National Infrastructure Advisory Council

Strengthening Regional Resilience

Final Report and Recommendations

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About the NIAC

The National Infrastructure Advisory Council (NIAC) provides the President of the United States with advice on the security and resilience of the critical infrastructure sectors and their functional systems, physical assets, and cyber networks. These critical infrastructure sectors span the U.S. economy and include the chemical; commercial facilities; communications; critical manufacturing; dams; defense industrial base; emergency services; energy; financial services; food and agriculture; government facilities; healthcare and public health; information technology; nuclear reactors, materials, and waste; transportation systems; and water and wastewater systems sectors. The NIAC also advises the lead Federal agencies that have critical infrastructure responsibilities. Specifically, the Council has been charged with making recommendations to:

- Enhance the partnership of the public and private sectors in securing and enhancing the security and resilience of critical infrastructure and their supporting functional systems, physical assets, and cyber networks, and provide reports on this issue to the President through the Secretary of Homeland Security, as appropriate.
- Propose and develop ways to encourage private industry to perform periodic risk assessments and implement risk-reduction programs.
- Monitor the development and operations of critical infrastructure sector coordinating councils and their information sharing mechanisms and provide recommendations to the President through the Secretary of Homeland Security on how these organizations can best foster improved cooperation among the sectors, the Department of Homeland Security, and other Federal government entities.
- Report to the President through the Secretary of Homeland Security who shall ensure appropriate coordination with the Assistant to the President for Homeland Security and Counterterrorism, the Assistant to the President for Economic Policy, and the Assistant to the President for National Security Affairs.
- Advise sector specific agencies with critical infrastructure responsibilities, to include issues pertaining to sector and government coordinating councils and their information sharing mechanisms.

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Executive Summary

Strengthening the resilience of regions and their critical infrastructures is essential for achieving national resilience. Over the past decade, adjacent regions and infrastructures have become more interconnected, enabling local disasters to ripple across multiple jurisdictions and sectors, causing disruption and damage over large geographic areas. Resilience is especially important in the lifeline sectors—energy, communication, water, and transportation—because they underpin the most essential functions of business, government, and communities. Much has been done to build partnerships and improve resilience nationwide. But when disaster strikes, the biggest hit is felt by the regions and local communities that must respond and confront the immediate consequences.

In February 2013, President Obama issued Presidential Policy Directive 21, making it the policy of the United States to strengthen the security and *resilience* of its critical infrastructure against both physical and cyber threats. This policy recognizes the importance of resilience in managing infrastructure risks and reaffirms that critical infrastructure security and resilience is a shared responsibility among all levels of government and owners and operators of critical infrastructure.

Improving regional resilience requires urgent action even though the full benefits may not be realized for many years. Severe weather and complex physical and cyber risks are straining aging infrastructure to perform beyond design limits. Meanwhile, our nation invests at least $1 billion each day in new and upgraded infrastructure that can make regions more resilient, provided they are designed with security and resilience in mind.[1] We have a special window of opportunity to make sure we build and rebuild infrastructures smarter to optimize resilience in each region.

Exhibit 1. Key Recommendations to Improve Regional Resilience

1. Form partnerships with senior executives from the lifeline sectors, based on the Federal government's successful executive engagement with the electricity sector.
2. Identify or develop regional, public-private, cross-sector partnerships, led by senior executives, to coordinate lifeline sector resilience efforts within a given region.
3. Designate the energy, communications, water, and transportation sectors as lifeline sectors and direct all agencies to recognize the priority of the lifeline sectors and the individuality of regions.
4. Integrate social media into public alert and warning systems and work with state and local government partners to develop social media information sharing capabilities to inform response.
5. Launch a cross-agency team to develop solutions to site access, waiver, and permit barriers during disaster response.
6. Create a strong value proposition for investment in resilient lifeline infrastructures and accelerate the adoption of innovative technologies in major infrastructure projects.

Organizing our policies, partnerships, and processes is equally important to provide flexible and agile disaster response. Decisions made by states, local jurisdictions, Federal agencies, and private businesses before, during, and after a crisis can affect the continuity of critical regional services and the effectiveness of response and recovery efforts. Recent disasters such as the Oklahoma tornados in June 2013, Superstorm Sandy in October 2012, and the North American derecho in June 2012 remind us that disasters have little regard for jurisdictional boundaries and underscore the need for a unified approach to risk management.

[1] See Appendix E: Investment in U.S. Infrastructure.

Study Objective and Approach

In April 2012, the National Infrastructure Advisory Council (NIAC) launched a study to examine how regions can become more resilient in the face of increasing risks and infrastructure interdependencies. The Council formed a Regional Resilience Working Group to examine the challenges that regions face in improving resilience and to recommend steps the Federal government should take to help regions become more resilient. To frame this topic, the Working Group posed the following questions:

1. **Best Practices**: What are the characteristics that make a region resilient and what steps can be taken by critical infrastructure owners and operators, state and local government, and the private sector to improve resilience within their region?
2. **Process Improvements**: How can public and private critical infrastructure partners best work together to improve regional resilience?
3. **Federal Role**: How can Federal government capabilities and resources help accomplish resilience goals and address any gaps that can make regions more resilient?

This study focuses on the resilience of "lifeline sectors" (energy, communications, water, and transportation) within regions that have complex multistate, multijurisdictional, and cross-sector interdependencies, and which would have large national impacts if they were to fail catastrophically. Interdependencies among lifeline sectors create a risk environment in which a disruption in one infrastructure or region can spread to other sectors and regions, often in unexpected ways.

The Working Group collected information from a variety of sources:

- 37 interviews with national leaders in resilience and disaster response, state and local emergency managers, regional resilience organizations, infrastructure owners and operators, and Federal agencies;
- Insights from State, Local, Tribal, and Territorial Government Coordinating Council studies; and
- More than 350 reports, studies, videos, news articles, testimonies, and policy directives.

The Working Group formed a Study Group to examine the regional impacts of Superstorm Sandy on the lifeline sectors and gaps in regional resilience between interdependent sectors. Though focused on a natural disaster, the event illuminated real-world infrastructure risks and lessons that would be present in any event, including accidents and terrorist acts. The Superstorm Sandy case study helped to show how regions can reduce infrastructure risks and to test initial Working Group hypotheses.

Findings

Our study revealed three fundamental principles of regional resilience that align with previous NIAC studies and recent Federal policy directives. These principles (Exhibit 2) recognize that national resilience is the logical outcome of regional resilience. Any national strategy to strengthen resilience must include all of these elements.

Exhibit 2. Principles of Regional Resilience

1. Resilience requires a whole-of-nation approach that integrates top-down policy and leadership with bottom-up community capability to withstand and survive disasters.
2. Regional resilience strategies must be tailored to the distinct needs of each region and designed to manage complex regional risks that span multiple jurisdictions and sectors.
3. Strong public-private partnerships and relationships that include senior executive involvement are the most effective and enduring strategy for achieving sustainable resilience.

The Council identified six findings of the challenges, critical needs, best practices, and essential strategies for improving resilience within regions. Full descriptions of these findings are provided in Chapter 5.

Finding 1. Lifeline sectors are top priorities for achieving regional resilience and their growing complexity creates hidden risks.

1.1 Four lifeline sectors–energy, water, transportation, and communications—are top priorities for strengthening resilience in all regions because they provide essential products and services that underpin the continued operation of nearly every business sector, community, and government agency.

1.2 The increasing interdependence and integration among lifeline infrastructures has created hidden regional risks that are not widely understood by the businesses, governments, and communities that depend upon them for essential services.

1.3 Joint regional exercises that engage public and private partners at all levels are highly effective in exposing gaps, identifying interdependencies and hidden risks, and improving response capabilities.

Finding 2. Regional resilience efforts are most successful when they are tailored to the characteristics and needs of each region.

2.1 National resilience is strengthened by the collective resilience efforts of all regions and their communities. Yet all regions are different, calling for a tailored approach to resilience that reconciles the types and density of a region's infrastructure with regional-based risk assessments.

2.2 A community's capacity to withstand a disaster is improved when regional emergency managers engage non-profit and community groups as critical partners in disaster preparation, response, and recovery.

Finding 3. Senior executive engagement creates strong public-private partnership, which is the most effective strategy for achieving long-term resilience within regions.

3.1 Public-private partnerships based on senior executive-level engagement prove to be the most robust because they enable partners to set strategic direction, establish priorities, provide resources, and exercise accountability.

3.2 Strong public-private partnerships across all levels of industry and government and active cross-sector coordination are the most important success factors in helping regions to achieve sustainable resilience.

Finding 4. Social media has emerged as a powerful but underutilized tool for communicating and collecting data during emergencies.

4.1 Social media can improve situational awareness, inform public decision-making, and mitigate rumors.

4.2 Government and business have not fully capitalized on the potential of social media in disaster response and recovery.

Finding 5. Rapid recovery of lifeline infrastructures is hindered by complex rules, regulations, and processes.

5.1 Incident response personnel in critical sectors encounter persistent problems gaining rapid access to disaster areas to repair damaged assets.

5.2 Complex laws and regulations at the Federal, state, and local level and inefficient processes for granting waivers and permits can delay interstate fleet movement and prevent the most effective and logical disaster response.

Finding 6. Without a strong value proposition, owners and operators are unable to invest in new and innovative infrastructure that can mitigate long-term structural risks within regions.

6.1 Owners and operators often find it difficult to establish the strong value proposition needed to invest in new or upgraded infrastructure without public support and the ability to recoup costs.

6.2 Regions can mitigate long-term risks by applying innovative technologies to build resilience into new and replacement structures, and rethinking systems and architectures using novel infrastructure designs that are inherently resilient.

Recommendations

The Council recommends six actions to improve regional resilience. Each recommendation is described in greater detail in Chapter 5.

Recommendation 1. The President should direct the heads of the appropriate Sector-Specific Agencies to form partnerships with senior executives from lifeline sectors, using a process modeled after the government's successful executive engagement with the electricity sector.

CEO-level executive engagement in the electricity sector has been a game changer over the last 18 months and the lessons learned can help guide the formation of similar senior executive partnerships in other lifeline sectors. As noted in four previous NIAC reports, senior executive partnerships help build key relationships, set mutual priorities, and address urgent infrastructure challenges.

To implement this recommendation, the Council recommends the following milestones.

1.1 **Within six months, the President should direct the heads of appropriate Sector-Specific Agencies to convene a meeting with CEOs or other owner/operator leadership with equivalent decisionmaking authority from each lifeline sector to explore the formation of a partnership to address high priority risks to the sector's infrastructure.**

1.2 **The U.S. Department of Energy, in collaboration with the U.S. Department of Homeland Security (DHS), should work with electricity and nuclear sector industry associations to document the process used for CEO engagement in the electricity sector** to discern lessons learned that can guide senior executive partnerships in other lifeline sectors.

1.3 **The President should task the NIAC to identify the highest priority cross-sector risks affecting national security and resilience** and produce a written report to the President within 18 months recommending potential executive-level, cross-sector action.

Recommendation 2. The Secretary of Homeland Security should facilitate efforts with governors, mayors, and local government officials to identify or develop regional, public-private, cross-sector partnerships, led by senior executives, to coordinate lifeline sector resilience efforts within a given region.

Productive executive partnerships at the Federal level can be leveraged to inform and build effective public-private partnerships at the regional level. Strong senior executive leadership at the regional level will help to identify, build, and fully integrate appropriate cross-sector regional partnerships to complement the national partnerships. The Council affirms and supports two prior recommendations on regional partnerships made by the State, Local, Tribal, and Territorial Government Coordinating Council that call for the DHS Office of Infrastructure Protection to promote and enable stronger cross-sector partnerships, and provide state and local governments with the tools to identify cross-sector interdependencies that could result in cascading effects, particularly in the lifeline sectors.

To implement this recommendation, the Council recommends the following steps.

2.1 **The Secretary of Homeland Security should facilitate the development of cross-sector partnerships within selected regions to improve the region's resilience to very large-scale events that could impact national security, resilience, and economic stability**. The Secretary should work directly with governors, mayors, and other local government leaders to assist them in building cross-sector partnerships with senior executives from the lifeline sectors located within each region. To coordinate and operationalize regional partnerships, the Secretary should work through the State, Local, Tribal, and Territorial Government Coordinating Council (SLTTGCC), and provide grant funding to states to assist with this effort.

2.2 **The Secretary of Homeland Security should initiate a pilot program with state and local governments in select regions to conduct regional joint exercises, develop risk maps of critical sector interdependencies, and extract lessons learned on regional needs and gaps for government and sector partners**. The program should actively engage regional owners and operators and government leaders in identifying and addressing critical gaps in the resilience of the lifeline infrastructures that could produce cascading disruptions throughout the region.

Recommendation 3. The President should designate the energy, communications, water, and transportation sectors as lifeline sectors and direct Sector-Specific Agencies to examine their policies, procedures, and programs to determine to what extent they recognize the priority of the lifeline sectors and the individuality of regions, amending or revising those that do not.

In designating energy, communications, water, and transportation as lifeline sectors, the President should ensure that Federal policies and programs recognize the priority status of the lifeline sectors in planning, coordination, and recovery for regional disasters. This will help to solidify the fundamental role these sectors have in maintaining the continuity of critical infrastructure services and government functions in all regions.

To implement this recommendation, the Council recommends the following steps.

3.1 **DHS should examine how the Federal government, state governments, and regional entities currently coordinate action with and provide support to the lifeline sectors in event response.**

3.2 **The Federal Emergency Management Agency (FEMA) National Response Coordination Center, Federal agencies, and state and local governments should modify their processes and plans for emergency operations to include the co-location of representatives of lifeline sectors** in their emergency operation centers during major disasters.

3.3 **The President should require that Federal agencies: a) explicitly consider and address the differences among regions when promulgating security and resilience rules, programs, or guidance**; and b) expressly state how they have customized implementation to each region if there is not generic applicability.

