now using active forms of transportation like walking or biking.[29] In suburban and rural communities, space is easier to dedicate to safe vehicle loading areas, but streetscapes in those areas are sometimes less safe for people walking or biking.[30]

The increased use of cars overlapping with bus operations has correlated with more pedestrian fatalities in recent years. The issue generates new urgency for engineers to design streetscapes that protect vulnerable road users on campus. Regional planning organizations and state or local departments of transportation have accessed federal money for "Safe Routes to School" since 2005.[31] The Infrastructure Investment and Jobs Act (IIJA) increased funding to the program by $1.4 to $1.5 billion annually, up from $850 million in 2019, and limited the ability of states to redirect the money away from these "transportation alternative" projects.[32] Although the resource is helpful, requests for these funds consistently outweigh availability, and extensive regulatory review at historic campuses hampers project delivery.[33]

Safety in numbers has been the approach of a growing movement, "walking school buses" or "bike buses," with experienced parents and school officials leading organized groups to and from schools.[34] Success of these programs are higher when financial incentives are provided, and school staff are involved in the operations of each bus for walkers and families biking.[35]

RESILIENCE AND INNOVATION

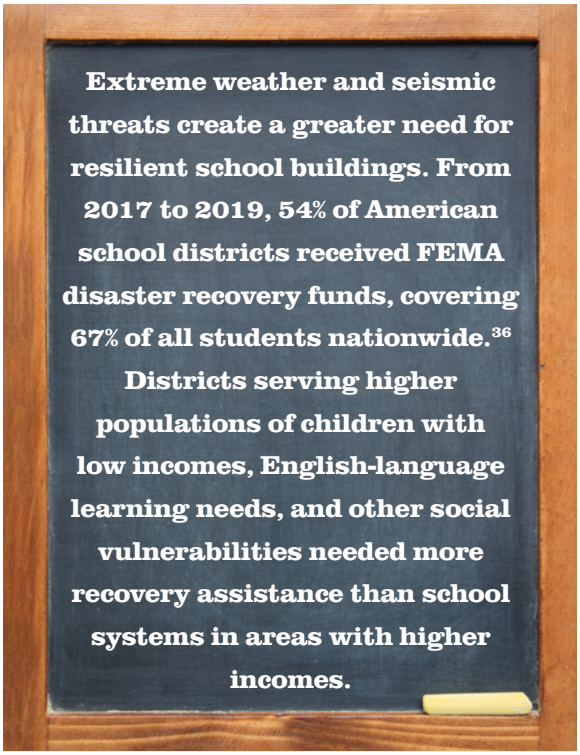
Extreme weather and seismic threats create a greater need for resilient school buildings. From 2017 to 2019, 54% of American school districts received FEMA disaster recovery funds, covering 67% of all students nationwide.[36] Districts serving higher populations of children with low incomes, English-language learning needs, and other social vulnerabilities needed more recovery assistance than school systems in areas with higher incomes.

Photo: Gordon Chaffin

The majority of public schools (93%) have some athletic facilities on site, with a gymnasium most frequently reported at 69%.[38] Those large spaces can be helpful for schools to serve as command centers and shelters during disasters. A 2021 University of North Carolina study showed demonstrated benefits of schools supporting disaster recovery in the aftermath of Hurricanes Matthew (2016) to Florence (2018).[39]

One example of a school serving community resilience is River Grove Elementary School in Lake Oswego, OR, which serves residents who need to evacuate. The school was recently rebuilt to withstand seismic events and to generate and store electricity on site with a microgrid. The facility, welcoming students in Fall 2024, was designed with high-performance building codes and structural integrity on par with a hospital or fire station.[40]

These upgrades typically come with high up-front costs, although they save money over time with reduced financial risks. The Batesville School District in Arkansas estimates that an initial investment toward solar power generation and conservation of water and electricity usage will result in $4 million of savings from utility bills over 20 years.[41] School leaders can seek creative funding sources to bridge the gap between up-front costs and accumulated savings.



One such source is competitive grants from the Renew America's Schools program housed within the U.S. Department of Energy, which helps schools perform energy retrofits and upgrade HVAC systems.[42] Another federal funding opportunity for schools is USDA's Rural Development Electric programs.[43]

Data show increasing extreme "heat day" closures at public schools each of the last few years.[44] Schools in Baltimore and Detroit closed early in September 2023 just as they had done in May of that year, as the previous school year was ending.[45] Philadelphia Public Schools moved their first school days from August 2023 to early September to mitigate heat closures suffered in the previous year, but 86 schools in the Philadelphia system ended up dismissing early anyway during the full opening week of SY23–24.[46]

To meet resilience needs and implement the latest research on public health, some state and local governments are rethinking school facility design.[47] In Oakland, CA, the public school system partnered with Trust for Public Land to create green spaces out of campus playgrounds. Natural landscape elements reduce extreme heat on hardtop play surfaces and improve social and emotional well-being of students.[48] One 2024 study estimated that most California public schools have less than 5% tree canopy, a measure of land area that is naturally shaded.[49] Tree planting also assists with stormwater management, a task with infrastructure regulations from which some school districts are exempt, like the Los Angeles Unified School District.[50]

Finally, broadband is key at school facilities where teachers now upload lesson plans, communicate digitally with parents, and even deliver multimedia instruction to students using devices for class in person. In 2023, 74% of public school districts met a Federal Communications Commission benchmark on bandwidth per student, up from 67% and 59% in the previous two years. Increased connectivity came with annual improvements in an affordability metric and coincided with a surge in federal money to states for broadband deployment and improvements.[51]

RECOMMENDATIONS TO RAISE THE GRADE

- Expand school facility data already collected by the National Center for Education Statistics and encourage the U.S. Department of Education to coordinate with school districts to collect and publish statistics on school infrastructure conditions, investment needs, and emerging threats to students and staff.
- Improve coordination across federal and state governments on necessary technical assistance and funding mechanisms to implement building condition assessments of existing school infrastructure and staffing to support ongoing, proactive maintenance.
- Establish regular, predictable funding mechanisms for physical school infrastructure, providing equitable investments in lower-income communities.
- Urge school districts to adopt life-cycle cost analysis principles in planning and design processes to evaluate the total cost of projects and achieve the lowest net present value cost, including life-cycle O&M, in addition to capital construction.
- Develop capital planning frameworks at the school district level to enhance resilience to extreme weather requiring new structures and retrofits to use the most up-to-date codes and standards.
- Update the Government Accountability Office's 2020 study on school facility conditions: "K–12 Education: School Districts Frequently Identified Multiple Building Systems Needing Updates or Replacement."
- Increase dedicated funding at national and state levels for Safe Routes to School projects; reduce regulatory compliance burdens for these traffic safety projects; and provide technical assistance to schools and districts seeking safer street designs for walking, biking, and driving at or near campuses.
- Explore alternative financing for public school facilities, including lease financing, as well as ownership and use arrangements, to facilitate school construction projects.

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Solid Waste
C+
GRADE COMPARISON
2025: C+
2021: C+
Photo: Sigmund

SOLID WASTE

EXECUTIVE SUMMARY

The nation's solid waste management system—trash and recycling—is managed by both the public and private sector and is funded by user fees and some government grants or dedicated program funds. Little data exists on solid waste, in part because of its management by private companies. Available information from federal and state government is updated infrequently. Based on public data, funding and capacity are currently sufficient to address immediate needs despite steady growth in the volume of municipal solid waste (MSW)—from 251 million tons in 2010 to 292 million tons as measured in 2018. Meanwhile, demand for recyclable materials has weakened, and alternative funding sources or market incentives have not been scaled. After rising in previous decades, recycling rates are plateauing, having grown from 14.5 million tons in 1980 to 65 million in 2010 and 69 million in 2018.[1] Potential risks to public health are emerging contaminants such as per- and polyfluoroalkyl substances (PFAS) found in legacy landfills. These chemicals will require improved monitoring and treatment. To enhance America's solid waste systems, decision-makers should update policies and practices to use MSW as a resource and mobilize improved catalysts for residential and commercial waste diversion.

BACKGROUND

Municipal solid waste (MSW), more commonly called trash or garbage, consists of everyday items that are used and then thrown away, such as product packaging, grass clippings, furniture, clothing, bottles, food waste, newspapers, appliances, paint, and batteries. After these items are removed from the waste stream for recycling and composting, the remainder is deposited into disposal facilities. The nation's solid waste management system comprises landfills, waste transfer stations, recycling centers, composting facilities, and waste-to-energy facilities, all of which are interconnected with the nation's other critical infrastructure systems, including roads, rail, energy grid, telecommunications, among others.

American cities lacked organized refuse collection removal until the early 1800s. The lack of state and regional funding made solid waste management a local responsibility, centered on municipal dumps. City and county sanitation departments expanded nationwide and included trucks, motorized street sweepers, incineration, and open landfills that were developed in the following decades. The Resource Conservation and Recovery Act of 1976 (RCRA) is the defining legislation for MSW management practice in America today. It forced the closure of open dumps nationwide, though not always properly, and required regional planning for MSW, including recycling.

The U.S. waste and recycling industry was worth an estimated $91 billion in revenue during 2022, up from $82 billion in 2021.[2] The sector employs 135,000 workers nationwide, and there are nearly 180,000 refuse trucks on the road in North America today.[3]

CAPACITY AND CONDITION

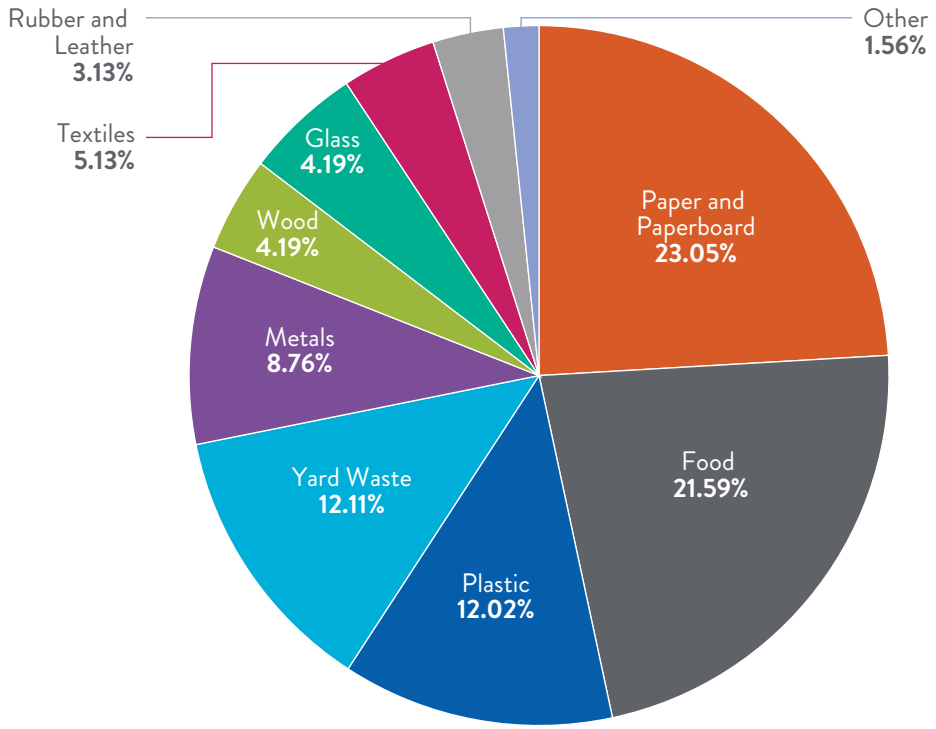
The Environmental Protection Agency (EPA) found that the total generation of MSW in 2018, the last year data was made available, was 292.4 million tons or 4.9 pounds per person per day. This compares to 262 million tons in 2015 and 251 million tons in 2010 and represents an increase in the per capita MSW generation rate from 4.45 to 4.51 pounds per person/day between 2010 and 2018.[4] Although MSW generation per person is growing, the 7.4% population growth over the same period accounts for much of that growth.[5] Approximately 69 million tons of MSW were recycled, 25 million tons were composted, and 35 million tons were combusted for energy recovery, which equates to 44.1% of this generated MSW being productively reused.[6]

For decades, the U.S. relied on selling recyclables in international markets to help manage the nation's municipal waste. From 2010 to 2017, the U.S. exported an annual average of $3.3 billion of wastepaper for recycling (accounting for 36% of the world's wastepaper exports in 2017), and China was the main wastepaper destination, averaging 60% of the exports over this period. In 2018, the Chinese government through its National Sword policy banned imports of various plastics and mixed papers and set a standard for contamination levels that most U.S. exporters of recyclables could not meet, thus reducing an important source of international demand for U.S. recyclables. A replacement for this market has proved challenging and seriously impacted the ability to expand recycling programs.[7]

According to the Organization for Economic Co-operation and Development (OECD), when dealing with plastic waste in 2019, the U.S. mismanaged (litter) 4%, placed in landfills 73%, incinerated 19%, and recycled just 4%.[8] Most plastics in use today are primary plastics, made from crude oil or gas. Global production of plastics from recycling has more than quadrupled from 6.8 million tons in 2000 to 29.1 million tons in 2019, but this is still only 6% of the size of total plastics production.[9]

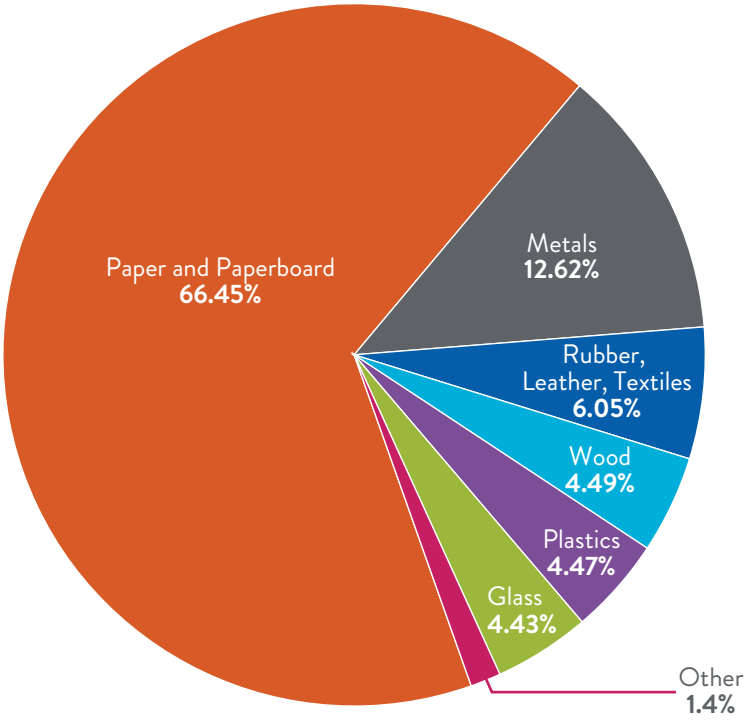
An additional 17.7 million tons of food waste management pathways are supported by animal feed, bio-based materials/biochemical processing, co-digestion/anaerobic digestion, donation, land application, and sewer/wastewater treatment. Finally, nearly 35 million tons of MSW (11.8%) were combusted with energy recovery, and more than 146 million tons of MSW (50%) were landfilled.[10]

EPA Source Generation, 2018



Source: National Overview: Facts and Figures on Materials, Wastes and Recycling | US EPA

EPA Recycling by Materials, 2019



Source: National Overview: Facts and Figures on Materials, Wastes and Recycling | US EPA

Although information on compost production and distribution, and characteristics of compost facilities and compost operations are limited, compost production appears to be growing in the U.S. According to the Environmental Research and Education Foundation (EREF), in a survey of over 300 composting facilities, the number of facilities increased by 55% between 2016 and 2021, whereas an 83% increase in tonnage was processed. Similar growth was also observed from 2016 to 2019 with a 39% increase in the number of active facilities and a 57% increase in the tonnage processed.[11]

In 2022, 63 U.S. power plants generated about 12.8 billion kW·h of electricity from burning about 26.6 million tons of combustible MSW for electricity generation. Biomass materials accounted for about 61% of the combustible MSW's weight and about 45% of the electricity generated. The remainder of the combustible MSW was non-biomass material, mainly plastics. Many large landfills also use landfill gas to energy facilities supplying power to the utility grid using the methane gas produced from decomposing biomass in landfills. In comparison to peer countries, Japan combusts approximately 75% of its MSW, whereas the United Kingdom combusts 42%. The lack of available land in those countries plays a role in the high usage of waste-to-energy facilities.[12]

Closed landfills are also used for solar power with government incentives such as the Inflation Reduction Act geared toward reducing carbon emissions. When the energy potential (methane) dwindles while the landfill is closed, a developer can use the interconnection already in place from a methane capture facility to add a solar facility.