Recommendation 4. FEMA should integrate social media platforms into public alert and warning systems to maximize message reach, and develop training programs and guides with state and local government partners that help them capitalize on social media's potential to provide innovative information sharing and response capabilities.

To implement this recommendation, the Council recommends the following steps:

4.1 **FEMA and the Federal Communications Commission should convene a task force of senior emergency managers from lifeline sector SSAs and representatives of leading private-sector social media and technology firms**—such as Twitter, Facebook, and Google—to examine how new and emerging social media apps, platforms, and capabilities can be used to support emergency notification and response and provide greater value to the public. The task force should publish its findings in a report on best practices.

4.2 **FEMA and the Federal Communications Commission should work with social media providers to integrate social media platforms into FEMA's Integrated Public Alert and Warning System** (IPAWS), enabling social media websites and apps to push emergency alerts from state and local emergency managers directly to registered users through a trusted system.

4.3 **FEMA non-disaster preparedness funding to state, local, tribal, and territorial emergency**

management agencies should require all recipient agencies to designate and train specific personnel to use the IPAWS system to issue geographically targeted emergency alerts.

4.4 **FEMA and the DHS Science and Technology Directorate (S&T) should work through the State, Local, Tribal, and Territorial Government Coordinating Council to develop a conference or webinar series for emergency managers on innovative social media use and best practices** in state and local emergency management, including social media successes in recent large-scale disasters. These webinars will also provide a platform for emergency managers to share lessons learned directly with peers.

Recommendation 5. The Secretary of Homeland Security, working with heads of appropriate Federal agencies, should launch a cross-agency team within 60 days to develop solutions to site access, waiver, and permit barriers during disaster response and begin implementing solutions within one year.

The Council reaffirms the recommendations in its 2009 *Framework for Dealing with Disasters* study that calls for DHS to work with Federal and regional government partners and lifeline sector owners and operators to streamline fleet movement, communications, and critical site access for lifeline sector response crews. Removing these barriers offers one of the best opportunities to speed disaster response and recovery after a major event.

To implement this recommendation, the Council recommends the following steps:

5.1 **DHS's Office of Infrastructure Protection and FEMA should collaborate with state, local, tribal, and territorial governments and owners and operators to develop a commonly applied process or system to credential lifeline sector owners and operators and grant them access to disaster areas** more effectively.

5.2 **DHS should work with state and local government and infrastructure owners and operators to catalog the waivers and permits commonly required during a variety of disaster scenarios and develop a streamlined process** for rapidly issuing those permits and waivers at the Federal, state, and local level.

5.3 **DHS should work with the transportation, energy, and other lifeline sector regulators to identify actions that will expedite waivers and remove impediments to fleet movement**, including driver-hour limitations, road and weight restriction, port access restrictions, and toll crossing processes.

Recommendation 6. The President should direct the Council of Economic Advisors and the Office of Science and Technology Policy to work with Federal agencies to create a strong and enduring value proposition for investment in resilient lifeline infrastructures — and their underlying physical and cyber systems, functions, and assets — and accelerate the adoption of innovative technologies in major infrastructure projects.

Strategies that "bake" resilience into the design and construction of physical and cyber structures—the wires, pipes, roads, and rails that connect our communities—offer one of the best opportunities to reduce long-term risks to regions. Although the long-term benefits of these intelligent infrastructures far outweigh the costs, significant barriers to investment exist due to outdated frameworks for evaluating

projects and ineffective financing and investment strategies for advanced technology projects.

To implement this recommendation, the Council recommends the following steps.

6.1 **Within one year, the Department of Energy, in conjunction with the Council of Economic Advisors and the White House Office of Science and Technology Policy, should complete a pilot analysis of the value proposition for investment in infrastructure grid modernization** and recommend any incentives or alternative mechanisms for cost recovery that may be needed to encourage long-term investment in the modernization of lifeline infrastructures. Using the electricity sector as the vanguard, all lifeline sector SSAs should work with their sector partners to establish the value proposition for investment and financing in other critical sectors.

6.2 **The President should direct the National Oceanic and Atmospheric Administration (NOAA) and appropriate Federal agencies to determine how existing weather and climate forecasting models and methodologies** can be used to better communicate both long-term and short-term predictions of severe weather events to enable private, state, and local partners to fully understand potential dangers and make informed investment decisions that manage risk.

6.3 **DHS should work through Federal research organizations, academic institutions, and the national laboratories to develop Applied Centers of Excellence for Infrastructure Resilience to provide an operating environment to test and validate innovative technologies and processes** that build resilience into new large-scale infrastructure projects, integrate next-generation R&D, and share results with other designers in other regions. By partnering with lifeline sector owners and operators, these centers will leverage opportunities for real-world testing, raise awareness of new capabilities, and speed commercialization of emerging technologies.

Conclusion

Our study underscores three important realities affecting the resilience of regions:

1. We live in a dynamic risk environment of increasing complexity and interdependence of related communities, regions, and lifeline infrastructures that must be reflected in our national strategies.
2. The model for planning and decision-making must include the collective expertise, commitment, and resources of key partners, including owners and operators, Federal, state, and local government, non-profits, and communities.

"[Today] we're dealing with levels of complexity and uncertainty and scale and scope that have dwarfed what we had to deal with in the past."

—Admiral Thad Allen
USCG (Ret.), Executive VP, Booz Allen Hamilton

(National Academy of Sciences 2012)

3. Despite our best efforts, disasters will continue to occur, requiring more flexible and agile systems to rapidly respond to and recover from events.

As sectors develop interdependent supply chains that are more efficient but also more fragile, they may unintentionally create risks to other sectors, producing a regional risk environment that no one entity fully understands or can plan for. The Federal government must work with regional partners to help them strengthen resilience and address the next disaster—and the next decades of disasters. However, it

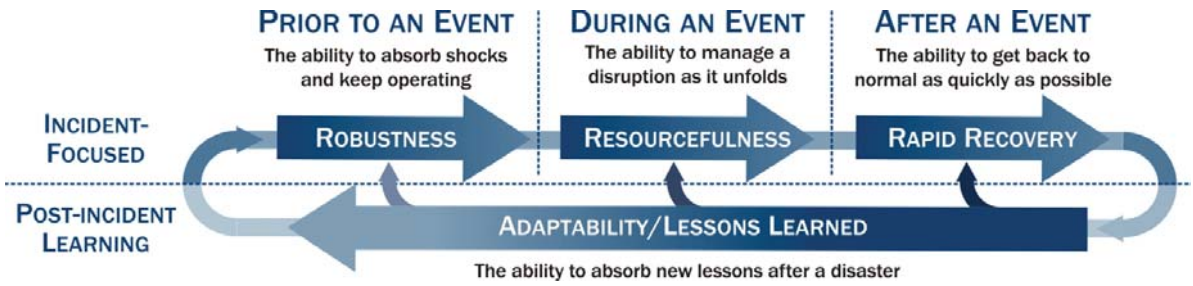
will require a paradigm shift in the ways regions think about, plan for, and fund disaster preparation, response, and recovery.

1. Regional Resilience and Lifeline Infrastructures

Businesses and communities increasingly use integrated physical and cyber systems to operate complex networks of interconnected infrastructures. As a result, an event occurring in one community or sector can cascade to other communities and sectors in ways that operators may not fully anticipate. This is particularly true of disruptions in the lifeline sectors—energy, water, communications, and transportation systems—which provide the essential services underpinning all sectors of the economy. Faced with an increasingly unpredictable threat environment that includes cyber attacks, accidents from aging infrastructure, and non traditional weather events, security partners in the lifeline sectors and state and local government realize that building resilience at the regional level is the key to achieving national resilience.

Resilience is the ability to reduce the magnitude and/or duration of disruptive events. A resilient region is one that is able to **anticipate, avoid, absorb, adapt to, rapidly recover from, work together, and learn from a potentially disruptive event**. Our definition builds upon the definition of resilience formed in the Council's 2010 *Framework for Establishing Critical Infrastructure Goals*. It emphasizes robustness in preparing for an event, resourcefulness in mobilizing resources to respond, rapid recovery of critical services, and a concerted effort to learn from past events and build stronger capabilities for the future.

Exhibit 3. NIAC Resilience Framework



When President Obama issued Presidential Policy Directive on Critical Infrastructure Security and Resilience (PPD-21) in February 2013, he recognized the importance of resilience in managing risks to critical infrastructures. PPD-21 establishes national policy for critical infrastructure security and resilience and affirms that strengthening and maintaining resilience is a shared responsibility among all levels of government and infrastructure owners and operators in the public and private sectors. This directive represents a shift from the protection of physical and cyber assets to building the resources, skills, and capabilities to rapidly detect, respond to, and recover from a wide set of risk scenarios that face the nation's infrastructure. PPD-21 identifies 16 critical infrastructure sectors that "must be secure and able to withstand and rapidly recover from all hazards." It also recognizes the diversity and complexity of these infrastructures, the growing physical and cyber interdependence among critical sectors, and the wide range of authorities that own, regulate, and depend upon the critical services they provide.

A regional perspective reflects the needs of multiple communities and is an essential for achieving national resilience. It enables diverse stakeholders—owners and operators, state and local government, non-profit organizations, and community groups—to leverage collective resources and expertise in

addressing complex infrastructure challenges. However, this will require new ways to think about, approach, and fund resilience.

Building National Resilience from Regional Resilience

All Regions Are Different

Each region has distinctive features—geography, infrastructure configurations, demographics, economic profile, and governance structure—that define its approach to regional security and resilience. The needs of New York City are different from the needs of Moore, OK and the strategies to build resilience for the risks each faces must also be different. While certain infrastructures, such as those in the lifeline sectors, are vital in all regions, **regional partners must ultimately determine which sectors are most critical to both their region and the nation and prioritize them for security and resilience improvements.** In Houston, for example, the oil and natural gas sector and the Port of Houston are critical to the local economy *and* to the security and resilience of the nation. In New York, the banking and finance sector and the information and communication infrastructures that support it are critical to New York and financial systems worldwide. Accordingly, a tailored approach, which reconciles the types and density of the region's infrastructure with regional-based risk assessments, is best for achieving sustainable, long-term resilience.

> "I don't believe it's one size fits all. In fact, I think when that's the case, it's generally the case that one size fits none."
>
> **—Richard Reed**
> Former White House Deputy Assistant for Homeland Security (current Red Cross Vice President for Preparedness and Resilience Strategy)
>
> (National Academy of Sciences 2012)

Interconnection Creates Complexity

As the economies and infrastructures become more interconnected, **local disasters can now cascade to multiple jurisdictions and sectors**, causing disruptions and damage across larger geographic areas. Three important trends now shape critical infrastructure strategies within a region and make a regional approach to resilience imperative: increasing interdependence of related communities, regions, and lifeline infrastructures; growing complexity from the integration of physical and cyber systems; and new and increasingly severe weather patterns resulting from a changing climate.

> "While multiagency leaders—at local, state, Federal levels and across public-private sectors—understand how to build and protect infrastructures (within their areas of responsibility), they often lack awareness of security imperatives facing other sectors in adjacent geographic or mission areas."
>
> **—Dane Egli**
> Johns Hopkins University Applied Physics Laboratory
>
> (Egli 2012: *Beyond the Storms*)

As sectors optimize operations and adopt more efficient but fragile supply chains, they become increasingly dependent upon the uninterrupted operation of services in other sectors, and may unintentionally create risks to other sectors or take on risks that they do not fully understand. In addition, as sectors adopt intelligent, automated cyber systems to control physical processes, they increase the complexity of the built infrastructure and introduce new cyber risks that they may not be fully prepared to respond to. **Stronger sector interdependencies may trigger cascading events that interrupt critical**

services, impede emergency response, and threaten public safety in unexpected ways. Tightly entwined operations among critical sectors were illuminated in recent disasters, such as Superstorm Sandy, where despite excellent planning, severe energy disruptions in some areas ultimately brought transportation, communication, or water services to a halt.

Growing interdependencies will compound in the coming years by stronger and more frequent weather events. Average annual temperatures across the mainland United States have increased by 1.5 degrees Fahrenheit since the turn of the 20th century, a trend that is expected to raise sea levels, increase air and water temperatures, and lead to more frequent and intense storms and flooding (U.S. DOE and NREL 2013). The past two years have served as striking harbingers of this change: 2011 set the record at 14 disaster events that each topped $1 billion in damage, followed by 2012, where the year's total damage of $110 billion, due in most part to Superstorm Sandy, made it the second costliest year for natural disasters since 1980 (NOAA 2013).

Together, **these trends are producing a regional risk environment that no one entity fully understands or can plan for**. The nation's core infrastructure, economies, regions, and supply chains are far too interconnected for stakeholders to make resilience decisions or investments in isolation. No company, sector, or government entity can completely understand the risks they face nor optimize for resilience by working within traditional organizational or jurisdictional boundaries. These conditions have led the Federal government to adopt a whole-of-nation approach to strengthening and maintaining resilience, in which a holistic examination of risks across the critical lifeline sectors within a region reveals both structural and non-structural opportunities to improve resilience (see Exhibit 4).

Exhibit 4. Structural and Non-Structural Resilience

The resilience and security of lifeline infrastructures within a particular region is determined by both **structural** and **non-structural** factors (National Academies 2012). **Structural factors include tangible physical and cyber assets**: the configuration and capabilities of the infrastructure and systems that are present within a given area such as the location and capacity of bridges, roads, wires, pipes, cell towers, and optical fiber. **Non-structural factors include human skills and assets**: the processes, procedures, and organization of capabilities to effectively plan and manage the infrastructure and the services and products it provides. Examples include emergency response procedures, public-private partnerships, capital planning processes, communication protocols, and exercises and training.

Scale and Scope of Critical Infrastructure Pose Challenges

The energy, water, transportation, and communication sectors are highly capital-intensive and have infrastructures with long lifecycles, lasting more than 100 years or more in some cases. **Those lifecycles are nearing the end for large portions of infrastructure in many critical sectors** (ASCE 2013). Long-term resilience can be improved by changing the design, capabilities, and configuration of new assets and systems. Beyond infrastructure hardening, new technologies and network architectures often add new functionality or adaptability that strengthens resilience. In the electricity sector, for example, use of intelligent digital devices and automation in the distribution system helps to pinpoint outages, reroute power, and recover faster. Innovative structural investments can deliver exponential resilience improvements, but require substantial capital expenditures and can be difficult to justify to customers, regulators, shareholders, and the public.

Long-term capital investment in resilient infrastructure is often hard to justify because **the costs and benefits of resilience are dispersed across a wide population and displaced in time**. The full costs of disasters are often borne by a large population of businesses, government organizations, and citizens,

while investments in infrastructure that could reduce disaster costs are typically borne by owners and operators of critical infrastructure. The cost of business losses from a disaster is typically much higher than the cost of the physical damage. It has been estimated that the 9/11 terrorist attacks caused $23 billion in damage at the World Trade Center, but the costs of business interruption were estimated around $100 billion (National Academies 2012). Most important, however, is that significant infrastructure upgrades require large near-term investments that may not show commensurate resilience benefits (i.e., disaster cost avoidance) for years, if not decades. For example, costly flood prevention upgrades for electrical substations near waterways may not deliver a return on that investment until the next exceptional storm—many years later—causes large-scale flooding that the infrastructure withstands. (See Exhibit 14. Red River Floodway: Capital Investment in Infrastructure Pays Huge Dividends Over 40+ Years for another example of cost and benefit displacement). Even then, a functional and resilient infrastructure produces benefits to society that often goes unnoticed until, or unless, it breaks.

This makes first-hand disaster experience one of the greatest motivators for improvements. Investments and lessons learned from Hurricane Irene in 2011 improved response a year later during Superstorm Sandy. After Sandy left $65 billion in damages in its wake, a Rebuilding Task Force is examining innovative infrastructure designs to help the region rebuild stronger and smarter, while electric utilities in New York and New Jersey have since proposed billions of dollars in infrastructure upgrades with support from political leaders. **Disaster damage offers a small window of opportunity to build in resilient features during infrastructure repair and replacement**, and the Northeast region is wisely working in partnership to assess and build resilience to future risk. Yet regional and national resilience will not be maintained through reactionary support for infrastructure investments following large-scale events.

While resilience investments are costly in the near-term, a review of FEMA's hazard mitigation programs showed that **every pre-event dollar spent on resilience yields a $4 savings in future losses** (Multihazard Mitigation Council 2005; Center for American Progress 2013). Other studies point to potentially higher levels of savings. **With much of the nation's critical infrastructure rapidly reaching the end of its useful life, the United States faces a limited opportunity to adopt innovative, adaptive designs that will increase resilience for decades to come**. The American Society of Civil Engineers gave U.S. infrastructure a grade of D+ in 2013, estimating that $3.6 trillion is needed by 2020 to substantially improve infrastructure condition and performance. Yet the U.S. invests only about 2% of its GDP in infrastructure renewal and maintenance, one of the lowest percentages in the world and about half what it was 50 years ago (see Appendix E. Investment in U.S. Infrastructure).

> "On the microscale, making an up-front investment in safeguards that mitigate risk and consequences is far more cost-effective than paying for response and recovery after a foreseeable hazard. On the macroscale, a society's level of resilience contributes to its global competitiveness."
>
> **—Dr. Stephen Flynn**
> Founding co-director of the George J. Kostas Research Institute for Homeland Security at Northeastern University
>
> (Flynn and Burke 2011)

Particularly during a weak economy, **long-term structural resilience investments will be difficult to justify if they do not offer discrete incentives in the form of a near-term benefit or social value**—such as increased efficiency, improved service, cost savings, or environmental benefits—in addition to resilience. As a result, long-term planning for infrastructure investments and emergency preparedness can no longer be done in isolation, not by sector nor government jurisdiction. Building the business case for next-generation technologies and architecture designs will require regions to bring together

government, infrastructure, and community stakeholders to identify regional risks and critical points of failure, align common priorities in addition to resilience (including operational efficiencies, climate change adaptation, compliance, and competitive advantage), and identify the investments that provide the widest benefit.

These conditions lay the backdrop for regional planning, response, and recovery, which represents a new paradigm for disaster resilience in the nation. Even when large-scale regional events require Federal involvement, **it is still the regional relationships, partnerships, processes, and architectures that determine the extent of the damage, how far it ripples throughout the economy, and how quickly and effectively the communities recover**. Our findings and recommendations focus on opportunities for the Federal government to support the development of resilient regions across the nation and mature the Sector Partnership to support this paradigm shift in resilience.

Lifeline Sector Resilience Affects All Sectors

Although the Federal government has not yet defined lifeline sectors, the term has been used by emergency managers and planners for more than a decade. The term "lifeline sector" generally refers to a sector that provides indispensable services that enable the continuous operation of critical business and government functions, and would risk human health and safety or national and economic security if compromised or not promptly restored (see Exhibit 5). These sectors provide the most essential services that underlie a regional economy. They are distinguished from "life support" sectors, such as emergency services and public health, which are indispensable for public safety and health in specific localities.

While different stakeholders may define lifeline sectors differently, there is widespread agreement across security and resilience literature that the following four sectors fit the characteristics of lifeline sectors for every region and event:

- Energy (oil and natural gas / electricity)
- Transportation (rail, aviation, highway, public transit, and marine)
- Communications (and supporting IT)
- Water (potable water and wastewater)

Exhibit 5. Defining Features of a Lifeline Sector

- Provides essential products and services that underpin the continued operation of nearly every business sector, community, and government agency.
- Typically delivers products and services that are ubiquitous in normal circumstances but can create life-threatening conditions if they are unavailable for long or even short periods of time.
- Encompasses complex physical and cyber networks that are highly interconnected within their sector, between sectors, and within and between adjacent regions.
- Its disruption or destruction can cause failures that cascade across dependent infrastructures and regions, producing a multiplier effect of impacts.

Other sectors could also be considered lifeline for a particular region or event. For example, the financial services sector in New York City and the ports and shipping industry of Los Angeles and Long Beach in Southern California are uniquely critical to both the region and the nation. Emergency services, public health and healthcare, and food and agriculture sectors also provide life-sustaining functions or contribute to the continuity of essential services in specific events. The nature of a disaster or regional condition could elevate one or more sectors to become a lifeline sector, and stakeholders in each region may determine which sectors are most critical for the continuity and recovery of essential services in that region.

2. Lessons from Superstorm Sandy

Since this study began in April 2012, Council members witnessed several disasters in which a disruption in one infrastructure or region spread to other sectors and regions. These include a three day disruption of 911 services in Virginia due to power outages from the June 2012 derecho; a virtual shutdown of the City of Boston when the transit system closed after the marathon bombing; massive tornados in Oklahoma that devastated whole communities; and cascading impacts due to extensive damage and disruption in the energy sector during Superstorm Sandy. These real world events produced widespread disruption of critical services, loss of human life, and large economic losses that elevated regional events to national events requiring Federal involvement. In 2012 alone, the United States lost $110 billion to weather related disasters—11 of which exceeded $1 billion each—making it second in disaster costs only to 2005 (the year of Hurricane Katrina) since 1980 (NOAA 2013).

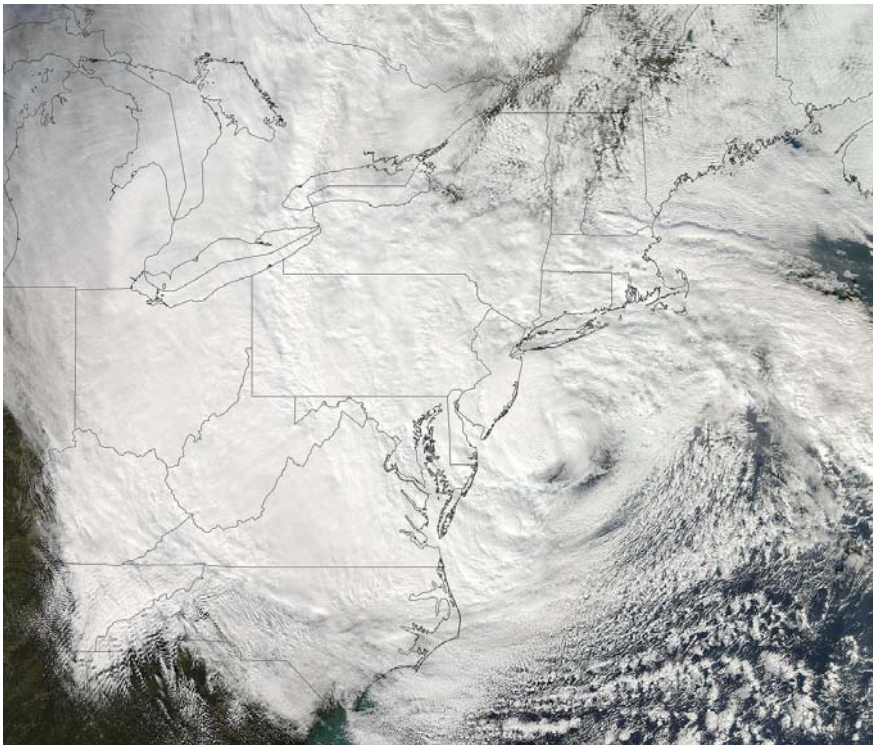
Superstorm Sandy provides an excellent (but unfortunate) example of a major natural disaster that disrupted lifeline sectors and caused widespread damage and disruption over a large geographic region. The Superstorm Sandy Case Study, conducted as part of this overall study, engaged infrastructure owners and operators and state and local government emergency managers to collect and analyze extensive data on the storm's impacts, lessons learned, and implications for regional resilience. Detailed sector-specific and cross-sector learnings are included in Appendix D. This chapter contains a distillation of key lessons learned that informed the NIAC's findings and recommendations. Additional text boxes contain mini-case studies of other regional disasters that affirm many of the lessons from Sandy.

Hurricane Sandy—one of the largest Atlantic tropical storms ever recorded—made landfall on Oct. 29, 2012 near Atlantic City, NJ as a post-tropical cyclone. For the next three days, heavy rains, 80–90 mph winds, and storm surges battered the East Coast as the storm drove inland toward Pennsylvania, causing massive flooding, widespread power outages, and severe damage to homes and infrastructure. Impacts were felt from North Carolina to Maine and as far west as Illinois. By the time the storm dissipated on Nov. 1, peak power outages totaled 8.6 million, damage estimates exceeded $60 billion, and 117 people had lost their lives. Just one week later on Nov. 7, a Nor'easter swept into the affected region with strong winds, rain and snow, and coastal flooding, giving Sandy the "superstorm" moniker. Heavy, wet snow blanketed the already damaged area, snapping storm-weakened trees and downing power lines, tacking an additional 200,000 people onto the list of more than 500,000 already without power in near-freezing temperatures (DOE 2012b; New York City 2013a and 2013b).

Exhibit 6. Key Lessons from Recent Disasters

- Strong public-private partnerships accelerate response
- Senior executive-level engagement removes critical barriers
- Increasing interdependencies harbor hidden risks
- Lifeline sector service restoration needs are critical and not fully understood
- Large-scale events reveal critical points of failure and risks of aging infrastructure
- Co-location of key partners improves coordination and decision-making
- Joint regional exercises build response muscle memory
- Strong communities reduce impacts and improve recovery
- Complex rules, regulations, and processes hinder lifeline sector response
- Innovative social media use can revolutionize response
- Business case for infrastructure investment is difficult to define
- Risk data is needed to build stronger and redefine best practices

Exhibit 7. Hurricane Sandy Approaches the East Coast on October 29, 2012



(Photo Credit: NASA Goddard Space Flight Center 2012)

Superstorm Sandy reinforced the importance of regional resilience. Prior to the storm, public and private partners worked extensively to build partnerships and exercise disaster response. But the storm also revealed new risks and failure points from the overwhelming damage. The following sections contain critical lessons that emerged from the actions of infrastructure owners and operators, state and local government, Federal agencies, and non-profit and community organizations.

Strong Public-Private Partnerships Accelerate Response

Public-private partnerships proved critical to rapid response and recovery during Superstorm Sandy. Personal relationships remained critical at the state and local level and were key success factors for coordination. When traditional communication channels were compromised, agencies used personal cell phone numbers and e-mail addresses to communicate. Creative problem-solving also stemmed from working directly with stakeholder contacts. A petroleum distributor who successfully built a relationship with a Philadelphia supplier (outside its normal operating region) was able to successfully use that relationship to source fuel for critical customers when sources within the hardest hit areas were compromised. In a prior storm, the same distributor lacked this relationship and had been cut off while trying to pre-stock critical customers with fuel. Sustaining and institutionalizing relationships will be key to future response agility. Agencies such as the Department of Energy (DOE), the Department of Transportation (DOT), and the Environmental Protection Agency (EPA) worked directly with utility owners and operators, trade associations, and state officials to expedite waivers enabling repair crews to cross state lines and transport heavy equipment through disaster areas.

"We need to understand there is no agency in government, no private sector firm, no not-for-profit or voluntary organization … [that] has the resources, the scale, and the competency to solve the complex problems we are dealing with today."