FUNDING AND FUTURE NEED

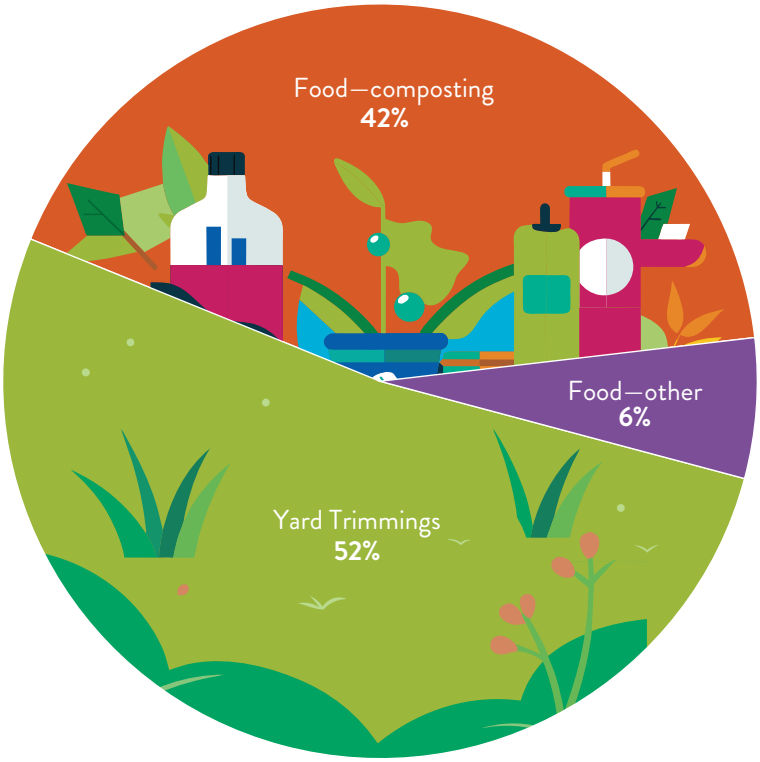
The solid waste industry, including trash collection, landfills, recycling facilities, and waste combustion costs, is self-funded through trash collection or tipping fees and the sale of recycled materials and energy. While the Infrastructure Investment and Jobs Act (IIJA) provided funding for the solid waste sector, funds were not eligible for Operation and Maintenance. Under IIJA, EPA is developing three new waste prevention, reuse, and recycling programs: Solid Waste Infrastructure for Recycling Grant Program, the Recycling Education and Outreach Grant Program, and the Battery Collection Best Practices and Voluntary Battery Labeling Guidelines.

Tipping fees are paid by those who dispose of waste in a landfill. The fee is based on the weight of the waste and used to cover the costs of landfill operations, including construction, operations, and closing costs. Some states have tipping fees that are collected by the state, while others allow local municipalities to collect the fees.

A survey of 342 landfills found a decrease in average tipping fees to $56.80 in 2023, a 3% drop from the 2022 fee of $58.47, but higher than the $55.36 tipping fee in 2019. The survey also measured weighting fees based on the relative amount of MSW disposed via landfills and the tip fee at each facility to create a ton-weighted average. The ton-weighted average decreased to $57.63 in 2023, a ten-cent decrease from the $57.73 weighted average in 2022. Tipping fees fluctuate over time and range widely among states, regions, and municipalities.[13]

Compost facilities rely on differing revenue sources with larger facilities relying on tipping fees for 80% of their revenue, while smaller facilities generate more revenue from product sales and "other" revenue streams. EREF market analysis shows that approximately one-third of the compost produced is sold for agricultural purposes, and landscaping was the most common market with 68% of materials sold to this market.[14]

EPA Composting, 2018



Source: National Overview: Facts and Figures on Materials, Wastes and Recycling | US EPA

OPERATION AND MAINTENANCE

The waste disposal industry operates largely at the local level. A 2001 snapshot of the U.S. waste disposal enterprise by EREF estimated 27,000 organizations, both in the private and public sector, provide solid waste collection and disposal in the United States; more than 55% of these were in the public sector, and the remaining 45% were privately held.

Landfills in the U.S. are subject to some EPA regulations designed to ensure public safety and protect the environment. Landfills are designed with multiple layers of protection to prevent leachate from entering the groundwater or polluting the soil. A layer of soil or other appropriate material reduces air emissions, odors, and wind-blown litter, discouraging scavengers. Once complete, landfills are subject to strict regulations and monitored following closure. While landfills are an unpopular necessity, they represent the final stop for waste that cannot be otherwise reused. When properly regulated, multiple safeguards are put in place to prevent decomposing waste from harming the environment or creating a public nuisance.[15]

In 1978, the Supreme Court recognized that interstate transportation of solid waste was "commerce" within the meaning of the Commerce Clause. The justices struck down a New Jersey regulation that banned the disposal of waste that originated outside the state, in turn limiting the ability of states to ban the import of MSW.[16]

States play a lead role in addressing federal criteria for operating MSW and industrial waste landfill regulations and may set more stringent requirements. Without an approved state program, waste facilities must meet federal requirements. Regulations address common design elements associated with landfills, including location restrictions, liner requirements, leachate collection, greenhouse gas emissions and removal systems, groundwater monitoring requirements, and closure and post-closure care requirements.

Photo: U.S. Environmental Protection Agency

States play a lead role in addressing federal criteria for operating municipal solid waste and industrial waste landfill regulations and may set more stringent requirements. Without an approved state program, waste facilities must meet federal requirements.

PUBLIC SAFETY

Solid waste management is closely tied to other infrastructure, such as roads, bridges, rail, energy, and inland waterways, such that service interruptions elsewhere can have an impact on solid waste collection and, in turn, compromise public health. Disasters often result in significant amounts of debris, which put pressure on local waste collection and disposal systems. These impacts can be amplified by damage to other forms of infrastructure such as roads and bridges, which compromise the removal of debris.

The Centers for Disease Control and Prevention found that most people in the U.S. have been exposed to a potentially harmful class of synthetic chemicals, called PFAS, for short, which are increasingly found in landfills. These chemicals are found in products that are discarded in landfills, such as nonstick cookware, waterproof clothing, and firefighting foams used to extinguish aircraft fires quickly and prevent them from reigniting. Exposure to certain levels of PFAS can cause adverse health effects, including cancer. Currently, no discharge limits are tied to leachate from landfills. However, some facilities are being asked to test their leachate and are being proactive with treatment of the leachate and managing residuals of treatment.[17]

RESILIENCE AND INNOVATION

Natural disasters are a concern for landfills and other waste management facilities as they are for all forms of infrastructure. Events such as floods, hurricanes, earthquakes, and others generate large amounts of debris, causing considerable disposal challenges for local public officials. However, facilities are designed factoring in safety when it comes to rainfall events, often placing them away from floodplains. Weather events are becoming more frequent, and clients, regulators, and designers are evaluating additional factors of safety beyond current design regulations.[18]

From innovative landfill designs to advanced equipment, new technologies are playing a role in improving landfill operations' efficiency, safety, and sustainability. One example is uncrewed aerial vehicles (UAVs). UAVs monitor and manage landfills using artificial intelligence to analyze data collected from landfills and predict potential issues. Machine learning algorithms can also be used to identify the types of waste being dumped at the landfill, which can help with waste segregation and recycling.

Innovative technologies and recycling efforts have proven successful in improving the safety, sustainability, and efficiency of the nation's waste disposal system. However, both the continued underuse of waste-to-energy practices and the potential of recycling highlights the need for research and development of new policies, economic feasibility plans, and management practices.

RECOMMENDATIONS TO RAISE THE GRADE

- Promote, enhance, or facilitate the development of resource recovery facilities, including those for recycling, composting, reuse, and energy recovery, as well as technologies for reducing waste generation.
- Develop cost-effective recycling and sustainable waste handling options for municipalities, specifically in communities where scale and the use of older outdated systems is an impediment.
- Emphasize source reduction through redesigning the manufacturer's packaging of goods, setting standards for the recyclability of materials (e.g., single-use plastics), and addressing the true cost of waste by implementing deposits on bottles and fees on plastic bags.
- Encourage programs that educate on the reduction of food waste and the composting of what is generated.
- Strengthen domestic markets for recycled materials in the U.S. by supporting companies looking to build domestic reprocessing plastic facilities and reuse plastics.
- Promote materials as reusable with a life cycle beyond initial use, and pivot solid waste beyond "garbage" or "trash" to potential resources.
- Oppose efforts to ban the interstate movement of MSW to regional solid waste facilities designed by state and federal regulations, recognizing that such transport may be appropriate and beneficial in regional solid waste planning efforts.
- Accelerate and increase investment in PFAS research aimed at the characterization, treatment, and analysis of these compounds and understanding their health impacts.

Photo: Wipeoutwaste Mecknc.gov

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Photo: Urban Drainage System

STORMWATER

EXECUTIVE SUMMARY

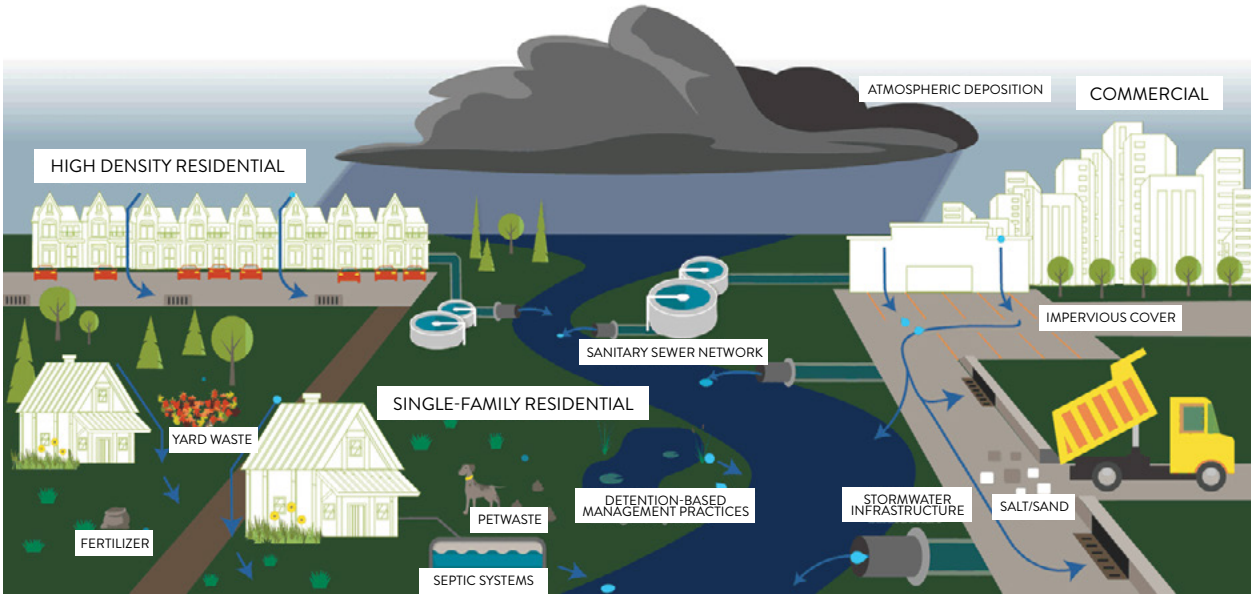
Across the U.S., stormwater utilities are working to manage the infrastructure that conveys rain or snowmelt from communities to nearby bodies of water. However, over the last decade, the length of impaired rivers and streams has increased from about 424,000 miles in 2010 to more than 588,000 miles in 2019, and in 2022, more than 703,000 miles. Although some of this may be attributable to increased monitoring and more stringent state-level assessment criteria, more than 60% of the nation's stormwater utilities have explained that aging infrastructure poses a significant concern for their long-term needs. To locally fund growing capital and maintenance costs, stormwater utilities are increasing fees as the average bill across the country is on the rise, though it is not keeping pace with the demands. Nationally, the U.S. Environmental Protection Agency's 2022 Clean Watershed Needs Survey (CWNS) estimated the 20-year need for large stormwater systems (Municipal Separate Storm Sewer Systems) had increased from $23.8 billion in 2012 to $115.3 billion a decade later. To address this need, Congress passed the Infrastructure Investment and Jobs Act in 2021 and the Inflation Reduction Act in 2022 with $46 billion in new funding for the stormwater, wastewater, and drinking water sectors between 2022 and 2026. While this funding has been useful, it still leaves a significant gap.

BACKGROUND

Stormwater runoff is the rain or snowmelt that travels over impervious surfaces, as well as landscaped or agricultural areas, that is then collected and carried into streams, rivers, lakes, bays, or oceans. No comprehensive national database of stormwater infrastructure exists, yet a 2021 estimate suggests there are 3.5 million miles of storm sewers, 270 million storm drains, and 2.5 million stormwater treatment assets across the country.[1,2,3,4,5,6,7] As the area covered by impervious surfaces expands at a rate of 1% every five years, impacts of stormwater runoff increase and can lead to urban flooding. [8,9,10,11]

An impervious surface reduces the natural movement of rainfall into groundwater, which is called infiltration. As cities develop, the area of natural, vegetated landscape is reduced, typically because it is replaced by roads, buildings, parking lots, and other features that do not facilitate infiltration.[12]

Stormwater Runoff in Urban Watersheds



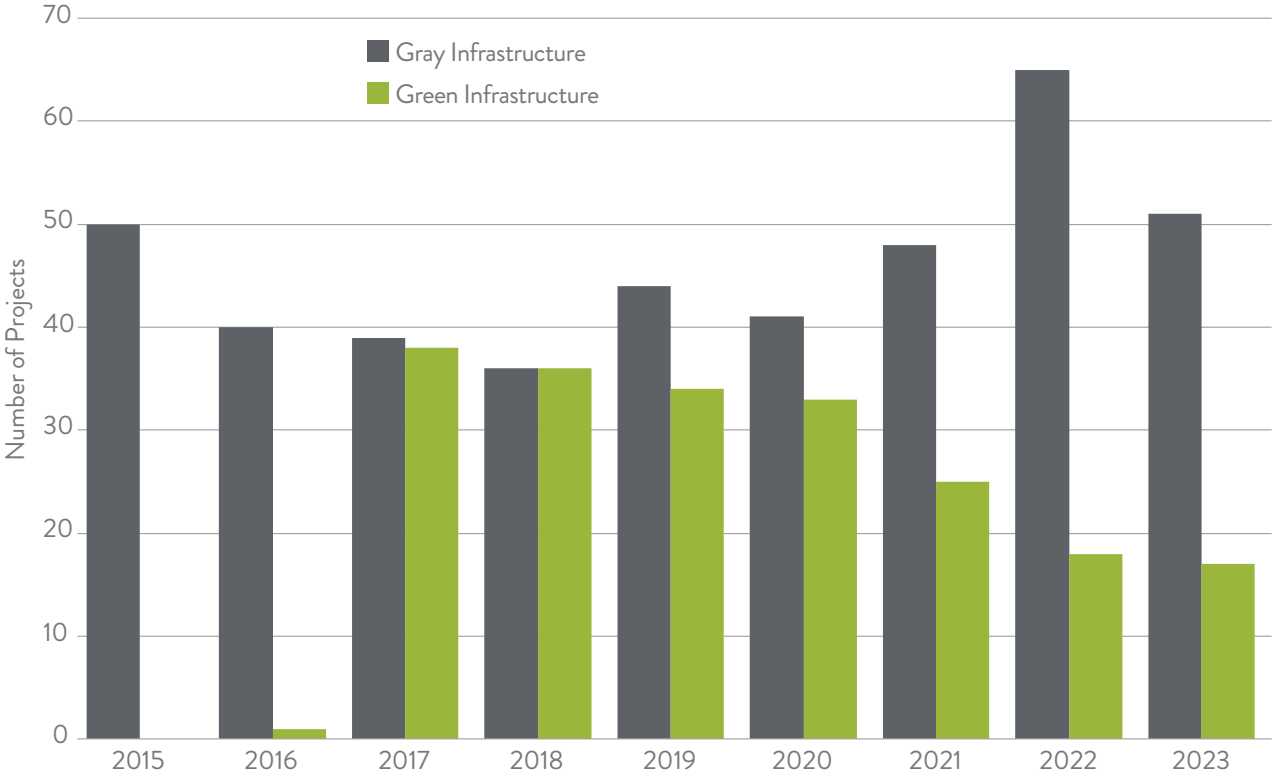
Source: *U.S. Geological Survey, "Stormwater Runoff in Urban Watersheds," 2023*

CAPACITY

In 2023, the U.S. Global Change Research Program published the Fifth National Climate Assessment and identified that intense, single-day precipitation events have been on the rise for the last few decades. While heavier precipitation does not necessarily mean the total amount of precipitation is increasing everywhere, it does mean the occurrences exhibit more of a "flash" or severe effect.[13] These changes to the frequency and intensity of precipitation strain the current capacity of the nation's stormwater infrastructure. In turn, implications exist for future design capacities of new and recently upgraded systems.

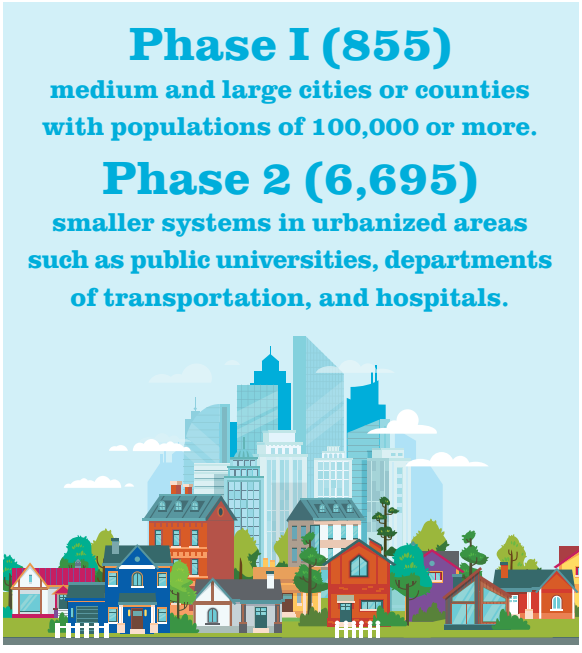
Stormwater infrastructure can take many forms, including piped systems, detention basins, ditches, canals, channels, and roadway conveyance systems. In recent years, green stormwater infrastructure has been incorporated into new developments, retrofitted alongside older systems, and coupled with traditional "gray infrastructure" to maximize the benefits from naturalized hydrologic conditions by using vegetation, soils, site grading, and natural filtration processes.[14] Green infrastructure, for example, rain gardens, constructed wetlands, vegetative buffers, roadway bioswales, and permeable pavements, provides benefits by reducing runoff, minimizing erosion, and contributing to water quality improvements.[15] Since 2015, the number of green and gray stormwater infrastructure projects funded by the Clean Water State Revolving Fund Program (CWSRF) has grown with gray infrastructure projects outpacing the implementation of green infrastructure in recent years.[16] Although green infrastructure is critical in addressing localized drainage and water quality, these systems cannot provide sufficient capacity to manage large-scale stormwater events.[17]

Change Over Time in the Number of Green and Gray Stormwater Infrastructure Projects Funded by the CWSRF Program



Source: U.S. Environmental Protection Agency, "Clean Water SRF Program Information National Summary," 2023

The U.S. EPA developed a classification of stormwater systems called Municipal Separate Storm Sewer Systems (MS4s) to address stormwater discharge from large urban or suburban areas. MS4s are publicly owned, discharge into U.S. waters, and are regulated by the EPA under the National Pollution Discharge Elimination System (NPDES) program. Apart from EPA regulations, states, counties, and local governments may require stormwater management practices through local ordinances, building codes, and development plans. According to the EPA, there are 855 Phase I MS4s (typically, medium or large cities and certain counties) and 6,695 Phase II MS4s (typically, smaller systems and other non-traditional systems) across numerous cities and counties subject to MS4 discharge regulations.[18]



CONDITION, OPERATION AND MAINTENANCE

Stormwater systems are designed to capture and move runoff to nearby bodies of water. However, performance efficiency and effectiveness can deteriorate as systems age. In the Water Environment Federation's (WEF) 2022 National MS4 Needs Assessment, more than 60% of surveyed stormwater utilities (643) cited aging infrastructure and workforce/staffing needs as critical challenges to properly functioning systems.[19]

To influence the performance of operation and maintenance (O&M) practices and ensure routine inspections, the MS4 NPDES permitting process has worked as an effective regulatory lever. Under the NPDES program, all MS4s are required to have maintenance plans for their stormwater systems. From 2018 to 2021, the number of stormwater utilities developing and implementing maintenance plans has increased from 38% to 42%. More MS4 Phase I respondents indicated having a stormwater asset management plan than the MS4 Phase II group, with 63% and 35%, respectively.[20]

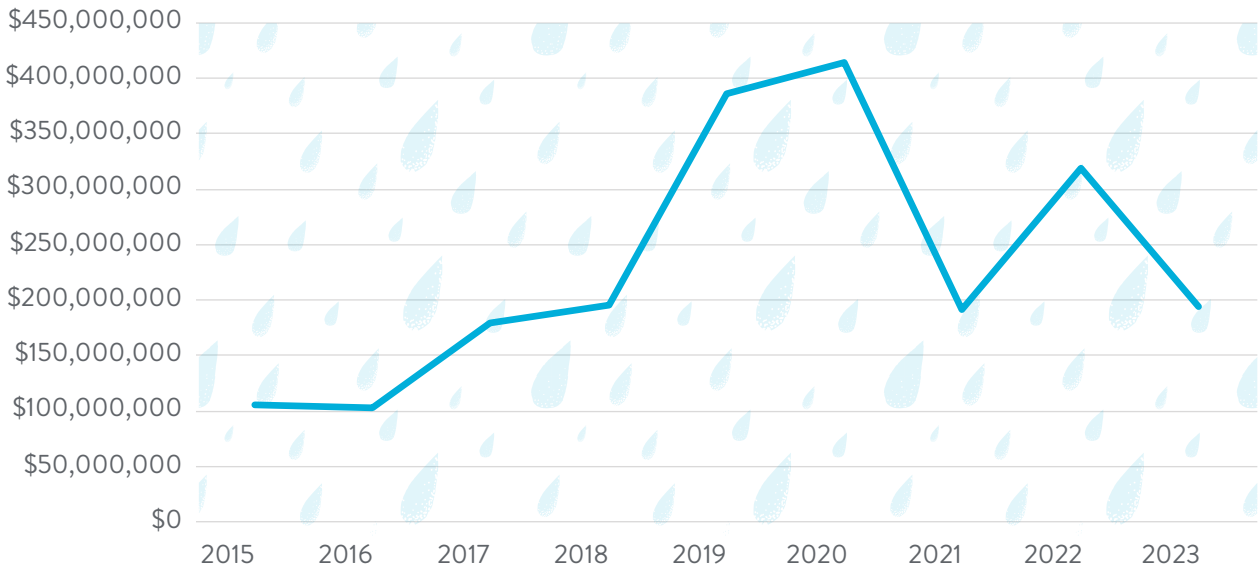
Stormwater assets may be implemented, owned, and managed by various public or private entities such as state or local governments, individual or corporate property owners, or homeowners' associations. When private entities, cooperatives, and individual homeowners are responsible for O&M, organizations can be ill-prepared or unaware of their sometimes expensive stormwater O&M responsibilities. A few consequences of deferred maintenance are the potential increase in the likelihood of urban flooding and threats to water quality. In the U.S., the length of impaired rivers and streams increased from about 424,000 miles in 2010 to more than 588,000 in 2018 to over 703,000 in 2022.[21] However, the EPA expects state agencies to set their own criteria for water quality monitoring and assessment. This includes the frequency of data collection, methods for analyses, and approach to impairment classification. As such, the increases may be due to higher reporting frequencies or more stringent water quality assessment criteria, among other factors.[22,23]

FUNDING AND FUTURE NEED

In 2021, the IIJA was enacted, soon followed by IRA in 2022, adding new funding of $46 billion to assist stormwater, wastewater, and drinking water sectors from 2022 to 2026. However, this funding is primarily focused on modest increases to low-interest loan programs.[24,25]

Around the same time, according to the EPA's 2022 CWNS, the 20-year capital improvement need was estimated at $115.3 billion for all MS4s and unregulated communities, an increase from $23.8 billion estimated in 2012.[26] Although the reported value does not encompass all stormwater infrastructure needs, it expands the scope of stormwater projects incorporated in the CWNS. The expanded scope includes the impacts of changing stormwater management requirements and the effects that more impervious surfaces have on the volume of stormwater utilities must manage. Overall, the recent funding, though helpful, does not meet the projected needs of the CWNS.

Change Over Time in the Amount of Federal Funding for Stormwater Infrastructure Projects Supported by the CWSRF Program

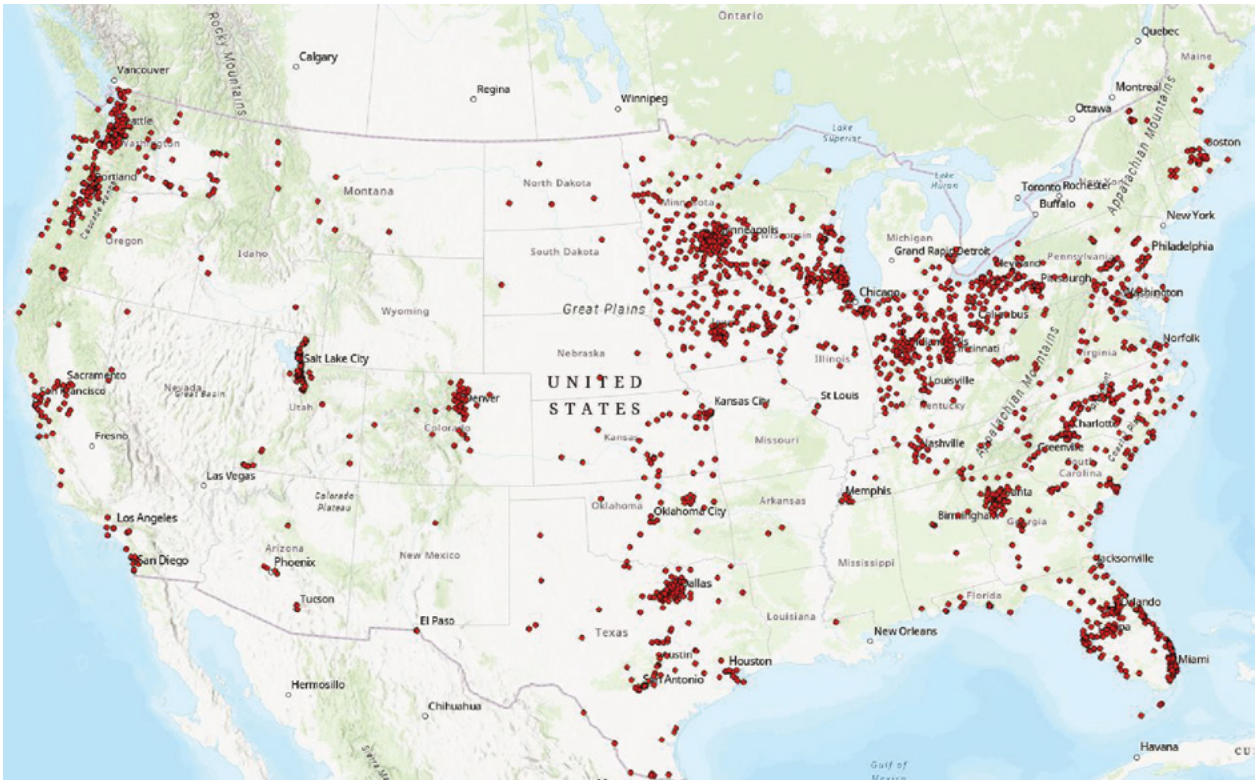


Source: U.S. Environmental Protection Agency, "Clean Water SRF Program Information National Summary," 2023

Stormwater utilities support a wide variety of community sizes and geographies. For instance, utilities provide services to populations as small as 80 households to more than 10 million people, with the average utility serving about 16,000 people. These services are provided in varied contexts, including coastal, midwestern, and mountainous areas across urban, suburban, and rural settings.[27] Further, as diverse as the nation's stormwater landscape is, so is the sector's approach to funding and financing the infrastructure's current and future needs. Mechanisms for bringing together financial resources include generating local revenue through stormwater fees, applying for state and federal grants and financing, and accessing non-traditional funding streams.