—Admiral Thad Allen
USCG (Ret.), Executive VP Booz Allen Hamilton

(National Academy of Sciences 2012)

The Federal Emergency Management Agency's (FEMA) Innovation Team—a multi-sector, cross-functional group of creative problem-solvers made up of government, industry, non-profit organizations, and community volunteers—also made its debut during the storm, enabling FEMA to tap into resources and expertise outside the agency and support a whole community approach to response. Designed to look at response problems from a broad perspective, rather than by agency or sector, and use its agility to quickly solve large, localized problems on the ground, the Innovation Team reached out to networks and volunteers to restore critical needs in hard hit areas like Red Hook, NY. Using its members' personal and professional networks, the team linked up with IT volunteer organizations to establish a mesh Wi-Fi network and a satellite communications link that enabled the community to contact family, apply for disaster assistance, and support its own response and recovery (Serino 2013).

Executive-Level Engagement Removes Critical Barriers

During Sandy, direct communication between senior executives in industry and government streamlined coordination, removed obstacles, and enabled resource and asset movement that would not have otherwise been possible. Unprecedented coordination among senior electricity executives and government leaders resulted in the largest movement of mutual aid resources ever in the electricity sector. President Barack Obama publicly declared zero tolerance for red tape, which became a catalyst for senior-level officials to identify critical resource needs and work directly with their counterparts in industry or government to rapidly move supplies and personnel without lengthy approval processes. Examples of effective senior-level coordination include the following:

- President Obama sent a Senior Assessment Team of government executives into the field to directly address and coordinate response on electricity sector issues. Members included the deputy FEMA administrator, a DOE deputy assistant secretary, a flag officer from U.S. Northern Command, and White House personnel.
- Electric utility CEOs nationwide and Edison Electric Institute (EEI) representatives participated with DOE senior leadership in daily coordination conference calls to improve situational awareness and facilitate resource deployment.
- A first-of-a-kind Energy Restoration Task Force at FEMA's National Response Coordination Center (NRCC) specifically supported power restoration and fuel availability.
- At President Obama's request, EEI embedded a representative in the NRCC for 10 days to serve as a point-person for representatives of FEMA, DOE, DHS, DOT, and U.S. Department of Defense (DOD), and coordinate with CEOs or member organizations, which represent 70% of the electricity delivered in the United States. This enabled unprecedented resource movement, including military airlifting of resources and personnel from the West Coast Federal power administrations to hard-hit areas on the East Coast.

Exhibit 8 describes a two-year, dedicated electricity sector effort to engage CEOs with Federal government executives to address national problems. This partnership largely contributed to the effectiveness of electricity sector response during Sandy, demonstrating the effectiveness of this model.

Exhibit 8. Transforming CEO Engagement in the Electricity Sector

Electricity executives once had limited engagement with the Federal government, but the Sector Coordinating Council (SCC) now includes 28 CEOs. Executive relationships were leveraged during Hurricane Sandy to speed restoration.

Catalyst: NIAC recommends senior executive engagement with Federal government

- 2008-2011: Four NIAC studies recommend senior executive engagement; one calls on the White House to establish an executive-level dialog with electricity/nuclear sector CEOs.
- Feb. 2011: Electricity CEOs write a letter to President Obama requesting a senior-level meeting.

Compelling Value Proposition: Electricity cyber threats rapidly escalate

- 2012: U.S. Secret Service (USSS) works with a trusted industry executive to connect with electricity CEOs and pilot cyber intrusion detection and response devices. Success builds CEO trust in the Federal partnership.
- Feb. 2012: Secretaries of Homeland Security and Energy convene electricity sector CEOs in July to address rising number of targeted electricity cyber threats. A CEO-level executive with appropriate security clearance acts as a facilitator and trusted partner for both industry and government during the meeting.

Executive Commitment: CEOs form Joint Electric Executive Committee to address urgent cyber issues

- July- Oct. 2012: The ad-hoc committee of about 20 senior executives, which included the senior executive facilitator, forms to address urgent cyber security issues and increase the USSS pilots. CEOs engage their next-level executives—COOs and CIOs—with the DOE and DHS Deputy Secretaries and plan tactical deliverables.

Proof of Concept: Superstorm Sandy tests efficacy of executive engagement

- Oct. 2012: The Joint Electric Executive Committee is used during Sandy to act decisively and enable companies and agencies to cut through red tape to restore power to devastated areas. CEOs meet with President Obama ahead of the storm to plan response, and daily CEO conference calls with Federal emergency managers facilitate rapid and unprecedented resource movement.

Clear and Enduring Process: Senior executive working groups formed to tackle key priorities

- Dec. 2012-Sept. 2013: The Committee formed three working groups of COOs and CIOs, which instituted regular conference calls with senior leaders from the DOE and DHS to tackle: 1) improved information sharing, 2) technology deployment, and 3) incident response. Working groups report progress and deliverables at quarterly meetings of senior Federal representatives and the Executive Committee.

Formalized and Continuous Engagement: Executives mature the Electricity Sector Coordinating Council

- Sept. 2013: The electricity sector has reconfigured the Electricity SCC to be led by senior executives. The SCC identifies key sector risks, sets priorities, and commits resources to partnership efforts.

Lessons Learned—Five success factors for public-private partnership:

1. **Senior executive-level engagement**: CEOs set strategic priorities and commit resources to them. By engaging top executives, the sector set the stage for coordinated efforts at all levels of the organization and sector.
2. **Trusted relationships**: CEOs became engaged at the urging of trusted and respected parties within the industry. Trust between industry and government built over time through several successful engagements.
3. **Simple process**: Meetings between executives and government officials had a set agenda, defined outcomes, and clear roles and responsibilities that respected participants' limited time and competing priorities.
4. **Value proposition**: A clear and growing cyber threat to the electricity sector provided the compelling catalyst for direct engagement. An established process and strong track record of success now provide the value proposition for continued engagement.
5. **Executive champion**: Executive partnership efforts were facilitated by a respected industry champion, who was trusted by both public and private sectors.

Increasing Interdependencies Create Hidden Risks

Superstorm Sandy greatly stressed the capabilities of lifeline infrastructures over a large geographic region and exposed hidden risks not well understood or foreseen by emergency managers in other sectors and government. Water sector owners and operators did not fully understand electricity restoration challenges, which made it difficult for them to communicate outages affecting critical water assets to electric utilities. The transportation sector experienced flooding when it found backup generators provided insufficient pumping capacity. Yet the most far-reaching issue of the storm was widespread petroleum shortages. It revealed a growing reliance on electricity and the fuels needed to run emergency generators that many sectors did not fully anticipate. Many owners and operators believed they had sufficient backup generation resources, but when power was not restored quickly, their fuel supplies dwindled and they were not able to replenish them. Heavily damaged refineries and terminals, combined with extensive power outages, caused unanticipated disruptions in the fuel supply chain—from pipelines and refiners to suppliers and distributors—including the following:

- Power outages to pipeline pumps and fuel terminals that could then no longer accept fuel forced the northern part of the Colonial Pipeline to shut down, effectively cutting the region off from a 2.4 million-barrel-per-day supply of petroleum.
- Without power, several refineries were unable to refine fuel for the region, receive fuel, or access their existing supply of fuel for supply and distribution.
- While refineries and supply terminals were initially offline due to a lack of power, many also suffered major water damage to primary switch gear and other internal electrical components that delayed operations long after power was restored. As of Nov. 5 (eight days after landfall), nine terminals in New York and New Jersey were still offline due to damages sustained. The second largest refinery in the region, with a 238,000-barrel-a-day capacity, was not able to begin restart until Nov. 20, more than three weeks after it shut down in preparation for the storm.
- Without commercial power, well-stocked gasoline service stations were unable to pump fuel to customers. Service stations with power quickly depleted resources as demand rose, and suppliers experiencing power outages or infrastructure damage could not refuel them.

These issues were further complicated by the SEC Regulation Fair Disclosure, which limits information sharing in the oil and natural gas sector and prevented public emergency managers from accessing data on the availability of fuel resources and causes of disruptions (U.S. Securities and Exchange Commission 2001). As a result, disruptions highlighted the region's high dependency on gasoline and diesel fuel to power backup generators and vehicles needed for restoration efforts. Backup generators at many critical facilities in other sectors had limited storage capacity, typically only a 24-hour supply of fuel, which created a large demand on distributors as restoration stretched on. In addition, requests for generators and support to obtain fuel for backup generators were not consistently prioritized by emergency management agencies, creating significant risks for cascading consequences.

Lifeline Sectors Service Restoration Needs are Critical and Not Fully Understood

Sandy emphasized that prioritizing the restoration of lifeline sector facilities is complex, condition-specific, and often difficult to communicate. Many partners and the public did not understand the criticality of some of the lifeline sectors, how lifeline sectors recover, the factors affecting priorities, and

who is involved. As a result, some utilities faced a lack of support for backup power and fuel requests from emergency managers and state and local officials who did not understand the cascading impacts of potential disruptions. In the water sector, limited recognition of water and wastewater criticality resulted in "near miss" events and service impacts that likely could have been mitigated. For example, emergency managers de-prioritized water utility requests for backup generation and fuel support in a Maryland county, resulting in 25 million gallons of raw sewage being released into a local body of water.

Misconceptions about the role of state and local government also existed in both the private sector and the public it serves. Most state and local emergency managers had worked with electric utilities to pre-determine restoration priorities, but many were served by flooded electrical distribution stations that required days to pump, dry, and clean. This required re-shuffling of priorities and increased communication with power companies to adapt to the real-time conditions and severity of Sandy. Increasing the understanding of the critical nature of the lifeline sectors and how they operate will aid in making reprioritization easier and response times faster. For example, communication services proved to be a force multiplier during Sandy that enabled community groups to leverage social networks and share information to support recovery. Pre-staging mobile cell platforms and satellite communications units proved effective to replace primary services; however to obtain them, states had to first request FEMA satellite resources under emergency declarations, which delayed mobilization of the units. Heightening the importance of all of the lifeline sectors will help aid in the removal of such barriers in the future.

Large-Scale Events Reveal Critical Points of Failure and Risks of Aging Infrastructure

Superstorm Sandy revealed critical points of failure that stemmed from unknown infrastructure weaknesses and the physical age of the components in use. In the transportation sector, subway tunnels and depots for both subway cars and buses in New York City lacked sufficient protections against extensive flooding and capacity to pump out water, which damaged electrical and communications components and aging systems. The unprecedented storm surge also exposed new critical failure points, such as stairwell entrances to subway tunnels and street-level gratings, which were overwhelmed by flooding. The sheer size and strength caused unparalleled damage for the region in almost every sector; Verizon's Vice President of National Operations Chris Levendos called it "the largest impact to our wireline infrastructure in our 100-year history" (NOVA 2013).

In addition, repair to aging infrastructures that rely on critical parts and equipment that are no longer manufactured resulted in a scramble to locate spare parts and repair delays, as did the size, weight, and cost of the replacement components. Even in newer infrastructure, many specialized components are rare or have long manufacturing lead times. Specific difficulties repairing aging and specialized equipment included the following:

- New York's 108-year-old subway system has unique and outdated parts that require extensive time and high costs to replace, which led to longer than anticipated shutdowns.
- During repairs, New York's Metropolitan Transportation Authority (MTA) used more than 80% of its equipment inventory, nearly exhausting replacement supplies, while the Port Authority Trans-Hudson (PATH) had to seek replacement parts from partners including the DOT Federal Transit Administration (FTA) and companies from as far as Louisville, KY; Pearl, MS; and Pittsburgh, PA.

- At the request of PATH, GE opened a plant in Puerto Rico specifically to manufacture replacement parts that have not been available for years.
- Critical components in the electricity sector, such as transformers, are prohibitively expensive for individual utilities to maintain as spares and have long lead times for emergency replacements.

Exhibit 9. June 2012 Derecho: Disruptions Cascade Across Multiple Lifeline Infrastructures

Event Summary: On June 29, 2012, a derecho—a widespread, long-lived, rapidly moving line of intense thunderstorms—traveled about 700 miles in 12 hours starting in Iowa and northern Illinois. Wind speeds reached 91 mph at Fort Wayne, IN; 82 mph in Dayton, OH; and between 60 mph and 80 mph in the Baltimore-Washington, DC corridor. The storm killed 13 people and caused massive power outages and property damage. More than 4.2 million customers lost power across 10 states and the District of Columbia, with the largest outages occurring in Virginia, Maryland, Ohio, and West Virginia. The majority of destruction was caused by falling trees crushing cars, homes, and buildings and bringing down power lines.

Impacts: Widespread power outages crippled the region. Without electricity, critical services from the energy, transportation, water, and communications sectors were severely disrupted for days. The storm knocked out power to several hundred traffic lights, while debris from the storm cut off primary and secondary roads causing widespread road closures. Many gas stations were unable to pump gas without power. Maryland's light rail system, buses, and other transportation services were disrupted due to damage and outages.

More than three dozen wastewater treatment facilities were without power in Fairfax County, VA following the storm, resulting in low pressure, discolored water, mandatory conservation, and boil water advisories for customers. A number of pumping stations in Montgomery County, MD had to rely on generators for more than a week.

Communications were disrupted by more than 150 downed utility poles and close to 900 downed fiber cables. Area cell phone towers were unavailable for short periods of time or working on backup generation. A backup generator failure caused four of Verizon's 911 call center locations in Northern Virginia to be unavailable for three days for residents in Fairfax and Prince William counties, and Manassas and Manassas Park. Other call centers in the area also reported 911-related problems, including lack of location information and loss of backup phone lines.

It took almost a week to restore power in some areas, while a heat wave descended on the region. Following the derecho, 34 people died from heat-related causes in areas without power.

Response & Recovery: More than 24,000 workers from Appalachian Power, Allegheny Power, Pepco, Dominion, and BGE worked on restoration, including workers from other states and Canada. Additional storms and excessive heat lengthened the time it took to restore power and other services.

Utility personnel were embedded with state and local emergency management agencies to facilitate communications and collaboration. All power was restored by July 8. Following the storm, utilities vowed to evaluate how infrastructure could be improved and in some cases were already in the process of making upgrades. Verizon also made changes to internal programs and procedures to ensure reliability of the system in the future.