Stormwater rates are critical for financially supporting utilities, but average bills vary significantly nationwide. According to 87% of utilities surveyed, stormwater rates are primarily determined by using impervious areas to estimate stormwater charges. However, land use and parcel attributes are dynamic and frequently subject to change, so utilities are being stretched to consider best practices for managing and analyzing data to effectively inform revenue generation and billing. At the same time, 54% of the utilities indicate they do not have a defined protocol to update and maintain the data that support an adaptive approach to stormwater billing.[28]

U.S. Stormwater Utilities



Source: Campbell, Warren, and Emily G. Davis, "Western Kentucky University Stormwater Utility Survey 2023," 2023

Although the average household bill for stormwater is increasing, it is not keeping pace with utilities' growing capital and maintenance costs.[29] According to Western Kentucky University's 2023 stormwater report, for a single-family home, the average monthly stormwater fee increased from $5.34 in 2018 to $6.06 in 2023.[30] Likewise, Black & Veatch's 2021 stormwater research determined nearly the exact value for the average monthly fee at $6.08.[31] Of the utilities that responded to B&V's 2021 Stormwater Utility Survey, 31% indicated the funding they currently generate is inadequate to meet both their O&M and capital revenue requirements, whereas 42% shared that they can cover all their O&M but only limited levels of capital needs.[32]

PUBLIC SAFETY AND INNOVATION

Data from the National Oceanic and Atmospheric Administration (NOAA) shows show an increase in the frequency and severity of disasters costing greater than $1 billion. From 2010 to 2019, there were more than 130 major disaster events; more recently, from 2019 to 2023, nearly the same number of major disasters (102) were recorded. Flooding is within the top three most costly and common threats to communities.[33] However, for communities with limited resources, additional vulnerabilities may exist. For instance, some low-income communities experience long-term flood risks, making them particularly vulnerable to the dynamic between increased rainfall intensity, rainfall frequency, and development of impervious surfaces.[34] Therefore, as stormwater infrastructure and design regulations are more carefully considered, communities become more protected from costly urban flooding, and waterways are safeguarded from significant water quality impacts.

One way of addressing design and planning needs for state and local infrastructure, especially in a especially as precipitation patterns shift, is the expected release of Atlas 15, NOAA's Precipitation Frequency Standard.

While this innovative tool will not be fully available until 2027, pilot outputs are being released on a rolling basis. Currently, Atlas 14 includes data used to assess floodplains, size sewers, design best management practices, and establish safe estimates of stormwater moving through urban and suburban landscapes. The next iteration of this tool will build on Atlas 14 through the critical inclusion of extreme weather in its assessments. Furthermore, the precipitation frequency estimates will be developed for the entire U.S. and its territories, accounting for temporal trends in historical observations and future climate model projections over time. Such information will be necessary for more informed design and planning of critical infrastructure such as the nation's stormwater systems.[35]

RESILIENCE

Impacts from climate change will present more frequent extreme weather across the nation.[36] Therefore, stormwater infrastructure resilience is reflected by an optimized mix of green, gray, and natural infrastructure; land-use planning and urban growth; updated asset management and emergency action plans; and, in water-scarce areas, the productive reuse of stormwater.[37,38]

To withstand the variable effects of extreme weather, stormwater infrastructure is increasingly developed with a context-sensitive approach that leverages a localized understanding of flood risk, land-use practices, and regulatory expectations. This approach informs the design, siting, and long-term sustainability of the stormwater systems. These localized approaches to resilience are often published in an emergency action plan, which aids a stormwater utility in handling all types of emergencies. In 2021, only 29% of the B&V Stormwater Survey respondents from MS4 Phase II indicated having an emergency response plan.[39] Similarly, WEF's MS4 survey revealed that only 26% of municipalities use updated design standards and specifications to address extreme weather and stormwater resilience.[40]

Photo: Irina Ukrainets

RECOMMENDATIONS TO RAISE THE GRADE

- Establish a database of the nation's stormwater assets.
- Develop a stormwater-specific funding and financing program based on best practices from the existing Clean Water State Revolving Fund and ensure stormwater infrastructure is fully eligible to receive funding and financing from federal programs supporting drinking water and wastewater infrastructure.
- Develop a comprehensive publicly facing education campaign on the true costs, savings, risks, and avoided hazards associated with resilient stormwater investments; disseminate these details through broadly accessible platforms.
- Develop state-based peer-to-peer partnerships to build local government capacity to create and manage stormwater utilities that sustainably fund, operate, maintain, assess, and, when necessary, expand stormwater infrastructure.
- Stormwater infrastructure and design regulations must be carefully considered to protect communities from costly urban flooding and waterways from significant water quality impacts.
- Establish a grant program for 21st century technical career training for "green collar jobs" in the stormwater sector that recruit the next generation's talent and mainstream tools for data-driven decision-making, such as asset management software, life-cycle cost analysis, and affordable rate structuring.
- Expand the inclusion of current and forecasted climate variability in codes and standards for the design, operation, maintenance, and expansion of stormwater infrastructure, and routinely provide funding to NOAA to update the climate data.
- Communities should create stormwater utilities that institute rates reflecting the true cost of treating and handling stormwater runoff.
- Encourage stormwater systems consisting of a combination of gray, green, and natural infrastructure and ensure these options are a mainstream part of the planning and development process nationwide.
- Address point source and nonpoint-source pollution through a watershed approach that encourages regional coordination to improve impacts from stormwater-induced flooding.

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Transit

D

GRADE COMPARISON

2025: D

2021: D-

Photo: Jared Murray

TRANSIT

EXECUTIVE SUMMARY

Public transit is essential to America's transportation network, with residents taking 34 million trips each weekday in 2023. However, ongoing and unexpected circumstances have positioned transit for a hard-to-predict future. The pandemic caused steep declines in ridership, as much as 80% in April 2020. By 2023, transit ridership only increased to 73% of pre-pandemic levels.[1,2] Both federal pandemic aid and infrastructure investment were pivotal in maintaining transit services. The Infrastructure Investment and Jobs Act (IIJA) provided transit with $108 billion in support, which is being used to address deferred maintenance and break ground on long-sought capital projects. However, due to years of deferred maintenance, a funding gap of $152 billion still exists over the next ten years for the nation's transit systems.[3] In addition, while states and localities are working to expand transit access, rising costs, a lack of support for operations, and the impact of work-from-home jobs create challenges. Greater transit access, reliable service, and increased ridership will depend on sustainable funding and communities incorporating transit into multimodal transportation plans.

BACKGROUND

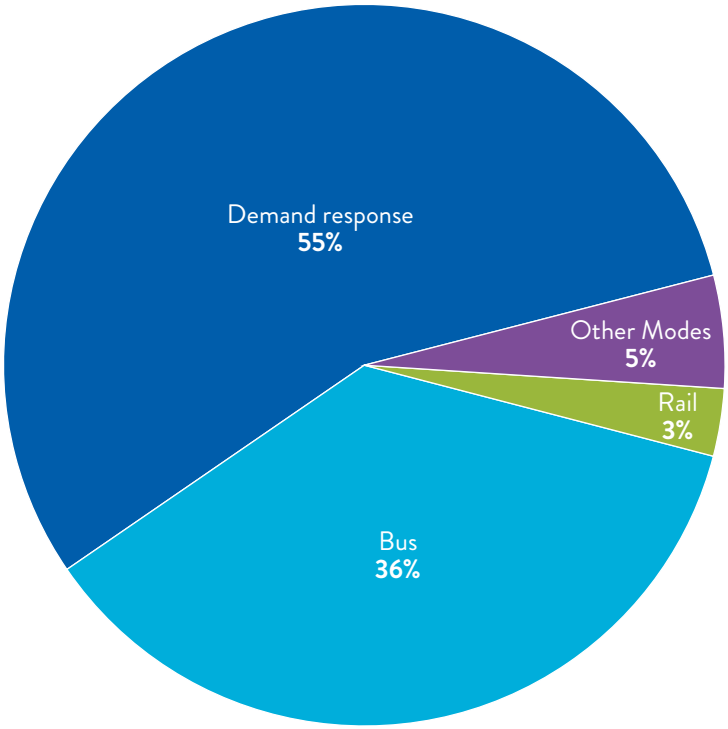
Public transportation in the U.S. has a rich and extensive history. From the first public ferry in the 1600s era Boston harbor to streetcar and rail operations in the 1800s, early advancements allowed mass movement of people in the nation's urban centers and beyond. In the 21st century, federally initiated policies such as the Fixing America's Surface Transportation (FAST) Act and Federal Transit Administration (FTA)-directed Transit Asset Management (TAM) Plans have led to comprehensive improvements across transit planning and development. As IIJA injected robust resources into the nation's infrastructure, local and regional transit agencies received critical support to advance transit facilities throughout the nation.[5]

According to the U.S. Census Bureau's 2023 national survey, 42% of respondents said they have access to bus, subway, or commuter bus service compared with 51% who reported a lack of access.[4]

CAPACITY AND CONDITION

There are 6,800 FTA-supported agencies responsible for providing public transportation in the U.S. The majority (4,850) are nonprofit organizations. Of the 2,210 National Transit Database reporting systems connected to federal programs—either through the Urbanized Area Formula Program or Rural Formula Program—1,281 are in rural areas and 929 are in urban areas. Most systems are demand response (1,797), followed by bus (1,182), rail (97), and other modes (173, i.e., made up of trolleybus, vanpool, ferryboat, and other fixed-guideway modes).[6] Despite this network of systems throughout the country, 51% of Americans report inadequate bus, subway, or commuter bus service.[7]

Transit Systems in the US



Source: American Public Transportation Association, "2023 Public Transportation Fact Book," 74th edition, March 2024

The top 15 metro areas have the largest share of transit riders in the nation. Based on ridership, MTA New York City Transit is well ahead of all other metro agencies with more trips reported than the next 14 agencies combined. In 2023, MTA NYC Transit reported 1.15 billion subway rides, up 14% from 2022, yet considerably below pre-pandemic levels. Meanwhile, bus ridership for MTA NYC Transit totaled 427 million trips in 2023, nearly identical to 2022's 426 million trips.[8]

Ridership in New York City Public Transit 2018–2023

Compared with airline passengers annually

Year	Subway	NYC Transit Bus	MTA Bus	Airport Security Screenings Nationwide (approx.)
2018	1,680,060,402	569,361,220	121,448,276	813,791,287
2019	1,697,787,002	557,036,504	120,551,580	824,000,000
2020	639,541,029	316,768,454	65,655,990	324,000,000
2021	759,976,721	311,893,583	71,431,466	585,300,000
2022	1,013,425,465	343,092,963	82,609,386	736,000,000
2023	1,151,998,158	340,766,398	86,216,666	858,000,000

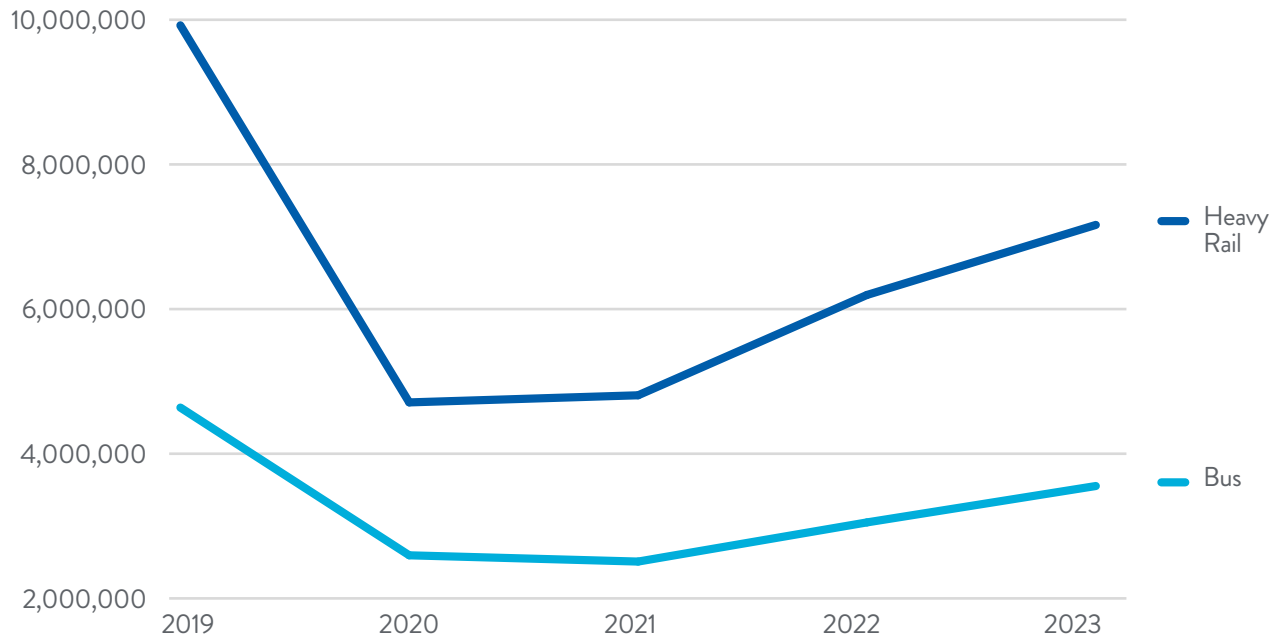
Note: Rail (68%) and bus (63%) of pre-pandemic levels compared w. Passengers Annually Airport Security.
Source: Metropolitan Transportation Authority, and Transportation Security Administration

Largest Transit Agencies

TRANSIT AGENCY	URBANIZED AREA	UNLINKED PASSENGER TRIPS (THOUSANDS)		PASSENGER MILES (THOUSANDS)	
		2020	2021	2020	2021
MTA New York City Transit	New York, NY	1,540,475.1	1,727,404.3	5,683,892.6	6,723,530.9
Chicago Transit Authority	Chicago, IL	197,499.8	195,980.6	781,888.7	798,583.3
Los Angeles County Metro. Transp. Auth.	Los Angeles, CA	305,907.0	194,719.8	1,523,635.3	752,826.9
Massachusetts Bay Transportation Authority	Boston, MA	277,410.8	120,951.8	1,273,921.3	483,531.5
New Jersey Transit Corporation	New York, NY	205,926.7	109,762.0	2,438,549.9	1,128,298.6
Southeastern Pennsylvania Transp. Auth.	Philadelphia, PA	241,553.2	105,812.1	1,092,751.8	432,509.8
Washington Metro. Area Transit Authority	Washington, DC	273,545.9	89,940.4	1,282,228.3	371,231.4
MTA Bus Company	New York, NY	72,562.2	82,347.8	202,709.6	230,457.7
City and County of San Francisco	San Francisco, CA	170,594.3	61,756.7	344,878.6	112,158.7
King County Department of Metro Transit	Seattle, WA	60,165.9	52,698.4	259,894.7	207,901.5
County of Miami-Dade	Miami, FL	56,397.2	51,159.8	313,635.8	289,879.9
MTA Long Island Rail Road	New York, NY	43,484.9	49,167.6	1,229,284.5	1,420,978.6
Denver Regional Transportation District	Denver, CO	52,314.7	48,777.2	290,743.3	291,260.3
Metropolitan Atlanta Rapid Transit Auth.	Atlanta, GA	90,827.8	46,393.8	534,601.9	250,586.3
Metro. Transit Auth. of Harris County, Texas	Houston, TX	65,047.5	44,914.3	388,402.4	254,476.5

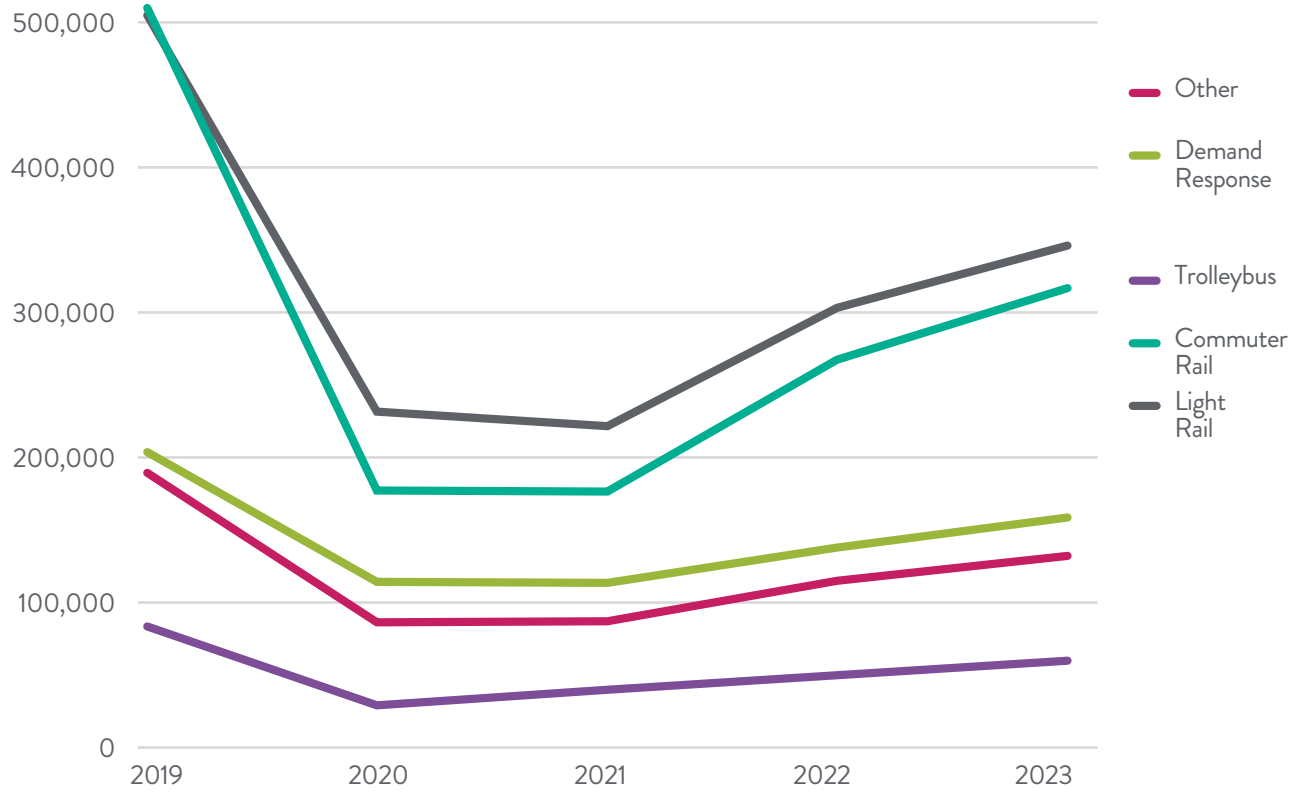
Note: Unlinked passenger trips - passenger boardings on public transit.
Source: American Public Transportation Association, "Public Transportation Factbook," 2024

Annual Ridership by Mode, 2019-2023 (per 1,000)



Note: Totals and individual modes over the last five years. Source: American Public Transportation Association, July 2024

Annual Ridership by Mode, 2019-2023 (per 1,000)



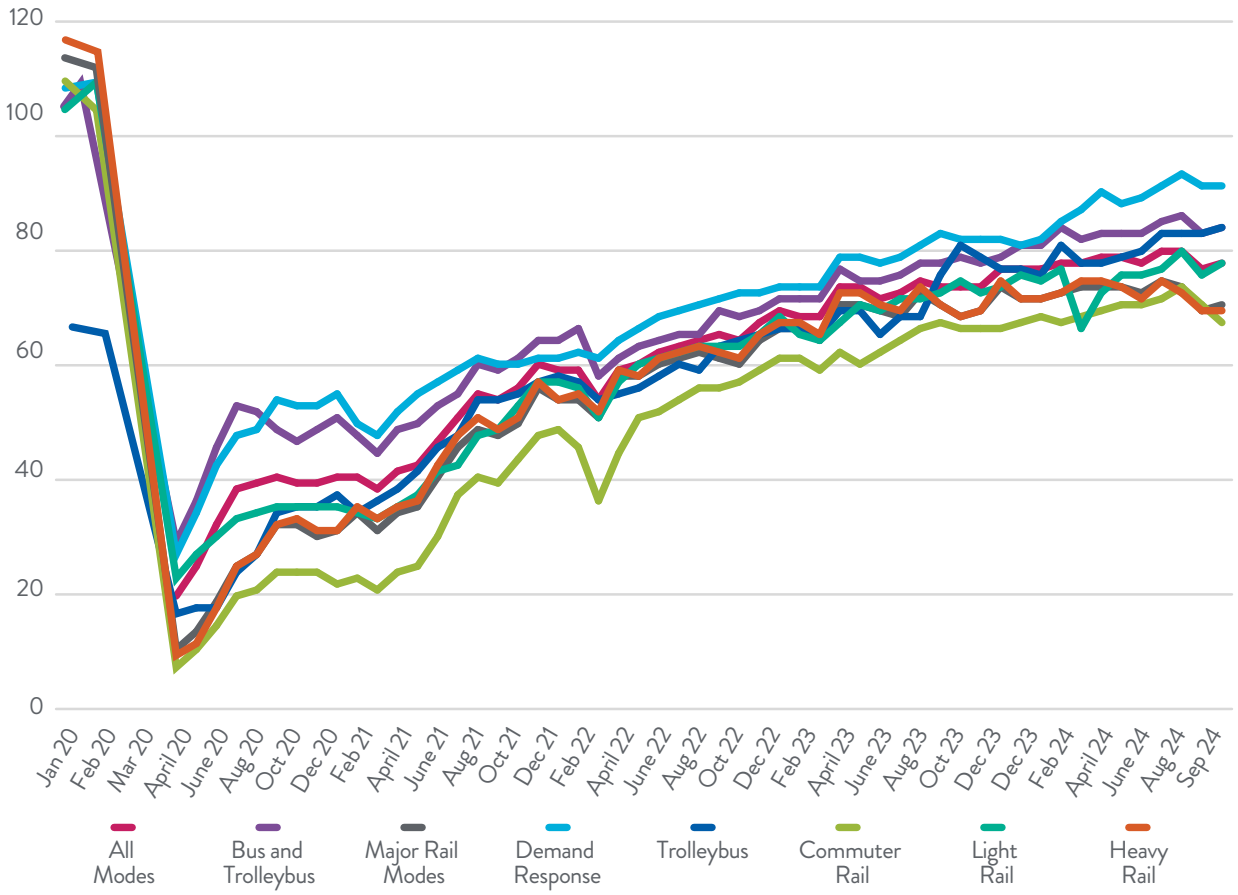
Note: Totals and individual modes over the last five years. Source: American Public Transportation Association, July 2024

Despite ridership declining prior to the COVID-19 pandemic—and only partially rebounding in the aftermath—some transit system expansion is underway across the U.S. due to federal investment from the IIJA.[9,10]

However, nationwide transit options have been growing unevenly. Expansion has happened in large metro regions—New York, Seattle, Washington, DC, and Los Angeles—but overall, the U.S. continues to fall behind other countries in accommodating people via public transit.[11] Planned expansions include New York Metropolitan Transit Authority's five-year, $55 billion capital improvement plan and Los Angeles Metropolitan Transit Authority's 75 projects worth $25 billion. In New York, a proposal to support transit projects through a congestion pricing program was slated to go into effect in January 2025.[12,13] In the Twin Cities for 2023, ridership was reported to be 16% above the previous year, owing in part to bus service enhancements, including more operators and increased safety measures for operators and passengers alike.[14]

Ridership continues to increase, but barriers exist. Ridership was declining even before the COVID-19 pandemic as the use of ride-hailing services grew and more employers offered remote work options; however, the pandemic significantly accelerated that momentum.[15] Approximately 92% of federal aid for transit has been spent as of December 2024.[16] Without new financing for operations, transit agencies may reduce service, increase fares, and suspend or cancel capital projects.[17]

Public Transit Ridership Recovery: January 2020 to September 2024



Source: American Public Transportation Association, 2024

Over the past several years, the percentage of revenue vehicles and infrastructure conditions considered in a state of good repair have been relatively level, with data showing a slight improvement for facilities. Going forward, significant gaps remain to bring 100% of assets into a state of good repair, and future funding uncertainty and cost increases will challenge the industry to maintain positive trends.

Transit Assets in a State of Good Repair (SGR), 2023

	Revenue Vehicles (Transport of Passengers)	Equipment (Service Vehicles)	Facilities	Infrastructure (Track Miles)
Percentage of Assets in SGR (2023)	77.6%	60.5%	92.5%	96.9%
Trend from 2019	Slight decline in condition	Decline in condition	Improvement in condition	Improvement in condition

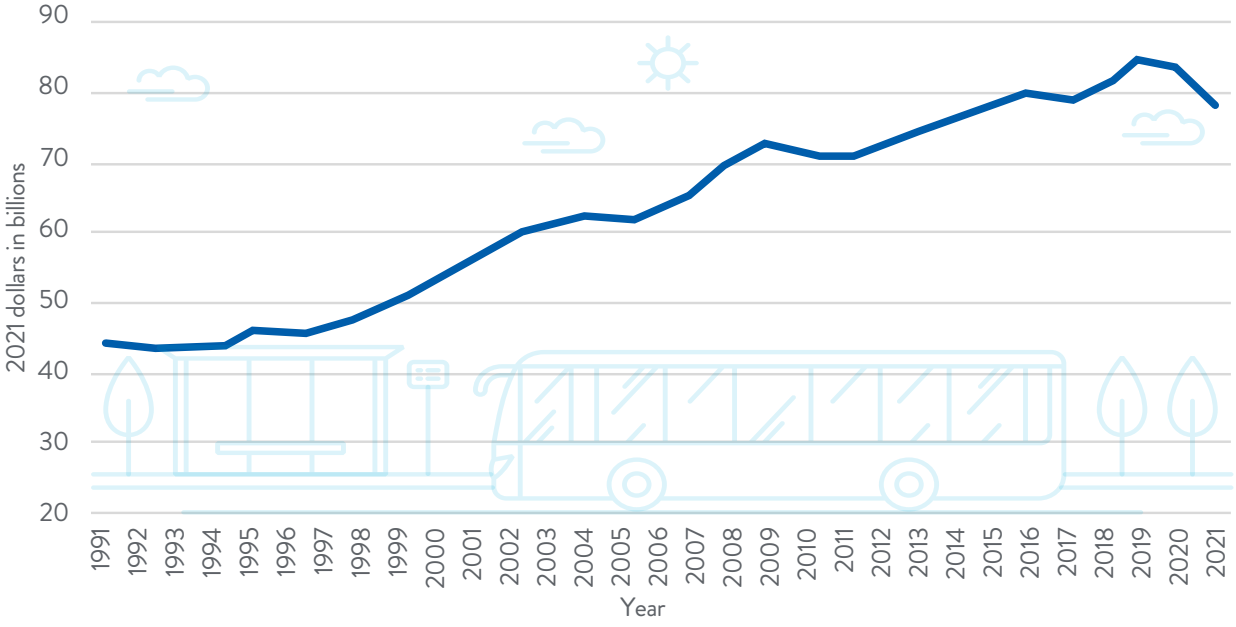
Source: Federal Transit Administration, National Transit Summaries and Trends, December 2024

Condition assessments extend to local transit agencies as well. NY DOT's latest TAM Plan revealed 35% of vehicles (bus, small passenger vehicles) and 39% of equipment are at or past their useful life, while the average age of facilities was nearly 40 years old.[18]