Sources: Johns, et. al. 2013; NOAA 2013e; Samenow 2012; National Weather Service Forecast Office-Baltimore/Washington 2012; Brown, et. al. 2012; Paramaguru 2012; MDOT MTA 2012; Fairfax County, 2012; WSSC 2012; Verizon, 2012a; Malady, 2012; Bensen, 2012; DOC, NOAA, NWS, 2013; Mills, 2012; Pepco, 2013

Exhibit 10. Cascading Impacts of the June 2012 North American Derecho

Electricity

- 4.2 million customers in 11 states and D.C. lose electricity for up to a week as 24,000 workers repair damage
- Power lines to substations require repair before lines to critical facilities (water, hospitals, communications)
- Derecho-related power outages cost MD alone almost $600 million

Communications

- 10% of cell phone towers unreachable in the first 2 days, 2% by day 4
- Verizon: 156 downed utility poles and 897 downed copper or fiber cables
- Cell calls and data downloads strain wireless capacity, causing service disruptions
- Many cell towers on backup generators
- Backup power and switching equipment failures at multiple 911 call centers

Transportation

- 184 state roads close in MD; 20 primary and 201 secondary roads close in VA from debris
- Hundreds of traffic lights out across MD and VA
- Many must drive to find fuel, food, and hotels

Oil & Natural Gas

- Service stations lose power and ability to pump gas, creating long lines and complicating travel

Public Health

- 80 crews needed to restore power to 4 MD nursing homes without electricity or AC
- 34 people die from heat-related causes
- Low water pressure, discolored water, mandatory conservation, and a boil water advisory in Fairfax County, VA

Water

- PJM load curtailment reduces water production
- 50 Washington Suburban Sanitary Commission facilities lose power
- Fairfax County loses power to 40 of 63 wastewater pumping stations; all 63 lose SCADA communications

Emergency Services

- 911 services unavailable or unreliable for 3 days in several VA and WV counties;17 call centers lose connectivity from communication failures
- 911 calls in Fairfax increase 415% over the 3.5 hours following the storm; fire and rescue dispatch increases by 2,400%
- Public safety officials direct traffic at dark intersections

Government & Office Facilities

- Federal workers have option for unscheduled leave
- Commercial buildings close without power or transport

Co-location of Key Partners Improves Coordination and Decision-making

Co-location of key officials from lifeline sectors and public agencies in state and Federal emergency operations centers (EOCs) improved communications and accelerated public-private situational awareness, coordination, prioritization, and decision-making during Sandy. The inclusion of utility representatives in state EOCs and the FEMA National Response Coordinating Center, in many cases for the first time, was quickly recognized as a best practice. As emergency managers and private utilities worked side by side to coordinate and mutually support response, electric utilities and communications companies with co-located assets also worked together to coordinate repairs, speeding up restoration of both services. Where co-location of emergency response officials was not possible, daily conference calls between government officials and owners and operators enabled tight coordination that greatly improved cross-sector situational awareness. Successful efforts to co-locate and coordinate included the following:

- New Jersey held pre-event conference calls with private-sector stakeholders, established a private-sector desk within the EOC to coordinate resource and information requests, and invited representatives from the Fuel Merchants Association of New Jersey, which represents the state's petroleum marketing industry, into the state EOC to enable state officials to coordinate fuel requests from other critical sectors. Officials in New Jersey also had contact information for owners and operators of state- and national-level critical infrastructure and had previously issued private-sector employee identification cards to improve access for essential employees to disaster areas.
- Activating the Philadelphia EOC brought together police and fire, water, transit, and energy officials in both the public and private sectors under one roof to coordinate. Any agency that had a role in the response was requested to staff the EOC to promote information sharing, streamline decision-making, and to prioritize scarce resources.
- Safety concerns typically require that electric utilities remove live wires and complete repairs before communications providers repair lines on shared poles or assets. Because of the sheer magnitude of damage, this process slowed restoration times for communications companies such as Time Warner Cable, which worked with utilities to develop mapping software that showed where power had been turned off, clearing the way for Time Warner to begin repairs. When Time Warner reached an area first, they put the electric poles back, and vice versa, using a collective agreement.
- In daily calls led by the New Jersey Office of Homeland Security, emergency managers and owners and operators received updates on restoration across the region and coordinated a more effective response. Senior Department of Energy officials led and participated in coordination calls to facilitate power restoration to affected fuel terminals and refineries.

Joint Regional Exercises Build Response Muscle Memory

Recent experience with storms, such as Hurricane Irene in 2011, and participation in joint exercises helped government and lifeline sectors to improve emergency response plans, flood preparations, infrastructure hardening, and communication procedures. Drills and exercises keep partners engaged between events, enable knowledge transfer, and build "muscle memory" to make response automatic and well-coordinated. Exercises also offer the opportunity to define the specific roles and responsibilities of state and Federal government agencies during an emergency to limit unnecessary

duplication of efforts and enable a more effective response. Critical exercises in the Northeast region helped partners prepare for hypothetical impacts that Sandy made a reality:

- Regional water utilities in New Jersey participated in the DHS-sponsored New Jersey Exit 14 Regional Resilience Assessment Program (RRAP) the year prior to Superstorm Sandy, which provided regional hydraulic modeling and system assessments to identify vulnerabilities, interdependencies with other critical sectors, and economic and social impacts of outages in particular parts of the region. This program enabled providers to identify resilience improvements that would specifically address regional risks.
- New Jersey's recent "Running on Empty" exercise with its infrastructure bureau and regional owners and operators in 2011 presaged the petroleum disruptions the sector actually faced in Sandy. As a result, petroleum owners and operators were not caught off guard by Sandy's impacts and were able to begin organizing a response more quickly.
- DOE and the National Association of State Energy Officials (NASEO) conducted regional exercises in 2011-2012 that simulated cross-sector, multi-jurisdictional disasters, including: a mid-Atlantic hurricane, droughts, severe winter storms, solar events, and cyber attacks. The exercises included owner and operators and state and local emergency managers to examine how adjacent states and energy companies would coordinate regional disaster response.

Exhibit 11. Blue Cascade Exercises: PNWER Offers a Best Practice for Regional All-Hazards Preparation

More than a decade ago, the Pacific Northwest Economic Region's (PNWER) Center for Regional Disaster Resilience started its Blue Cascades Exercise Series to evaluate interdependencies among infrastructure and make recommendations for improvements. Since 2002, exercises have been held on a range of issues, including physical disruptions to the energy grid; physical and cyber disruptions; recovery and restoration from a major earthquake; critical infrastructures and pandemic preparedness; critical supply chains—food, fuel, water—after a major earthquake; and floods and H1N1. Participants include local, state, and Federal government; utilities; businesses; non-profits; academia; and community institutions. Following the tabletop exercises, the stakeholders develop an action plan to address issues identified. Because of their wide-ranging issues and cross-sector, cross-regional participation, PNWER's exercise programs are widely regarded as best practices for regional preparation to all-hazards events (PNWER CRDR 2013; CRDR 2010).

Complex Rules, Regulations, and Processes Hinder Lifeline Sector Response

Existing laws and regulations at the Federal, state, and local level and uneven processes for receiving waivers hindered rapid response during Sandy. Requirements for various permits, tolls, waivers, and worker credentials across states complicated movement of fleets of emergency repair crews, substantially delaying their ability to aid in recovery efforts—as a two-hour delay in fleet movement can effectively delay that crew from beginning restoration work for 24–48 hours. Sectors that used mutual aid assistance from repair crews outside the affected area relied on emergency waivers of driver-hour limits and minimum rest periods, and rapid load permitting for inter-state movement to speed response and recovery—and this sometimes required a complex and lengthy request process. Potential improvements have been suggested by regional groups:

- Nationwide or regionally consistent toll booth procedures to simplify payment processes (e.g., the East Coast's EZ-Pass system).

- Improved private-sector access to automated permitting systems to help speed fleet permits (e.g., the Pennsylvania Department of Transportation's [PennDOT] Automated Permit Routing/Analysis System [APRAS]).
- A centralized database for mobilization information that would provide utility fleets with details about state/local permitting requirements, toll road and payment protocol information, and updates on where emergency declarations have been issued and which waivers are in place as a result.

Federal, state, and local regulations—many designed to protect consumers—ultimately inhibited information sharing and limited fuel supply shipments from outside the region during Sandy. Limited visibility into regional fuel supplies made it difficult for owners and operators, government officials, and dependent sectors to assess the problem and prioritize response. State emergency managers and other critical sectors also lacked insight into the status of all links in the supply chain and the significance of disruptions, which complicated decision-making. Excellent Federal, state, and local coordination both before and during the storm swiftly delivered waivers in many cases. But sometimes the waiver process or lack of waivers significantly delayed restoration of fuel deliveries in the region. Other regulations were not easily waived and further exacerbated the disruption:

- Antitrust laws, which place limits on market-sensitive information sharing and competitive conduct, restricted the owners' and operators' ability to share information regarding their fuel supplies with government partners and other companies.
- SEC Regulation Fair Disclosure—which states that any material nonpublic information that a petroleum company discloses to another entity must also then be disclosed publicly—made petroleum companies reluctant to share sensitive supply status and operations information with state emergency managers and other sectors.
- Anti-gouging laws, established by the state to prohibit a service station from excessively raising the price of fuel (10% above normal prices in New Jersey; in New York, "unconscionably extreme" increases are barred [Yglesias 2012]) limited fuel supplies. The laws discouraged suppliers and distributors from bringing in fuel from other regions, as the increased transportation costs and subsequent fuel price increases would risk the appearance of price gouging.
- Uniform Commercial Codes, adopted by all 50 states, dictate that refineries and distributors cannot discriminate among customers and must first meet their contractual obligations. As a result, operators could not redirect fuel deliveries unless stated in existing contracts.

In addition to policy and regulatory challenges, Sandy also stressed utility mutual aid agreements and made securing sufficient response crews prior to the storm a challenge. Sandy demonstrated that when large storms follow unpredictable paths across a broad geographic region, companies tend to implement plans earlier and hold onto resources longer, forcing utilities to cast a wider net for mutual aid.

Strong Communities Reduce Impacts and Improve Recovery

The impacts of recent regional disasters are starting a culture shift toward community readiness and personal responsibility for short-term survival. Non-profit and community groups played a key role in assisting communities to respond in flexible and innovative ways and during long-term recovery from Sandy. In many cases, these organizations replaced lifeline sector services when major providers were

still performing restoration, by providing generators, transporting food and water, and replacing internet and wireless communications that were indispensable in the first few days. Some non-profits also work regularly with communities to train and prepare for disaster response, while community groups offer strong networks of individuals that can be leveraged in an event. While the potential severity and wide geographic reach of storm events is raising public awareness of the need to maintain self-sufficiency immediately following a disaster, continued support and education is needed. Building community capacity to shelter-in-place and withstand longer power and critical service outages can decrease the strain on state and local resources and improve recovery. The public needs education on disaster preparation and consistent messaging from state and local officials to build the expectation for individuals to be self-reliant for at least 72 hours following an event with major service disruptions.

Exhibit 12. Oklahoma Tornadoes: Experience and Lessons Learned Reduced Impact of Extended Disruptions

Event Summary: On May 20, 2013, an EF-5 tornado with winds between 200 and 210 mph moved about 14 miles from Newcastle, OK and ended a few miles east of Moore, OK, cutting a path 1.1 miles wide and killing 24 people, injuring hundreds, and damaging about 13,000 homes. The storm's damage is estimated at about $2 billion. The tornado was part of a string of severe weather events the state experienced in the spring and summer.

On May 31, a tornado tore through an area near Oklahoma City. The broad storm hit during rush hour and caused flash flooding. Almost two dozen people were killed, there was extensive property damage, and more than 86,000 customers lost power. At the end of July, a derecho with winds between 60 and 80 mph caused more than 100,000 homes and business to lose power primarily near Tulsa.

Impact: Following the May 20 tornado, there were widespread disruptions to cell phone and internet service, primarily due to cell tower damage and power outages. Wireless providers encouraged residents to use text messages rather than make calls. Some providers also waived voice, data, and text overage charges in the affected areas for a month following the tornado.

Businesses reported losing perishable inventory multiple times due to the number of power outages from the storms, along with losses from extended business closures due to damage or power outages. In Moore, an estimated 6,000 businesses were affected by the storm, the majority of which were small businesses. Public health services were also impacted by the severe weather. The May 20 tornado destroyed a hospital, while the July derecho forced the evacuation of 100 residents of an assisted living facility because of power outages.

Response & Recovery: Moore, OK is no stranger to tornadoes—major tornadoes ripped through the town in 1998, 1999, 2003, and 2010. Officials credited the response following the tornado to preparedness and experience. Businesses served as collection sites for donated goods and donated portions of sales to the Red Cross.

Two of Oklahoma's urban search and rescue units responded to help find survivors. An additional unit responded from Texas under a mutual aid agreement between the states. The Federal Emergency Management Agency sent three disaster survivor assistance teams, which used tablets to quickly register people and record unmet needs. In an example of private sector coordination, Moore's public affairs office reached out to a local advertising firm that supplied professionals to update social media and take reporters' requests.

Improvements in forecasting gave residents additional time to prepare in 2013. The National Weather Service issued a warning for the area including Moore 16 minutes before the tornado was expected to touch down, but it took an additional 20 minutes to reach the area, giving residents about 36 minutes' warning . The National Weather Service also used social media, such as Twitter, to issue warnings and provide information about the location of the tornadoes.