FUNDING AND FUTURE NEED

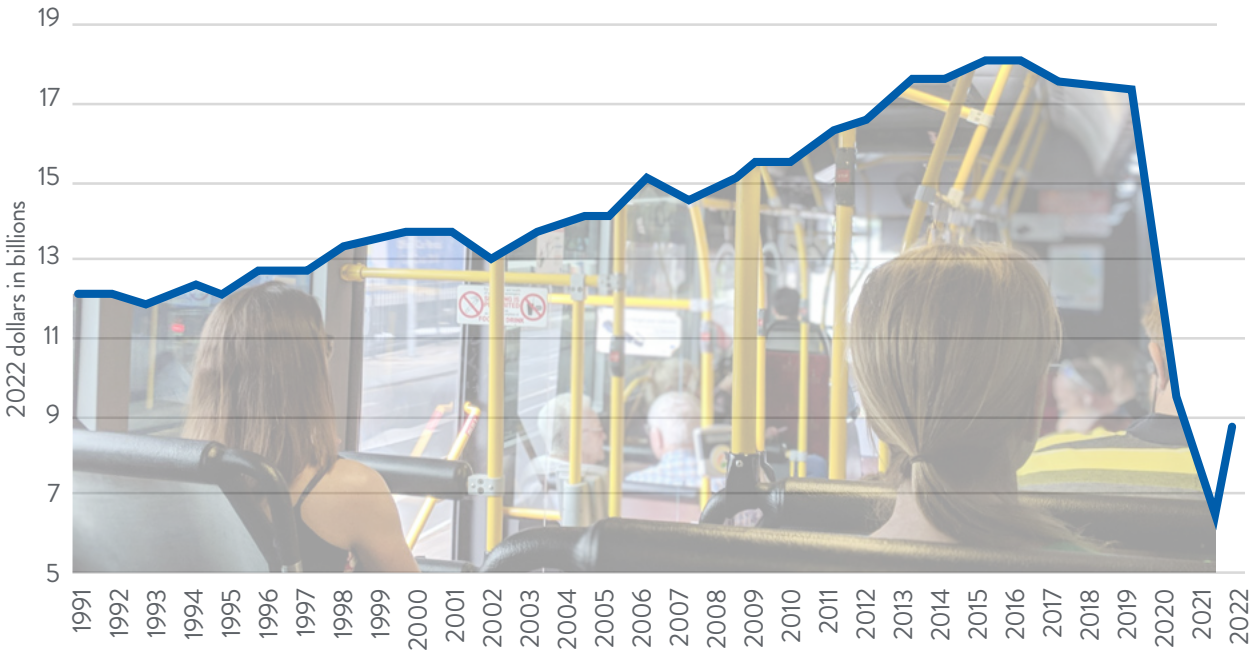
Public transit is funded by passenger fares, transit agency earnings, and support from federal, state, and local governments. Although overall funding for transit has increased over the last decade-plus, revenue generated has declined owing to the sharp decline in ridership in 2020 and subsequent years, as well as fare amounts remaining unchanged.[19] It is estimated that the nation's transit programs will require $20.3 billion annually to achieve a state of good repair (SGR) by 2038. Using 2014-2018 spending levels, the SGR is expected to increase slightly from $101.4 billion in 2018 to $106.2 billion in 2038.[20] **Total infrastructure needs for transit are estimated to be $618 billion. If current funding levels continue from 2024 to 2033, expected funding would total $466 billion resulting in an estimated gap of $152 billion.[21]**

Total Funding for Public Transit (in 2021 Dollars): Capital and operating combined (in billions)



Source: American Public Transportation Association

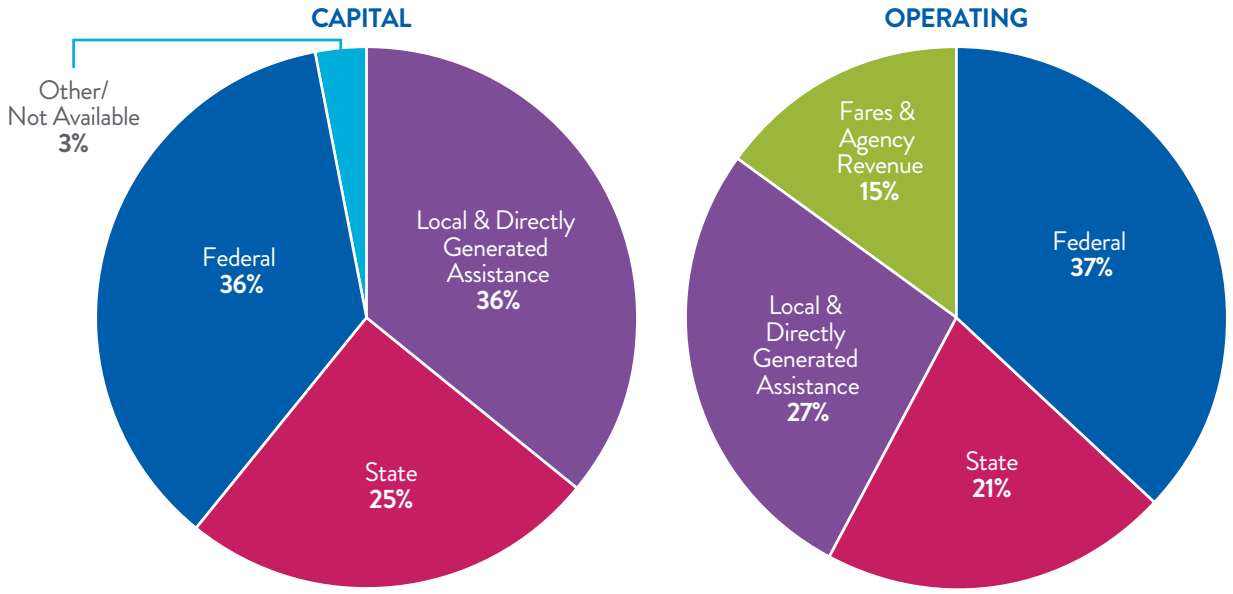
Passenger Fare Revenue—All Modes (inflation adjusted in 2022 dollars)(in billions)



Source: American Public Transportation Association

For capital expenses in 2021, federal assistance contributed 36%, states provided 25%, and local and direct assistance funds supported 36%. Operating costs were split between federal (37%), local and directly generated assistance (27%), state assistance (21%), and fares and agency revenues (15%). Since 2020, federal COVID-19 response aid totaling $69 billion has been directed to both operating and capital expenses.[22]

Capital & Operating Funding in 2021



Source: American Public Transportation Association, Public Transportation Fact Book, 2024

Supplemental investment from IIJA authorized $108 billion for FTA programs from FY22–26, $42 billion or 67% above previous annual spending levels.[23] Another $14 billion and $31 billion, respectively, in additional funds were provided to the FTA through the FY21 appropriations law and the 2021 American Rescue Plan, both of which prioritized operating and payroll expenses to avoid layoffs.[24] With FTA programs funded at $20.8 billion for FY24, federal investment will match state and local funds to facilitate project completion.[25] These investments play a considerable role in enhancing transit service, especially in less-populated areas, which have experienced a greater increase in ridership since that pandemic than large metro areas.[26]

Although ridership rates have increased since 2020's sharp decline, uncertainty remains on its ability to address costs and meet demand moving forward. Funding received through additional fares obtained by increased ridership is insufficient to address public transit costs alone. Beyond increased ridership, continued federal assistance and other financing options will be necessary for transit systems to remain solvent. Transit agencies will also need to diversify funding sources, strengthen operational efficiencies, and support rainy day funds.[27]

Some states and localities are pursuing plans to aid struggling transit systems. The governors of Massachusetts and Pennsylvania are proposing an additional $300 million in each state, supported by new taxes on high-income earners (MA) and an increase on the percentage of sales tax dedicated to transit (PA). At the direction of the Massachusetts governor, the state also established a commission to propose long-term solutions to budget shortfalls.

Ballot measures have also supported transit in recent years, with 46 transit ballot measures worth $25 billion receiving approval in 2024 alone. Past successful examples include a 2020 local tax increase in Austin, TX, for transit operations, maintenance, and capital improvements; the approval of a three-eighths of a cent sales tax in Kansas City in 2023 for improvements to the area bus system; the passage of a half-cent sales tax in Fort Collins, CO, with 25% going to transit infrastructure; and a measure in Miami-Dade County in 2024 for an expanded passenger rail system estimated to cost $6 billion. Consolidation is also being considered by the Illinois state legislature to avoid a $730 million shortfall for Chicago area transit agencies after 2026.[28,29,30,31,32,33,34]

OPERATION AND MAINTENANCE

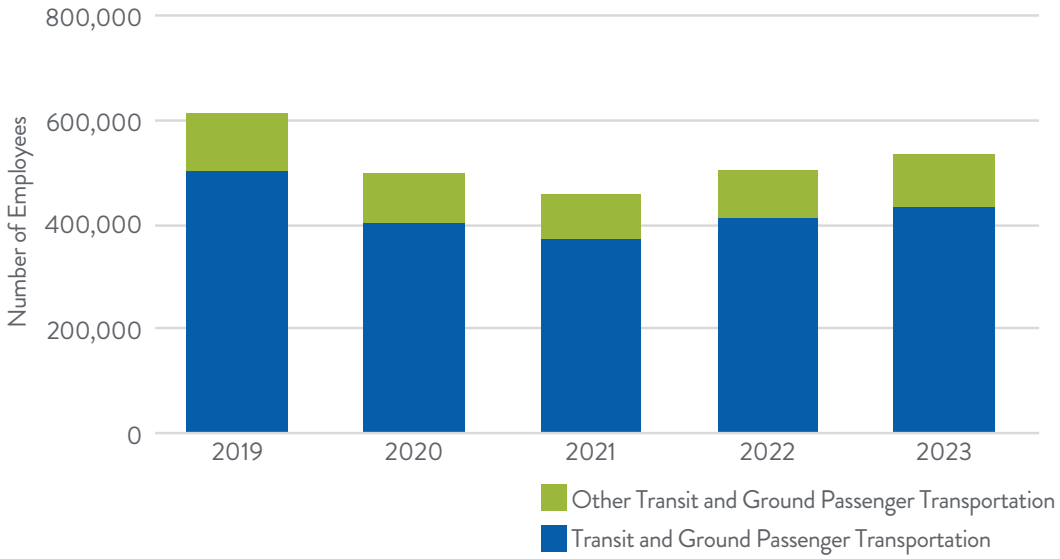
Operation expenses are about two-thirds of all transit costs. Nationwide large budget gaps are expected for operations in FY24 and beyond.[35] Although the recent influx of federal assistance along with renewed funding from state and local governments has benefited transit networks, gaps remain in accommodating facilities and services. As federal programs address capital improvements, less support is typically available for operations. Increased costs associated with operations make it more difficult for systems to keep routes and trips consistent. Both conditions are predicted to cause hundreds of millions of dollars or more in deficits to individual U.S. transit networks in Philadelphia, Chicago, and Los Angeles.[36] In 2019, the 50 transit systems with the highest operating expenses had a farebox recovery rate of 36% with total revenue of $13.5 billion.[37] While it makes up less than half of the generated revenue, transit agencies rely greatly on fares for their operating expenses. Large agencies rely considerably more on fares to support operating expenses, whereas for midsize and small agencies, fares do not contribute as much.[38]

Congress eliminated transit operating assistance for large urban areas in the late 1990s, yet retained it for small urban (50,000–199,999 population) and rural areas. Large transit systems typically have greater ability to cover operating expenses since monies can be applied from available capital resources. On the other hand, small transit agencies rely more on the flexibility of federal assistance since capital expenses vary year by year and federal aid may need to be shifted to operations to mitigate changes in services.[39]

Workforce needs are impacting operations as well. For 2023, an estimated 433,810 people worked in transit and ground passenger transportation, an increase from 411,670 in 2022 and 371,630 in 2021. While employment trended upward, many transit employees are near retirement age.

In 2023, 37.9% of transit workers were 55 and older; this is considerably higher than all transportation sectors (24.3%).[40] Also, compared to other industries, transit agencies receive a higher rejection rate for employment with many workers leaving for jobs outside of transit altogether versus retiring or leaving the workforce. Since compensation and schedules are recognized as the leading challenges to attract and retain employees, agencies are identifying proactive steps to accommodate staff. For example, Central Ohio Transit implemented a system to better share scheduling information between the agency and operators. IndyGo in Indianapolis, IN, adopted four 10-hour schedules per week instead of the standard five 8-hour shifts.[41]

Transit Employment, 2019 to 2023



Source: Bureau of Transportation Statistics

Finally, to better gauge and support maintenance, FTA requires transit agencies that receive federal assistance to develop and update TAM plans every four years. Key components of TAMs include inventory of capital assets, condition assessment, investment prioritization, and implementation strategy.[42]

PUBLIC SAFETY

Public transit is one of the safest modes of transportation. In 2023, there were 327 transit-related fatalities, compared to an estimated 40,990 highway fatalities. Among the transit fatalities, 210 were related to rail and 117 non-rail. Rail-related fatalities declined from 2022 (227), whereas non-rail fatalities remained level (117) compared to the previous year. Injuries in 2023 totaled 21,244 with 15,508 or 73% of these non-rail incidents.[43,44,45]

Recipients of FTA formula grants are required to maintain agency safety plans to identify, assess, and mitigate risks and hazards; implement safety trainings; determine safety performance targets; and conduct annual reviews.[46] FTA also offers funding for safety through several programs, including – State Safety Oversight Program (SSO), Enhance Transit Safety and Crime Prevention Initiative, and Safety Research and Demonstration Program.[47]

RESILIENCE AND INNOVATION

Rail and bus lines are frequently interrupted by extreme weather. MTA in New York reported that 200 subway stations—representing half of the total stations in the system—have flooded in recent years. In response, MTA is planning $6 billion in improvements to protect facilities from weather-related events. TriMet in Portland, OR, suspended its light-rail service in January 2024 due to an unusual winter storm featuring freezing temperatures and snow. Extreme heat can also disrupt or damage transit infrastructure, such as creating rail damage, unsafe transit stops for riders, and damaged electrical lines.[48,49]

FTA published its Transit Resilience Guidebook in May 2024, offering guidance for transit agencies to prepare for, anticipate, and recover from extreme weather and climate change impacts.[50] In addition, state and regional transportation agencies have produced plans to facilitate climate-related response. For example, the Virginia Department of Transportation issued its resilience plan in 2022 emphasizing enhanced data collection on assets including transit facilities.[51] The National Capital Transportation Planning Board also published its Transportation Resilience Improvement Plan in 2024, which includes a risk-based vulnerability assessment and priority project list for the regional transportation network.[52]

In practice, transit agencies have responded to natural disasters and maintain emergency response plans. **Transit is especially useful for evacuation and relief to vulnerable populations such as those without access to private vehicles or with special needs.** In 2017, Houston prepared for Hurricane Harvey by using 150 buses to transport citizens impacted by the storm. Several transit agencies maintain hurricane evacuation plans including the New Orleans Regional Transit Authority, which includes assigned routes and vehicle protection.[53,54]

FTA is also focused on sustainability, creating programs incentivizing renewable energy and zero-carbon vehicles, as well as developing technical assistance and training programs for agencies across the country. For example, the Buses and Bus Facilities Program and Low and No Emission Bus Grants direct federal resources to the acquisition of cleaner American-made transit buses as well as fueling and maintenance infrastructure improvements.[55] Because of programs like these, states and regional transit agencies are increasingly purchasing zero-emission buses (ZEBs). The number of full-size transit ZEBs is over 6,100 as of September 2023, with California and New York having the highest share of these vehicles.[56]


Photo: Justlight

Meanwhile, rural areas are addressing transit needs through new approaches. On-demand public transit or microtransit is increasingly in use in small communities where residents request a ride and in return pay a small fee.[57] A 2023 study of Wabasha, MN, offered a host of potential transit solutions, including using community members to offer underused buses and private cars.[58]

New technologies also are promoting transit use. The ongoing transition from closed to open loop systems will allow electronic payments of fares, improving convenience and safety for customers. Open-looped cards are expected to grow from 1 million in 2020 to 13 million by 2025.[59] Boston's regional transit invested nearly $1 billion in 2024 for contactless payment, joining other cities such as New York, Denver, Chicago, Baltimore, and San Francisco with similar automated platforms.[60] Agencies are also sharing payment methods such as TriMet and C-Trane between Portland, OR, and Vancouver, WA, and San Francisco's Bay Area Rapid Transit and other regional agencies in northern California.[61] Virginia Railway Express and Maryland Transit Administration recently announced a cross-honor program allowing customers to purchase and use tickets between the two regional transit systems.[62] Los Angeles Metro and other agencies are increasingly adopting fare capping as a way to bring down costs and improve access to transit.[63]

RECOMMENDATIONS TO RAISE THE GRADE

- Support consistent and long-term financing approaches, including additional flexibility to use funds for planning, maintenance, state of good repair, and operations across all asset classes and types to align with local and regional transit plans.
- Prioritize network and multimodal connectivity, including emerging bikeshare and micromobility as well as regional and interagency connectivity to improve passenger experience, accessibility, functionality, service, and flexibility.
- Address workforce and staffing needs through community outreach and training programs to ensure operational resiliency, including operators, control center staff, and critical transit maintenance and operations personnel.
- Encourage good asset management practice to prioritize and address ongoing state of good repair needs, maximize the impact of available funds, and improve the overall condition of our systems.
- Embrace approaches to address and fund investments in sustainability, resiliency, and risk mitigation to effectively and proactively address challenges of climate change and economic shocks.
- Encourage collaboration between local and regional transportation planning for sustained capital improvements, maintenance, and operations.
- Identify, adopt, and invest in new and emerging technologies that improve service, deliver operational efficiencies, and improve safety.


Photo: Сергей Кураженко

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Wastewater

D+

GRADE COMPARISON

2025: D+

2021: D+

Photo: Michael Jarmoluk

WASTEWATER

EXECUTIVE SUMMARY

The nation's sewers are estimated to be worth over $1 trillion and include nearly 17,500 wastewater treatment plants that operate to protect public health and ensure the well-being of communities. As the ability to detect and address emerging contaminants has improved, environmental regulations have tightened, and public opinion on pollution has changed, the wastewater sector is increasingly expected to produce advanced treatment outcomes, even as systems age. However, over the last decade, the sector's renewal and replacement rate for large capital projects decreased from 3% to 2% while the average number of collection system failures for combined water utilities increased from 2 to 3.3 per 100 miles of pipe, indicating the impacts of aging infrastructure. The number of combined sewer systems has modestly decreased from 746 to 738 (2004 to 2023), and occurrences of sanitary sewer overflows have also decreased from 0.7 to 0.16 overflows per 100 miles of utility pipe (2015 to 2021). To fund these needs, the average bill for residential wastewater customers is increasing from $35 to nearly $65 per month from 2010 to 2020, but locally generated funds still fall short. In 2024, the wastewater and stormwater annual capital needs were $99 billion, whereas the funding gap was $69 billion, meaning only about 30% of the sectors' infrastructure capital needs are being met. Assuming the combined wastewater and stormwater sector continues along the same path, the gap will grow to more than $690 billion by 2044.

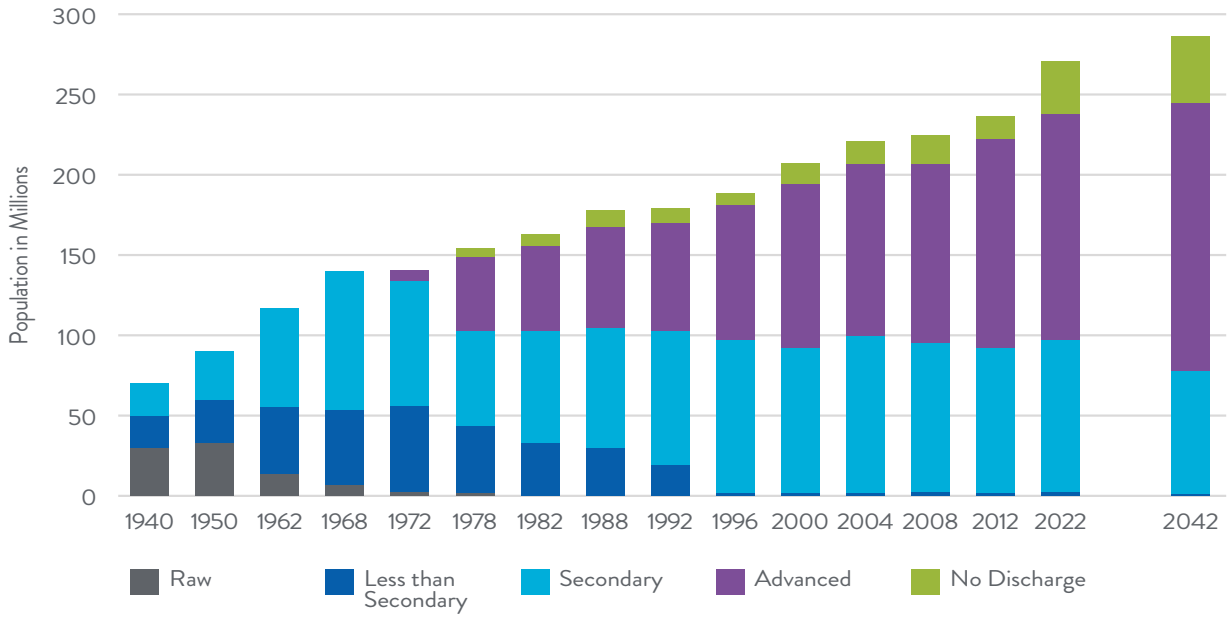
BACKGROUND

Infrastructure that removes and treats wastewater is critical for ensuring the public health and well-being of any community. Wastewater infrastructure includes a network of sewer pipes that collect and carry household, business, and industrial effluents to wastewater treatment systems—on site or centralized facilities. Within these treatment systems, wastewater undergoes processes to remove harmful constituents and reduce pollution to levels regulated by the Environmental Protection Agency (EPA) and state agencies. After these processes, treated effluent is discharged into nearby bodies of water or, in some cases, recovered for water, energy, and nutrient reuse. Treatment processes also create waste products that are disposed of in landfills or, in some instances, productively reused for energy or soil amendments, among other things.

CAPACITY AND CONDITION

From 2012 to 2022, the number of publicly owned treatment works (POTW), or centralized wastewater treatment systems, increased from more than 16,000 to upward of 17,500 facilities of various sizes.[1,2] According to the U.S. EPA's 2022 Clean Watershed Needs Survey (CWNS), approximately 200 additional POTWs will come online by 2042.[3] Of the existing centralized treatment plants, 38% currently provide advanced treatment, a number that is likely to increase to 42% over the next 20 years.[4]

Population served by various levels of wastewater treatment systems from 1940 to 2022 and projected values, to 2042, if all needs are met.



Source: U.S. Environmental Protection Agency, "Clean Watersheds Needs Survey (CWNS) 2022 Report to Congress," 2024

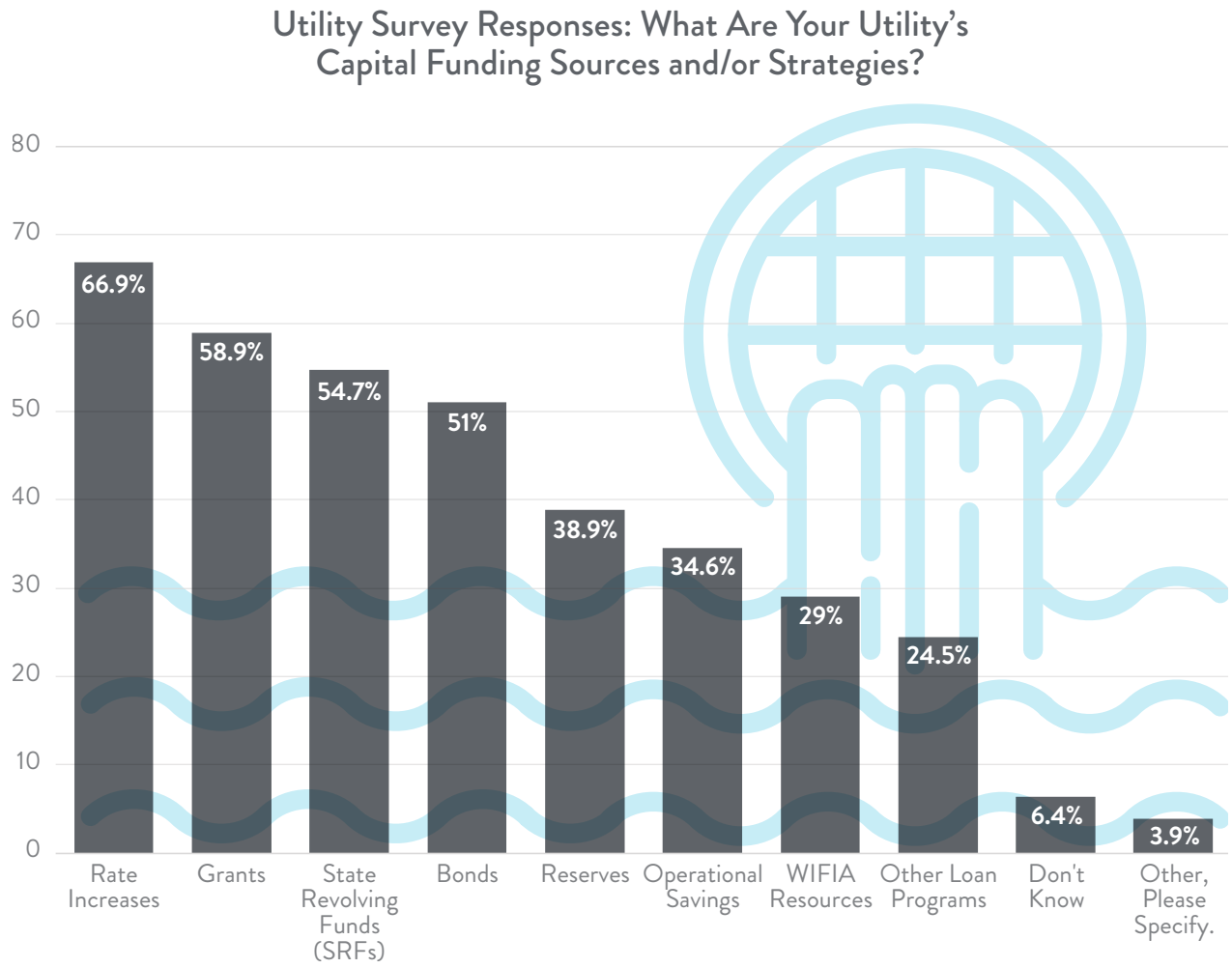
Over time, wastewater treatment systems are increasingly expected to produce advanced treatment capabilities owing to tightening environmental regulations, improved ability to detect and address emerging contaminants, and changing public opinion about pollutants, among other reasons.[5,6] Over the next 20 years, these needs will be met by upgrading the level of treatment for some systems, and the rest of the needs will be met by constructing new treatment facilities. Some of these new or upgraded facilities are expected to be non-discharging, meaning the effluent is not released to surface waters but evaporated or beneficially reused (e.g., spray irrigation, groundwater recharge, or other purposes). By 2042, the EPA's 2022 CWNS expects the population served by non-discharging facilities to grow by 21% or 8.8 million people.[7]

However, not all communities depend on centralized wastewater treatment facilities.[8] For some small communities and rural areas, on-site systems such as septic tanks or small, community systems are used to manage and treat wastewater needs.[9] Since 2017, the portion of U.S. households using on-site systems has remained steady at nearly 1 in 5 or more than 66 million households.[10]

Whether meeting the needs of urban or rural areas, wastewater conveyance systems provide critical service connections to homes, businesses, and communities. From 2019 to 2024, the combined length of urban and rural conveyance pipes has increased from 1.3 million miles to upward 1.87 million miles.[11] Furthermore, since 2017, the measure of collection systems' integrity (number of failures per 100 miles of pipe) for combined water utilities has been steadily hovering around two failures per 100 miles of pipe. However, in 2021, the value modestly increased to 3.3 failures per 100 miles of pipe, likely indicating the impact of the aging infrastructure.[12]

FUNDING

The wastewater sector combines various forms of funding and financing to provide infrastructure systems and services that protect public health and the environment.



Source: American Water Works Association, "State of the Water Industry 2023," 2023

Among these financial mechanisms, wastewater rates are critical for funding utilities. Although the average bill for residential wastewater customers is increasing from upward of $35 per month in 2010 to nearly $65 per month in 2020, it is not keeping pace with the growing costs for utilities to provide routine operation and maintenance (O&M) and preventative maintenance.[13,14] At the same time, the average wastewater bill varies significantly across the country, and according to EPA's affordability guidelines, which recommend spending around 2% of a household's median income on sewer rates, more than 15% of the 50 largest cities (8 of 50) have rates that pose challenges for those who are economically disadvantaged.[15]

Federal grants and additional financing options offer financial support for the wastewater industry. Since 2021, the federal government has taken significant strides to increase funding to the sector with the passage of the Infrastructure Investment and Jobs Act (IIJA) and Inflation Reduction Act (IRA), wherein an additional $46 billion over five years was provided to the water sector (drinking water, wastewater, and stormwater). In particular, the IIJA supported more than $11.7 billion in Clean Water State Revolving Funds (CWSRF), where 49% of funds were available for grants or principal forgiveness loans, 51% of funds were available for low-interest loans, and state matches were reduced from 20% to 10%. From Fiscal Year 2010–2021, annual appropriations averaged $1.6 billion annually for CWSRF. With IIJA funding, available funds will increase, from $1.9 billion in FY22, up to $2.6 billion by FY26.[16]

Most IIJA funds to the wastewater sector were for loans and loan forgiveness, many of which emphasized support for disadvantaged communities. Therefore, IIJA did not provide significant additional resources to many utilities, particularly those in good financial standing, because when interest rates are favorable on the open market, it is easier to access bonds rather than take out a State Revolving Fund (SRF) loan.[17]

Notably, IIJA is the first time Congress specifically directed funding ($1 billion over five years) to address emerging contaminants within the framework of eligible CWSRF activities. Over five years, the program received $100 million in the first year and $225 million each following fiscal year.[18] Federal funding also increased to the Water Infrastructure Finance and Innovation Act (WIFIA) program, which provides credit assistance to particularly large, multisector infrastructure projects: starting at $69.5 million in FY22 and increasing to $72.3 million in FY24.[19]


Photo: DC Water

FUTURE NEED

In 2024, ASCE's *Bridging the Gap* economic study reported the water infrastructure (drinking water, wastewater, and stormwater) investment gap at $99 billion annually, up from the $81 billion estimated in ASCE's 2021 "Failure to Act" report. Taking a closer look at only wastewater and stormwater values, the future needs become more apparent, and the gap is reported at $69 billion annually. This means about 30% of the nation's total wastewater infrastructure capital needs are being met. Assuming the combined wastewater and stormwater sector continues along the same path, the gap will grow to more than $690 billion by 2044.[20]