Sources: CNN 2013; Jonsson 2013; NWS 2013a; Plushnick-Masti and Murphy 2013; Murphy 2013; NWS 2013c; *Tulsa World* 2013; Smith 2013; Arnold 2013; Kirgan 2013; Grenoble 2013; Bland and Muchmore 2013; Palmer 2013; *Tulsa World* Staff Reports 2013; Anderson 2013; NWS 2013b

Innovative Social Media Use Can Revolutionize Response

Social media became a valuable communication tool during Sandy that provided new information streams to support situational awareness, provide notifications, and control rumors. It was used extensively by state and local governments as well as utilities to communicate updates to the public and help reduce panic, while confirming information and reports following the storm. For example, students from Franklin High School in New Jersey solicited feedback from Twitter to map which gas stations were closed or open and shared it on Google crisis maps, which governments and citizens used to help manage the fuel disruptions. In addition, social media served as a critical tool for organizations to survey and match community needs with resources and personnel, and enabled ad-hoc community groups to assist with emergency response outside of traditional processes. State and local governments began utilizing social media to inform and support critical operations in ways they never had before. However, social media also complicated traditional communication and was only partially used by government agencies and owners and operators, who are often learning by trial and error. Government agencies, community organizations, and infrastructure owners and operators are examining training and opportunities to better leverage social media during normal operations and disasters.

> "Social media are transforming the way rescuers and survivors respond to crises. These new tools have the power to turn traditional, top-down emergency management on its head."
>
> **—Dr. Stephen Flynn**
> Founding co-director of the George J. Kostas Research Institute for Homeland Security at Northeastern University
>
> (Testimony before the 112th Congress 2012)

Specific examples of the innovative ways social media was leveraged during Sandy include the following:

- Philadelphia's integration of social media into its Office of Emergency Management (OEM) and 311 mobile platform showed how social media could be used to reach large populations in real time and request information from citizens to improve response. The City of Philadelphia used the new "Philly311" mobile app, launched in September 2012, to share information with the public and receive non-emergency requests from residents across the city during Superstorm Sandy. More than 400 requests were made via the app, and the @Philly311 Twitter account gained approximately 2,000 followers and sent 1,000 tweets during the storm.
    - The city is now exploring opportunities to: better coordinate social media into its Joint Information Center; train and dedicate personnel to social media management to improve messaging frequency and relevance; and engage in social media "mutual aid" agreements with agencies in other states that provide personnel to monitor and aggregate social media inputs from followers in a disaster. The city is also exploring the use of platforms such as Google Forms with private-sector providers to gather information on which grocery stores, restaurants, service stations, and key businesses are operational during an event and provide that information to the public.
- The New York MTA adjusted service maps online and communicated all updates to bus, subway, commuter rail, and bridge and tunnel service via a multi-channel information push; it also posted pictures and videos of the damage to help the public comprehend the severity.
- New Jersey Transit offered free park-and-rides, shuttle buses, and ferries into Manhattan to mitigate congestion on open bridges and tunnels, and alerted customers via its website and updates on Twitter, Facebook, and the "My Transit" e-mail alert system.

Exhibit 13. Boston Marathon Bombing: Transit Shutdown Impact and Innovative Social Media Use

Event summary: During the prestigious Boston Marathon on April 15, 2013, at about 2:50 p.m., two bombs made from pressure cookers were detonated within seconds of each other near the finish line, killing three people and injuring more than 260. Almost 27,000 people run in the marathon, while more than half a million spectators line the 26.2 mile route.

As first responders rushed to help the injured, law enforcement began a massive manhunt. On April 18, the FBI released pictures of the two suspects—brothers of Chechen origin who immigrated to the U.S. and were living in Boston. That same day, the suspects are accused of killing a Massachusetts Institute of Technology police officer before hijacking a car in Cambridge. During a police chase early on April 19, one of the suspects was injured and later died. The remaining suspect escaped, and authorities instructed residents to stay inside, essentially putting the city into lockdown on Friday, April 19, until the remaining suspect was discovered around 6 p.m.

Impact: The social and economic impact was significant. Businesses near the bombings experienced millions of dollars in losses, while the combined value of tickets to canceled performances and a basketball game was more than $2 million. Financial analysts estimated that the lockdown cost between $250 million and $333 million per day based on the area's gross domestic product.

The Boston transportation sector faced a near-total shutdown. The Massachusetts Bay Transportation Authority (MBTA) suspended public buses and subway transit; Greyhound Bus closed it Boston terminal; MegaBus canceled 35 trips to and from Boston; and even taxi service was halted. Train service was suspended or modified with Amtrak stopping its service between Boston and key regional terminals, including Providence, RI and New York. Airspace over Boston was limited by the Federal Aviation Administration, but the airport remained open, and airlines waived fees for customers unable to get to the city's airport. Costs of the shutdown include $1.56 million in lost fares to MBTA, lost parking ticket revenue of about $8 million, and $180,000 in costs for canceled Amtrak service.

Response & Recovery: On April 15, an 80-person Multi-Agency Coordination Center was operated out of the state's Emergency Operations Center. Extensive event preparation included an operational plan for a wide range of incidents and a tabletop exercise in early April before the marathon. Kurt Schwartz, director of the Massachusetts Emergency Management Agency, credited the quick and effective response to the state's preparedness efforts. As Schwartz told a congressional committee in July, "There was unity of focus and unity of purpose at the command level and through the ranks all the way to the first responders on Boylston Street on April 15th and the thousand-plus police officers that participated in the state's largest manhunt on April 18 and 19."

Following the bombing, the MBTA and Boston Police Department used social media to provide information on the investigation and suspects to the public; drive users to their See Something, Say Something website and app to report new information; and communicate hospital and transit system updates to the public and media immediately after the event when cell phone service was extremely limited. Boston Police Department saw its Twitter followers swell from about 50,000 to more than 300,000 in the days following the bombing.

By putting out accurate information quickly, law enforcement established themselves as a trusted resource for information and would often "break" stories that the media would have traditionally reported first. They were also able to use tweets and posts to correct misinformation circulating on social media. Given the unprecedented nature of the event, residents released information about police searches, and law enforcement was able to quickly educate the public on the danger from such information releases.

Sources: CNN 2013; Malone 2013; Jeansonne 2013; Dedman and Schoen 2013; Green and Winter 2013; Booton 2013; Mayerowitz 2013; Schwartz 2013

Innovative ways social media was leveraged during Sandy (*continued*):

- Commuters connected with other drivers and passengers through neighborhood networks, picked up strangers, and shared taxi rides using social media to help meet HOV-3 restrictions.
- The Jersey Shore Hurricane News, a Facebook- and Twitter-based news platform originally created by a digital journalist in advance of Hurricane Irene in 2011, provided accurate news reports and crowdsourced information about food, water, gas, and shelter, and deliveries of supplies to residents, emergency responders, and community organizations. When 911 was overloaded, the New Jersey Office of Emergency Management used the platform to communicate with people requesting rescue.
- The American Red Cross' Social Engagement team used pertinent posts from its Facebook page to inform its Mass Care team's response and influence change in ground operations. In its D.C.-based social media disaster operations center, volunteers also monitored hashtags and keywords on Twitter, Facebook, and blogs to determine need and inform service delivery plans. The Red Cross also offered a Hurricane App to assist in individual recovery.
- Through social media and firefighter websites, grassroots organization Operation Breezy was able to spread the word that people were in need, resulting in volunteers coming in from around the country to help gut and pump water out of residents' homes.
- A 14-year-old girl used Facebook to found Survivors Silver Lining, which continues today to communicate needs (e.g., building supplies) and match donors with Hurricane Sandy survivors. She has also used the site to keep interest in donating alive after media attention dwindled.

Business Case for Infrastructure Investment is Difficult to Define

Critical infrastructure owners and operators in the region increasingly recognize the need for investment in innovative infrastructure upgrades, both in the short term and over longer time frames, to make infrastructures more resilient and protected against risks the region has not yet faced. However, it is difficult to justify large capital investment in resilient infrastructure without public support and the ability to recoup costs. Recent experience with losses from catastrophic events like Sandy provides tangible evidence of the economic and public health consequences of weak infrastructures. The unprecedented flooding and damage that occurred during Sandy caught many operators and public officials off guard, creating a strong business case in the public and private sectors for billions of dollars of investment in infrastructure hardening and technology upgrades. In addition, prior investment in fiber cable and undergrounding for resilience paid off for communications companies. On the same streets in lower Manhattan, tons of copper cable was corroded by saltwater, while fiber lit back up once switches came back online; even above ground, fiber did not break as often as copper.

Where the business case does exist, rate recovery for resilience investments can be a political challenge, even after large storms. Although public and political support is high for resilience investments in the immediate aftermath of a storm, that sentiment can quickly fade as time passes and rate hikes are discussed. In addition, public officials and owners and operators who wish to rebuild smarter are often uncertain what level of resilience is needed to address future risks. Utilities need a clear cost-benefit case for resilience improvements in proposals to public utility boards. Energy companies in New York and New Jersey have proposed significant grid modernization and hardening following Sandy, while some transit agencies have already identified future innovative system improvements, including the following:

- Relocate key data centers outside of flood zones and build redundant or backup control centers to transfer operations if one is damaged.
- Design reusable watertight coverings for vents and electronic equipment in the short term, and even rebuild with submersible components in the long term.
- Engage with surrounding counties to responsibly plan drainage from new developments, such as shopping malls and parking lots, to decrease drainage around critical infrastructure.

Exhibit 14. Red River Floodway: Capital Investment in Infrastructure Pays Huge Dividends Over 40+ Years

A flood in Winnipeg, the capital of Manitoba, Canada, during the spring of 1950 caused the evacuation of 100,000 residents, destroyed 10,000 homes, and resulted in about $125 million in damages (or about $1 billion in today's dollars). Following the flood, Duff Roblin, a backbencher of the minority party in the Manitoba legislature, championed the construction of a diversion channel around the city to prevent future flood damage. The plan faced heavy criticism and was nicknamed "Roblin's Folly." Despite opposition to the floodway, Roblin, then-leader of the minority party, made the project a key issue for the 1958 provincial election. Roblin won the election and, as premier, he pushed forward with construction of the floodway.

The floodway took six years to construct, cost about $63 million, and in terms of scale was the second largest earth-moving project behind the Panama Canal construction at the time. The artificial waterway was completed in March 1968 and has been operated 20 times since its first use in 1969. The floodway has prevented more than $30 billion in flood damages, according to the Manitoba Floodway Authority.

Lessons Learned: A "Flood of the Century" in 1997 threatened to exceed the Red River Floodway's capacity, but the city remained protected from damaging flood waters. Grand Forks, North Dakota, located less than 150 miles away over the U.S. border, experienced more than US$1.5 billion in damages because of the flood. The flood damaged 83% of the city's homes and 62% of the city's commercial units, and required the evacuation of 52,000 people.

As a result of the 1997 flood, the Red River Floodway was expanded to provide 1-in-700 year flood protection. The project, completed in 2009, protects more than 450,000 Manitobans, 140,000 homes, and 8,000 businesses. The expansion cost about $665 million, paid equally by the Government of Canada and the Province of Manitoba.

The floodway, commonly known as "Duff's Ditch," has been studied by representatives from other flood-prone communities. Following Roblin's death in 2010, the construction of the floodway—despite fierce opposition—was noted as his greatest accomplishment and lasting legacy.

Sources: MFA 2013a; MFA 2013b; MFA 2013c; Martin 2010; CBC News 2010; Grand Forks 2011

Risk Data is Needed to Build Stronger and Redefine Best Practices

Sandy's storm surge caught many operators and public officials by surprise, overwhelmed some critical facilities, and damaged or destroyed infrastructure. Forecasts during Sandy from the National Oceanic and Atmospheric Administration (NOAA), while accurate, were communicated in a confusing way and, as a result, were not well understood by emergency personnel and utility owners and operators (NOAA 2013a and 2013b). Outdated FEMA flood maps and NOAA SLOSH (Sea, Lake, and Overland Surges from Hurricanes) maps meant many decision-makers did not fully understand the impact of nor take

immediate action based on NOAA's predictions. Had they understood the warning language and its implications, more owners and operators would have preemptively shutdown at-risk facilities to avoid equipment damage.

Rising sea levels, larger and more frequent storms, and altered drainage patterns due to new construction mean that flood walls may no longer be high enough, and new potential failure points may emerge. City planners and utility owners and operators need updated, detailed data on forecasted impacts of climate change that could increase infrastructure risks during storm events. New modeling tools—with updated climate change and flood predictions—can help regions revise system-wide risk assessments and identify new and future failure points. Examples of the need for new data and tools include the following:

- New York is re-examining the subway system using NOAA SLOSH maps to build more accurate flooding and failure predictions that address changing street elevation and potential surge heights. This study is addressing new critical failure points from Sandy, such as stairwells and entrances that caused the majority of subway tunnel flooding, where agencies can prioritize future hardening.
- A large wastewater treatment plant in Philadelphia operates under gravitational flows, with no effluent pump. As sea levels rise during storm surges, or over time through climate change, the treatment capacity of the plant drops and creates the potential for sewage backflow. Accurate forecasts are needed to determine when and what infrastructure investments will be needed to keep this plant operating.

3. Common Characteristics of a Resilient Region

One objective of our study was to identify the characteristics of a resilient region. Several organizations and academic institutions are developing or piloting processes to help regions measure and compare their resilience in a quantitative and consistent manner. However, benchmarking measurements are complex, not yet fully developed or widely available, and may not yet provide concrete and tailored paths to improvement for regional partners across sectors. Yet our study uncovered eight key characteristics that are common to resilient regions. Interviews with regional organizations and resilience leaders, a real world testing of resilience in the Northeast region, and a wide body of resilience research and literature point to eight characteristics that resilient regions universally exhibit.

A resilient region is like a healthy immune system: rather than preparing for every possible scenario, the region fortifies the underlying resources and capabilities that enable it to quickly mobilize and respond effectively to any disruptive event (National Academy of Sciences 2012, Allen). Much like in a human body subjected to an illness, the extent of damage and time to recover in a region often depend on the pre-existing conditions, or "health" of the region, not just the severity of the assault. For most disasters, the timing, size, location, and strength of a disaster cannot be controlled. However, the pre-existing conditions in the region are the factors that stakeholders *can* actively improve prior to a disaster. Rather than provide a quantitative measure of resilience, the following model presents the components of resilience and disaster response that a region most needs, and that stakeholders can actively control.