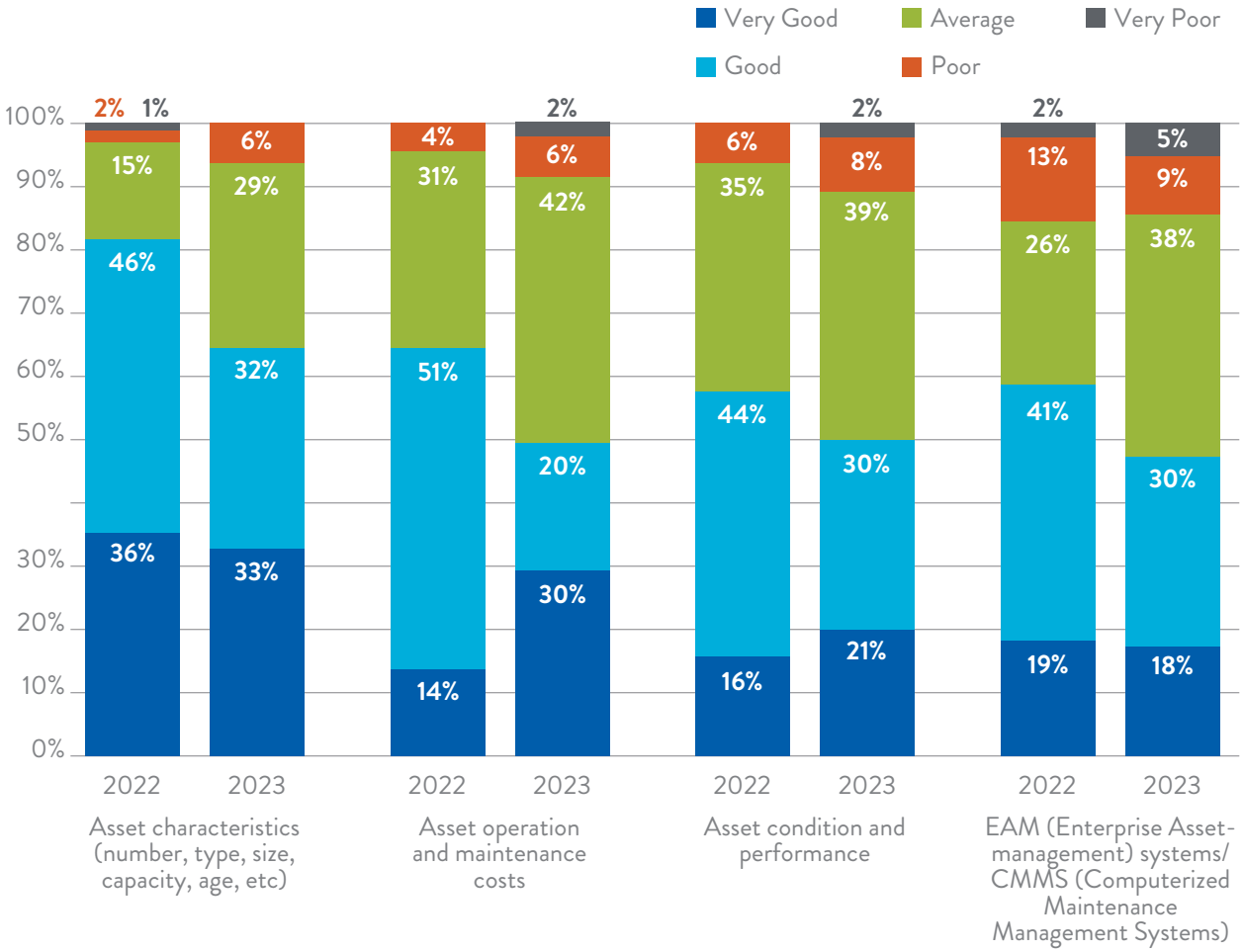
The value of wastewater and drinking water assets is nearly $1 trillion. Over the last decade, combined utilities' renewal and replacement rates have hovered between 1.1%–2.0%. However, this is likely a significant underestimate when considering the projected costs for expanding asset management, extending the life of aging infrastructure, and addressing emerging contaminants such as per- and polyfluoroalkyl substances (PFAS).[21] Current health advisories and uncertainty ahead regarding PFAS were the top concern among surveyed utility respondents of the American Waterworks Association's 2023 "State of the Water Industry" report.[22]

OPERATION AND MAINTENANCE

In general, assets are aging while the materials for upgrading or replacing components are becoming more expensive.[23] Therefore, the wastewater sector has had to adapt by expanding its focus from capital investment programs to maximizing the abilities of existing systems to extend their performance. This requires a shrewd balance of higher operational costs while maintaining performance conditions, a challenge addressed through the efficient and effective use of data.[24]

In a 2023 survey, 65% of more than 450 surveyed utilities said they were using digital tools to meet their increasingly complex operation and maintenance needs. However, 54% of these utilities also noted that, though they are collecting data, it is not being effectively leveraged.[25] In most cases, the commonplace digital tools being used to guide O&M efforts include geographic information systems (GIS), analysis of customer data and information, computerized maintenance management systems, and automated or advanced metering. However, other utilities are using more advanced approaches to operations and asset management through the adoption of digital innovations, including data science, artificial intelligence, digital twins, and various forms of scenario modeling.[26]

Utility Survey Responses: How Would You Describe the Quality of the Information That Your Utility Has on the Assets That It Owns and Operates?



Source: Black and Veatch

On the whole, widespread adoption of digital innovations is not yet prevalent in many utilities around the country because of constraints including resource limitations (48%), the use of legacy data and systems (45%), inadequate levels of funding (35%), and a lack of supportive leadership or guidance (35%). While digital O&M tools provide valuable data and process efficiency improvements, there are workforce impacts from streamlining these tools and implementing more automated treatment technologies. The U.S. Bureau of Labor and Statistics names automation as one of the causes of a 6% staffing decline in the industry by 2032, with other causes including routine job changes, retirements, and low recruitment. Overall, as digital approaches to asset management and monitoring as well as automated treatment technologies become more commonplace in the wastewater sector, it is important to build current and future workforce capacity along the way.[27,28]

PUBLIC SAFETY

The total number of combined sewer systems (CSOs) has decreased slightly from 746 in 2004 to 738 municipalities across the country in 2024.[29] Combined sewer systems collect rainwater runoff, domestic sewage, and industrial wastewater into one pipe and are vulnerable to overflowing in heavy rain events. Progress on uncoupling combined systems is slow, partly because many of these systems are in historic, densely populated areas, making the updates logistically complicated and expensive.[30]

Starting in 2019, EPA's enforcement efforts, which typically focused on roughly 200 of the largest CSOs, discontinued the requirement of annual reports on the status of addressing CSOs. Although municipalities are still required to collect water quality data related to their CSO discharges, the agency does not consistently collect, analyze, or publish data at a national level, which is necessary to evaluate the infrastructure's impact on water quality.[31]

Furthermore, as collection systems age and decline in condition, groundwater and stormwater enters the networks through cracks, joints, or illicit connections as inflow and infiltration. When wastewater collection systems are overtaxed, sanitary sewer overflows (SSOs) can occur.[32] Occurrences of SSOs have decreased from 0.7 overflows per 100 miles of wastewater utility pipe in 2015 to 0.16 overflows in 2021.[33]

RESILIENCE

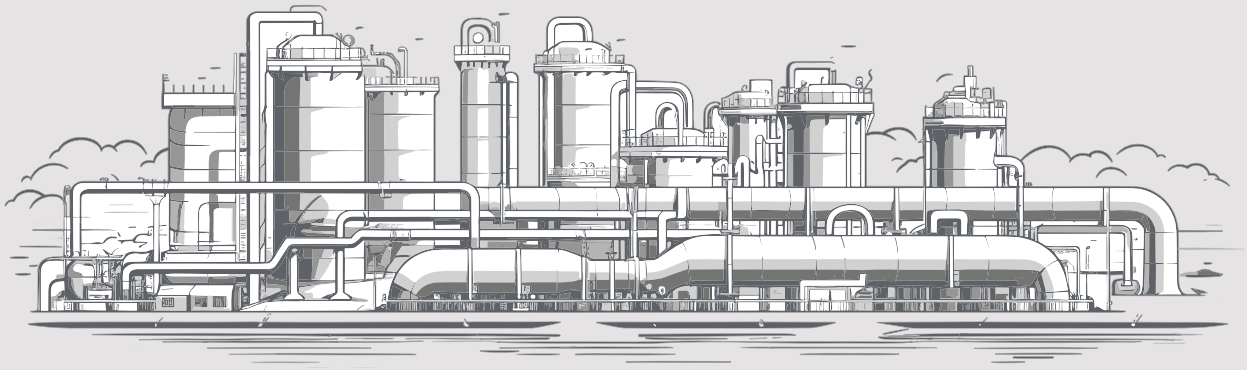
Utility managers, wastewater treatment plant operators, engineers, and elected officials bring aspects of resilience into the foreground of the design, siting, and planning phases of their wastewater infrastructure. Because wastewater vulnerabilities vary by geographic location, type of treatment system, infrastructure age, and ownership status, there is no one-size-fits-all solution. For instance, some wastewater systems are in low-lying areas that are especially prone to the impacts of flooding, while others may be in drought-prone regions or areas with increasingly frequent wildfires. Rather than continuing to operate under a business-as-usual framework, some infrastructure decision-makers are shifting from solely focusing on short-term metrics like population growth, capacity demands, and affordability to incorporate long-term, resilience-related factors into planning such as sea level rise, frequency, intensity, and likelihood of natural disasters, cybersecurity threats, and post-interruption recovery time. To support this effort, in 2022, the Providing Research and Estimates of Changes in Precipitation (PRECIP) Act was signed and resources were provided to NOAA to update the probable maximum precipitation (PMP) estimates that have previously remained static over the past several decades. As new estimates are brought more in line with a changing climate, utilities will be better equipped to design the nation's wastewater infrastructure for future conditions.[34]

INNOVATION

For more than a decade, the Institute for Sustainable Infrastructure has developed and improved upon a comprehensive sustainability framework and rating system for infrastructure projects. The goal of the assessment process is to help those working on implementing civil infrastruture projects (e.g., communities, municipal decision-makers, engineers) to do so holistically through the consdieration of sustainable, resilient, and equitable approaches. Currently in the U.S. there are nearly 30 projects that have been assessed with only three related to the wastewater sector. In an effort to better streamline sustainability-related innovations, organizations directly and tangentially supportive of the wastewater sector (e.g., the Water Environment Federation, American Public Works Association, the American Society of Civil Engineers, and the American Council of Engineering Companies) have crafted tools, fact sheets, and case studies to encourage the use of best practices and key features from the framework while the data-intensisve process continues to gain traction.[35]

Photo: Wayne Hill Water; Kiewit Corporation

According to the Water Environment Federation, the Circular Water Economy "recycles and recovers resources within the water use and treatment cycle to maximize value for people, nature, and businesses." This paradigm and practice exists through collaboration among public and private sectors to optimize and recover valuable resources from water and wastewater. Doing so enables these sectors to combat climate change and support economic development, among other outcomes. Circular water economy initiatives also keep products and materials in use, regenerates natural systems, and seeks to reduce waste and pollution.[36]



RECOMMENDATIONS TO RAISE THE GRADE

- Urge infrastructure owners to emphasize asset management practices across infrastructure sectors to extend the lifespan of assets and target limited funding to priority needs. Asset management must include continuous assessment of the condition of assets and prioritize investment decisions based on a comprehensive suite of data.
- Identify new grant programs and funding mechanisms to eliminate and/or decouple the nation's remaining combined sewer systems.
- Expand collaboration between researchers, technologists, wastewater utilities and operators, and federal decision-makers to develop and quickly deploy effective regulations, systems, public safety education, and policies that address 21st-century concerns such as PFAS (forever chemicals) or novel biological components.
- Incorporate geographically specific projected impacts of climate change into wastewater infrastructure planning and long-term funding decisions.
- Ensure utility rates cover the full cost of service including operation, maintenance, and capital needs; clearly communicate rate increases to the public; and balance local issues of affordability.
- Improve wastewater resiliency and mitigation of natural threats through implementation of vulnerability assessments and emergency response plans.

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Infrastructure Report Card History

The concept of a report card to grade the nation's infrastructure originated in 1988 with the congressionally chartered National Council on Public Works Improvement report, *Fragile Foundations: A Report on America's Public Works*. A decade later, when the federal government indicated they would not be updating the report, ASCE used the approach and methodology to publish its first *Report Card on America's Infrastructure* in 1998. With each new report in 2001, 2005, 2009, 2013, 2017, 2021, and now 2025, the methodology of the Report Card has been rigorously assessed so as to take into consideration all of the changing elements that affect America's infrastructure.

In 1988, when *Fragile Foundations* was released, the nation's infrastructure earned a "C," representing an average grade based on the performance and capacity of existing public works. Among the problems identified within *Fragile Foundations* were increasing congestion and deferred maintenance and age of the system; the authors of the report worried that fiscal investment was inadequate to meet the current operations costs and future demands on the system. In each of ASCE's seven Report Cards, the Society found that these same problems persist. Our nation's infrastructure is aging, underperforming, and needing sustained care and action. Elected officials from both sides of the political aisle and at all levels of government regularly cite the Report Card, beginning with the very first release in 1998, when President Bill Clinton referenced the Report Card's grade for Schools. News reports reference the Report Card on a daily basis, with mentions in *The Wall Street Journal, The New York Times, USA Today, The Washington Post, and the Los Angeles Times, as well as on National Public Radio, NBC's Today Show, 60 Minutes, CBS Evening News,* and *HBO's Last Week Tonight with John Oliver*, among many others.

CATEGORY	1988		1998	2001	2005	2009	2013	2017	2021	2025
Aviation	B-	...	C-	D	D+	D	D	D	D+	D+
Bridges	-	...	C-	C	C	C	C+	C+	C	C
Broadband	-	...	-	-	-	-	-	-	n/a	C+
Dams	-	...	D	D	D+	D	D	D	D	D+
Drinking Water	B-	...	D	D	D-	D-	D	D	C-	C-
Energy	-	...	-	D+	D	D+	D+	D+	C-	D+
Hazardous Waste	D	...	D-	D+	D	D	D	D+	D+	C
Inland Waterways	B-	...	-	D+	D-	D-	D-	D	D+	C-
Levees	-	...	-	-	-	D-	D-	D	D	D+
Ports	-	...	-	-	-	-	C	C+	B-	B
Public Parks	-	...	-	-	C-	C-	C-	D+	D+	C-
Rail	-	...	-	-	C-	C-	C+	B	B	B-
Roads	C+	...	D-	D+	D	D-	D	D	D	D+
Schools	D	...	F	D	D-	D	D	D+	D+	D+
Solid Waste	C-	...	C-	C+	C+	C+	D-	C+	C+	C+
Stormwater	-	...	-	-	-	-	-	-	D	D
Transit	C-	...	C-	C-	D+	D	D	D-	D-	D
Wastewater	C	...	D+	D	D-	D-	D	D+	D+	D+
Overall GPA	**C**	**...**	**D**	**D+**	**D**	**D**	**D+**	**D+**	**C-**	**C**

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