Like elements of an immune system, these components work together to support coordinated planning, prevention, detection, response, and recovery. As a result, these eight characteristics (in no priority order) represent practical areas where public and private stakeholders can focus their efforts and resources to improve regional resilience:

1. **Strategic Intent and Unity of Effort**: A resilient region has the strategic guidance, leadership, and organization to quickly align diverse partners toward common objectives. Resilient regions have engaged in Federal strategies, including the national policies, planning frameworks, and partnership models that encourage public and private coordination. We found such regions have strong leaders in both industry and government providing senior executive guidance that influences actions at all other partnership levels.
2. **Partnerships and Executive Engagement**: Public-private, cross-sector partnerships are the highly effective mechanism that enable regions to build and execute a resilient response. When those partnerships are spearheaded by strong engagement between senior critical infrastructure and government executives, regions can remove barriers and red tape, effectively allocate limited resources, and accelerate a coordinated response (see Exhibit 15. Characteristics of Effective Public-Private Partnerships).
3. **Elevated Priority of Lifeline Functions**: Resilient regions routinely prioritize the response and recovery of lifeline sector services in emergency response plans, supported by strong relationships among public emergency managers and lifeline infrastructure owners and operators. Partners ensure a coordinated response during an event by co-locating personnel or ensuring backup communications are available for pre-determined contacts. Pre-event exercises and relationship-building among infrastructure owners and operators and emergency services personnel prior to an event ensure a rapid and coordinated response that prioritizes and

ensures life safety. Resilient regions have strong emergency support functions that are well-coordinated at local, state, and Federal levels using standards such as the National Incident Management System.

Exhibit 15. Characteristics of Effective Public-Private Partnerships

Public-private partnerships have become somewhat commonplace throughout government. But certain partnerships are much more effective than others. The Council identified the distinguishing features of highly effective partnerships that should be pursued when developing regional partnerships.

- **Strong value proposition** in which partners recognize distinct benefits from participation that strengthens by building a strong track record of success.
- **Shared goals and objectives** that define how partners will work together to realize increased resiliency and risk management outcomes.
- **Trusted relationships** between industry and government built over time enable partners to candidly discuss sensitive matters and share information in a protected environment.
- **Mutual commitment of resources** in which partners jointly contribute their relative expertise and resources to achieve mutually beneficial goals and objectives.
- **Senior executive-level engagement** that facilitates coordinated efforts at all levels of the sector and enables CEOs to set strategic priorities and commit resources to them.
- **Simple process** for highly effective meetings between partners that includes a set agenda, defined outcomes, and clear roles and responsibilities for participants.
- **Neutral champion** who can efficiently facilitate the group partners in identifying priorities and actions, and is respected and trusted by both public and private sector partners.
- **Clear deliverables** that are well defined, actionable, and produce the desired outcomes that achieve shared goals.
- Common **metrics** to track progress and create accountability.

4. **Healthy and Active Community Resources**: Resilient communities recognize that a strong and prepared public—through citizens, community groups, and local businesses—resists victimization and instead actively contributes to public health and safety and service restoration during both immediate response and long-term recovery. A whole-of-community approach to resilience leverages the capacity of all institutions, not just critical infrastructure, to respond to an event. During Sandy, areas with strong community ties, established organizations and networks, and pre-event citizen preparation and training exhibited an innovative, nimble, coordinated, and life-saving response.
5. **Exercised Coordination and Information Sharing**: Regions that have participated in joint, cross-sector exercises have been better able to prepare for disasters, anticipate impacts, and leverage partnerships and relationships to communicate and coordinate during disaster response. Public-private, cross-sector regional exercises enable regions to test response capabilities to reveal new risks, strengthen and refine capabilities, and ensure strong communication processes and mechanisms exist prior to an event.

6. **Clear Value Proposition**: Resilient regions find clear value in investing in resilient infrastructure designs, processes, and practices. They are able to align resilience benefits with other operational and societal benefits, successfully making the case for investment to senior executives, regulators, lawmakers, and customers. A clear, shared value proposition creates opportunities for creative financing and joint investment.
7. **Intelligent Infrastructure and Innovation**: Long-term investment in new architecture designs, next-generation technologies, and innovative uses of emerging tools and capabilities such as social media will enable regions to become more resilient to new and more frequent disasters. After Sandy, sectors and communities who had already begun to design and build adaptive and innovative infrastructure with intelligent technologies ultimately faced fewer disruptions and were able to more quickly respond and restore critical services.
8. **Resilience Measurement and Risk Management**: To optimize resilience, regions have effectively brought together diverse, cross-sector partners to map interdependencies, identify vulnerabilities, and develop collaborative risk management plans that look holistically at regional risks, not in silos at sector or business vulnerabilities. State-of-the-art risk data, models, and measurement tools are critical resources to help regions examine their distinctive priorities and opportunities for strengthening resilience, and to inform regional best practices for infrastructure security and resilience.

Exhibit 16. Common Characteristics of Resilient Regions and Example Components

4. Findings

The Council finds that achieving regional resilience is the key to achieving national resilience. This cannot happen without a whole of nation, whole of community approach in which the collective capabilities of security and resilience partners at all levels of government and industry are combined to face the challenges of our complex risk environment. The common characteristics of a resilient region provide the essential building blocks for strengthening resilience. However, each region has distinct needs that must be considered in designing an effective resilience strategy. The Council's findings focus on the central role that the lifeline sectors play in achieving regional resilience and the importance of sustained public private partnerships at the highest level.

Our study revealed three fundamental principles of regional resilience that align with previous NIAC studies and recent Federal policy directives.

Exhibit 17. Principles of Regional Resilience

1. **Resilience requires a whole-of-nation approach that integrates top-down policy and leadership with bottom-up community capability to withstand and survive disasters.** Resilience cannot be achieved only by driving improvements from the Federal government, nor by grassroots efforts alone. Both are necessary to provide a unity of effort and a whole-of-nation approach that engages all possible stakeholders and resources.
2. **Effective regional resilience strategies must be tailored to the distinct features and needs of each region and designed to manage complex regional risks that span multiple jurisdictions and infrastructure sectors.** Regions have different geographies, economies, infrastructure designs, populations, resources, risk, and needs. Building strong and resilient infrastructures and partnerships means working to meet the specific requirements of the region at hand.
3. **Strong public-private partnerships and relationships that include senior executive engagement are the most effective and enduring strategy for achieving sustainable resilience.** Partnerships are the singular element that enables coordinated response and decision-making. Strong partnerships and established relationships enable all other capabilities and resources to operate effectively and transform a response effort.

These principles recognize that national resilience is the logical outcome of regional resilience. Any national strategy to strengthen resilience must include all of these elements.

The Council identified six findings of the challenges, critical needs, best practices, and essential strategies for improving resilience within regions.

Finding 1. Lifeline sectors are top priorities for achieving regional resilience and their growing complexity creates hidden risks.

1.1 Four lifeline sectors—energy, water, transportation, and communications—are top priorities for strengthening resilience in all regions because they provide essential products and services that underpin the continued operation of nearly every business sector, community, and government agency. They typically deliver just-in-time services that are ubiquitous in normal circumstances but

can create life-threatening conditions if they are unavailable for long or even short periods of time. Their disruption or destruction can cause failures that cascade across dependent infrastructures and regions, producing a multiplier effect of impacts. We find that maintaining the continuity of services of the lifeline sectors is paramount to regional resilience.

1.2 The increasing interdependence and integration among lifeline infrastructures has created hidden regional risks that are not widely understood by the businesses, governments, and communities that depend upon them for essential services. Increasingly complex networks of interconnected physical and cyber infrastructures within and between regions have allowed disasters to ripple through adjacent regions and sectors, causing disruptions and damage across large geographic areas. Tight regional interdependencies mean that disruptions can trigger cascading events that may interrupt critical services, impede emergency response, and threaten public safety in unexpected ways. We find that public officials and infrastructure owners and operators need to better understand the operations, response, and recovery processes used within the lifeline sectors to improve regional disaster coordination and response.

1.3 Joint regional exercises that engage public and private partners at all levels are highly effective in exposing gaps, identifying interdependencies and hidden risks, and improving response capabilities. Public-private, cross-sector exercises help regions identify interdependencies and potential gaps, prepare for catastrophic events, and build cross-sector partnerships between disasters. Well-designed exercises—which include full participation by public- and private-sector partners, cross-sector and cross-jurisdictional partners, and senior executives (for catastrophic events and resource prioritization)—enable participants to "experience" unprecedented events, exposing and addressing new coordination challenges. Owners and operators of lifeline sectors need a stronger value proposition to participate in regional exercises, and greater recognition and participation from senior state and Federal officials is needed.

Finding 2. Regional resilience efforts are most successful when they are tailored to the characteristics and needs of each region.

2.1 National resilience is the collective outcome of the resilience of all regions. Yet all regions are different, calling for a tailored approach to resilience that reconciles the types and density of a region's infrastructure with regional-based risk assessments. Each region has distinctive features—geography, natural and man-made risks, demographics, infrastructure mix, and economic and governance structure—that define its approach to regional security and resilience. While certain infrastructures are vital in all regions, regional partners must determine which sectors are most critical to both their region and the nation, and prioritize them for security and resilience improvements. In Houston, for example, the oil and natural gas sector and the Port of Houston are critical to the local economy and to the security and resilience of the nation. In New York, the banking and finance sector and the information and communication infrastructures that support it are critical to New York and financial systems worldwide. Accordingly, we find that a tailored approach is best for achieving sustainable, long-term resilience.

2.2 A community's capacity to withstand a disaster is improved when regional emergency managers engage non-profit and community groups as critical partners in disaster preparation, response, and recovery. No matter the size of a disaster, it is the local businesses, volunteers, and agencies that immediately respond, making national resilience the collective output of resilient regions,

communities, and individuals. Recent disasters have precipitated a culture shift toward community readiness and personal responsibility for short-term survival. Communities and organizations who actively engage in planning and response training with non-profit and community groups prior to disasters are able to mobilize resources and assistance faster when disaster strikes.

Finding 3. Senior executive engagement creates strong public-private partnership, which is the most effective strategy for achieving long-term resilience within regions.

3.1 Public-private partnerships based on senior executive-level engagement prove to be the most robust. because they enable partners to set strategic direction, establish priorities, provide resources, and exercise accountability. Strong relationships and partnership between senior private and public executives streamline coordination, in a way not possible through other means, to efficiently address strategic infrastructure priorities and expedite decision-making during catastrophic disasters of national importance. Senior-level government and industry task forces allow leaders to cut through "red tape" and lead to effective and innovative response. As four prior NIAC studies have emphasized, senior executive-level partnerships are central to the long-term security and resilience of critical infrastructures. Engagement at the most senior levels precipitates seamless coordination throughout all levels of government and organizations. Where there is strong senior-level engagement, partnerships at operational and tactical levels become automatic and effective.

3.2 Strong public-private partnerships with relevant partners and active cross-sector coordination are the most important success factors in helping regions to achieve sustainable resilience. We find that healthy partnerships at all levels across industry and government are a defining characteristic of resilient regions. Effective partnerships are based on four fundamental building blocks: 1) trusted relationships, 2) leadership and senior executive engagement, 3) a clear value proposition, and 4) a simple process (including a focused agenda, defined deliverables, and clear roles and responsibilities). The nation is in a transformative period where institutions, business models, and funding models are being reframed to embrace public-private partnerships, make them an integral part of business operations, and use them as a vehicle for proactive engagement. As risks become more complex, organizations increasingly need the right mechanisms to bring together a range of capabilities from the public and private sector to address them. As regional and sector interdependencies increase and risks change, active regional partnerships provide a strong mechanism to develop adaptation strategies.

Finding 4. Social media has emerged as a powerful but underutilized tool for communicating and collecting data during emergencies.

4.1 Social media can improve situational awareness, inform public decision-making, and mitigate rumors. When social media is leveraged effectively, organizations increase transparency, gain recognition as a credible source, influence stakeholder decisions, and collect a new stream of real-time information that becomes valuable when other communications fail. For example, social media was indispensable for emergency managers during Superstorm Sandy and the Boston Marathon bombing to inform and influence public action and source new operational information

(see Exhibit 13. Boston Marathon Bombing: Transit Shutdown Impact and Innovative Social Media Use and surrounding text for details).

4.2 Government and business have not fully capitalized on the potential of social media in disaster response and recovery. Social media platforms enable real-time, two-way, communication between infrastructure owners and operators and the public, yet businesses and government are just learning how to effectively use available tools. When used improperly, social media enables other parties to control the conversation, shape public perception, perpetuate rumors, and question the credibility of organizations that do not engage. Any organization dealing with a complex disaster that doesn't take social media into account and proactively engage with it will face a public reality created by someone who may not be knowledgeable or consequential. We find that social media has become a permanent feature of the nation's social ecology; organizations can choose to suffer its blows, manage it effectively, or further adapt their use to realize its untapped potential to support future disaster response.

Finding 5. Rapid recovery of lifeline infrastructures is hindered by complex rules, regulations, and processes.

5.1 Incident response personnel in critical sectors encounter persistent problems gaining rapid access to disaster areas to repair damaged assets. State and local law enforcement routinely deny crews access to restricted areas because they do not consider employees of water, communication, oil and natural gas, or transportation companies to be "emergency responders." Incident response workers lack a commonly accepted credential, despite three prior NIAC studies that have called for nationwide credentialing and access protocols.

5.2 Complex laws and regulations at the Federal, state, and local level and inefficient processes for granting waivers and permits can delay interstate fleet movement and prevent the most effective and logical disaster response. Overall, coordination among Federal, state, and local government agencies and critical infrastructure owners and operators in preparing for and responding to disasters has matured and improved. Despite improvements, persistent barriers continue to impede rapid response and recovery. As noted in prior NIAC studies, regulatory issues exist in the petroleum sector, including antitrust laws and fair disclosure regulations that place limits on market-sensitive information sharing, and state anti-gouging laws that during Sandy prevented suppliers from procuring fuels from outside regions to avoid suspicion. For all lifeline sectors, widely varying permits, waivers, and processes for interstate fleet movement and toll crossing complicates or delays the movement of mutual aid repair crews.

Finding 6. Without a strong value proposition, owners and operators are unable to invest in new and innovative infrastructure that can mitigate long-term structural risks within regions.

6.1 Owners and operators often find it difficult to establish the strong value proposition needed to invest in new or upgraded infrastructure without public support and the ability to recoup costs. While state and local governments may seek larger goals of sustainability and social benefits, investment in resilient infrastructure is difficult to justify for private-sector owners and operators unless upgrades contribute to the bottom line and/or qualify for cost recovery through the rate structure or other means. The value proposition for investment is more easily established when all

stakeholders come together to align public- and private-sector goals. Regional resilience efforts should not aim just for loss avoidance because this approach misses abundant opportunities to improve the economic, social, and environmental well-being of citizens within the region. Resilience can also provide a competitive advantage for companies and regions, attracting new business that support social and economic growth. As the threat environment grows beyond the ability of the private sector to respond alone, incentives and cost recovery mechanisms for infrastructure owners and operators are needed at the Federal, state, and local level.

6.2 Regions can mitigate long-term risks by applying innovative technologies to build resilience into new and replacement structures, and rethinking systems and architectures using novel infrastructure designs that are inherently resilient. Federal and private R&D partners continue to deliver new, intelligent technologies and designs that can improve the delivery of regional services, isolate disruptions, better control interdependent systems, and exploit data analytics to optimize response and recovery. By building and rebuilding "smarter," regions can address a variety of long-term goals, including climate change adaptation and sustainability, economic growth, and operational efficiency. We find that improving resilience is a long-term proposition that must engage public and private partners to determine the best approach for designing regional infrastructures, creating investment in innovative technologies, and training a workforce that can install and use new technologies.

5. Recommendations

The Council recommends six concrete actions for the Federal government that will help build resilience within regions. While each recommendation has merit on its own, the Council believes that pursuing these recommendations as an integrated strategy will produce benefits that are greater than the sum of their parts.

Recommendation 1. The President should direct the heads of the appropriate Sector-Specific Agencies to form partnerships with senior executives from the lifeline sectors, using a process modeled after the government's successful executive engagement with the electricity sector.

Strong, trusted relationships among senior Federal leaders and senior executives of lifeline sector companies establish a high-level framework and direction that support regional and community partnerships. The Administration should make it a priority to form partnerships with lifeline sector CEOs of private infrastructure or executives with equivalent responsibilities because service disruptions within lifeline sectors can severely harm regional industries, public health, and safety.

Four previous NIAC reports have recommended the formation of senior executive partnerships between Federal leaders and industry CEOs to build key relationships, set priorities, take collective action, and commit resources to address urgent infrastructure challenges. CEO-level executive engagement in the electricity sector has been a game changer over the last 18 months and the lessons learned can help guide the formation of similar CEO partnerships in other lifeline sectors. The electricity sector partnership was used to expedite power restoration during Superstorm Sandy, help the industry better understand and prepare for cyber threats, and make key government agencies more aware of the electricity sector's capabilities to protect the electric grid (see Exhibit 8. Transforming CEO Engagement for details).

To implement this recommendation, the Council recommends the following milestones.

1.1 Within six months, the President should direct the heads of appropriate Sector-Specific Agencies to convene a meeting with CEOs or other sector leadership with equivalent decisionmaking authority from each lifeline sector to explore the formation of a partnership to address high priority risks to the sector's infrastructure.

1.2 Within one year, DHS should collaborate with electricity and nuclear sector industry associations to document the process used for CEO engagement in the electricity sector to discern lessons learned that can guide senior executive partnerships in other lifeline sectors. These senior executive partnerships should be formed within the Critical Infrastructure Partnership Advisory Council (CIPAC) framework to foster trusted, direct discussions among leaders. To ensure success, the partnerships should be built upon four fundamental principles, which were found to be the foundations for success in the electricity and nuclear sectors: 1) trusted relationships, 2) leadership and senior executive engagement, 3) a clear value proposition, and 4) a simple process. Each lifeline sector should work through its existing trade organizations to

coordinate CEO participation and work with Federal partners to identify a compelling value proposition for executive engagement.

1.3 The President should task the NIAC to identify the highest priority cross-sector risks affecting national security and resilience and produce a written report to the President within 18 months recommending potential executive-level, cross-sector action. Cross-sector risks stem from threats large enough to affect multiple sectors, and risks that arise from interdependencies and common vulnerabilities between lifeline sectors. By better identifying where risks intersect among lifeline sectors, government and industry partners can better allocate resilience resources.

Recommendation 2. The Secretary of Homeland Security should facilitate efforts with governors, mayors, and local government officials to identify or develop regional, public-private, cross-sector partnerships, led by senior executives, to coordinate lifeline sector resilience efforts within a given region.

Productive executive partnerships at the Federal level can be leveraged to inform and build effective public-private partnerships at the regional level. Strong senior executive leadership at the regional level will help to identify, build, and fully integrate appropriate regional cross-sector partnerships to complement national partnerships. The Council affirms and supports two prior recommendations on regional partnerships made by the State, Local, Tribal, and Territorial Government Coordinating Council in their 2011 report, *Landscape of State and Local Government Critical Infrastructure Resilience Activities & Recommendations*. This report recommends that the DHS Office of Infrastructure Protection promote and enable stronger cross-sector partnerships (SLTTGCC recommendation #2) and provide state and local governments with the tools to identify cross-sector interdependencies that could result in cascading effects, particularly in the lifeline sectors (SLTTGCC recommendation #3). Our recommendation is intended to implement and build upon these two SLTTGCC recommendations.

The Council recognizes that regional and local partnerships must be led by the state and local government leaders who have ultimate authority for ensuring security and resilience within their jurisdictions. These leaders should engage private sector chief executives who own and operate lifeline infrastructures within their region to build sustainable, regional cross-sector partnerships. To be most effective, the regional partnerships should include multiple jurisdictions and sectors and have a clear value proposition for private executive participation.

The inclusion of regional cross-sector partnerships among senior executives in state and local government and the private sector represents the maturation of the national partnership and recognizes that national resilience is the logical outcome of regional resilience efforts.

To implement this recommendation, the Council recommends the following steps:

2.1 The Secretary of Homeland Security should facilitate the development of cross-sector partnerships within selected regions to improve the region's resilience to very large-scale events that could impact national security, resilience, and economic stability. The Secretary should work directly with governors, mayors, and other local government leaders to assist them in building cross-sector partnerships with senior executives from the lifeline sectors located within each region. To coordinate and operationalize regional partnerships, the Secretary should work through

the State, Local, Tribal, and Territorial Government Coordinating Council (SLTTGCC), and provide grant funding to states to assist with this effort.

- To leverage effective partnerships at the national level, CEOs or other sector leadership with equivalent decisionmaking authority from the lifeline sectors should be encouraged to meet with governors, mayors, and other local leaders through state and government associations, such as the National Governors Association, U.S. Council of Mayors, National Association of Counties, and National League of Cities on the merits of and lessons learned from creating senior executive public-private partnerships.
- To coordinate and operationalize sustainable regional partnerships, the Secretary should work through the State, Local, Tribal, and Territorial Government Coordinating Council (SLTTGCC) and its network of alliances of critical infrastructure security and resilience coordinators and emergency managers, and provide grant funding to states to assist in building and strengthening regional cross-sector partnerships. Where appropriate regional partnerships do not exist, regional partners may benefit from engaging a neutral "convener," such as national laboratories, universities, or non-governmental organizations. It is important that each partnership include an executive steering committee, consisting of industry CEOs, governors, mayors, and relevant senior Federal Sector Specific Agency representative(s) to provide executive guidance and leadership on an annual or more frequent basis. Each regional partnership should be built on a shared value proposition that enables engagement across all levels within organizations and government, from executives to operators.

2.2 The Department of Homeland Security should initiate a pilot program with state and local governments in select regions to conduct regional joint exercises, develop risk maps of critical sector interdependencies, and extract lessons learned on regional needs and gaps for government and sector partners. The pilot program should actively engage regional owners and operators and government leaders in identifying and addressing critical gaps in the resilience of the lifeline infrastructures that could produce cascading disruptions throughout the region. The program should include the following elements:

- Joint Regional Cross-Sector Exercise – Each regional partnership should conduct a regional cross-sector exercise, with full participation by public- and private-sector partners at the executive and operational level, to simulate a catastrophic event across a large geographic region. The exercise should be led by the regional partners and supported by DHS experts, processes, and tools as needed. Such an exercise will allow participants to "experience" unprecedented events, identify coordination and communication challenges, and help expose hidden physical and cyber risks due to lifeline sector interdependencies. The results of the exercise should be used to create an action plan to address needs and gaps.
- Regional Risk Maps – An assessment of regional interdependencies should be conducted to create a regional risk map that helps stakeholders prioritize resilience initiatives and optimize investments on a regional scale. The assessment should identify critical infrastructure nodes that are essential for core functions within each region and recommend a plan to harden and protect them and/or provide for alternative services. In conducting these assessments, DHS should leverage the expertise and capabilities of multiple organizations (such as national laboratories, universities, cities and states, NGOs, and Federal agencies) for maximum value.
- Sharing Lessons Learned – The program should require each region to share results and lessons learned from the exercise and interdependency assessment with other regional

partnerships, while protecting sensitive information. DHS should offer to leverage its existing information sharing platforms, such as the Homeland Security Information Network (HSIN), to enable regional groups to share best practices (possibly on a sector-specific basis) and build relationships within and between regions. To foster the proactive sharing of best practices and lessons learned from exercises and past disasters, DHS should work with the SLTTGCC to, a) host an annual national conference for members of regional resilience partnerships and consortia, and b) facilitate a series of regional information sharing workshops to exchange disaster experiences and lesson learned, and document best practices for sharing, within and across regions.

Recommendation 3. The President should designate the energy, communications, water, and transportation sectors as lifeline sectors, and direct Sector-Specific Agencies to examine their policies, procedures, and programs to determine to what extent they recognize the priority of the lifeline sectors and the individuality of regions, amending or revising those that do not.

The Council commends the Administration for recognizing energy and communications systems as being uniquely critical to all critical infrastructure sectors in PPD-21. In addition, the Council recognizes that water and transportation systems also provide vital services that underpin essential functions of critical infrastructures and, if disrupted or destroyed, can create life-threatening conditions during times of crisis. By designating four sectors—energy, communications, water, and transportation—as lifeline sectors, the President should ensure that Department policies and programs recognize the priority status of the lifeline sectors in planning, coordination, and recovery for regional disasters. This will help to solidify the fundamental role these sectors have in maintaining the continuity of critical infrastructure services and government functions in all regions. However, this does not preclude other sectors from being considered as lifeline sectors in specific incidents or regions if it is deemed critical for the continuity and recovery of essential regional services, especially in the first 24-72 hours. To implement this recommendation, the Council recommends the following steps:

3.1 DHS should examine how the Federal government, state governments, and regional entities currently coordinate action with and provide support to the lifeline sectors in event response. This examination should: a) consider organization principles around working with the private sector, decision-making protocols, and Federal and state regulatory bodies, b) identify areas where processes can be streamlined and where the Federal government can facilitate resource movement or resolve long-standing process barriers, c) reinforce the Sector-Specific Agencies for lifeline sectors as the lead for resilience coordination and direct them to work with DHS and other agencies to approach owners and operators with one voice, and d) develop criteria to help identify additional sectors that may be considered lifeline within specific regions.

3.2 The Federal Emergency Management Agency (FEMA) National Response Coordination Center, Federal agencies, and state and local governments should modify their processes and plans for emergency operations to include the co-location of representatives of lifeline sectors in their emergency operation centers (EOCs) during major disasters. The practice of including operational personnel from energy, communications, and other lifeline sectors in EOCs during Superstorm Sandy improved situational awareness, streamlined communications, and expedited response and recovery.

- *State and local government*: State and local governments should make planning and coordination with the lifeline sectors a high priority.
- *Owners and operators*: Owners and operators should work through trade organizations and with state and local government partners to conduct outreach, communication, and education up front to avoid diverting resources during an event to educating partners on the basics of sector operations.

3.3 The President should direct Federal agencies to: a) explicitly consider and address the differences among regions when promulgating security and resilience rules, programs, or guidance; and b) expressly state how they have customized implementation to each region if there is not generic applicability. The mandatory express statement will help offices cultivate the practice of regional customization, and assure owners and operators that Federal resilience programs or rulings will not be implemented without applicability. Where possible, policy and guidance should leave flexibility for executives to further customize implementation to fit the characteristics and needs of their region.

Recommendation 4. FEMA should integrate social media platforms into public alert and warning systems to maximize message reach, and develop training programs and guides with state and local government partners that help them capitalize on social media's potential to provide innovative information sharing and response planning capabilities.

Based on recent experience with large-scale disasters, state and local emergency management agencies, non-profit organizations, and owners and operators have tested out new ways to use social media to communicate with the public, gather new information streams from stakeholders, and organize and streamline disaster response planning and resource movement. Because social media is a rapidly evolving tool, this recommendation includes methods to share lessons learned and best practices from pioneering organizations. To implement this recommendation, the Council recommends the following steps:

4.1 FEMA and the Federal Communications Commission should convene a task force of senior emergency managers from lifeline sector SSAs and representatives of leading private-sector social media and technology firms—such as Twitter, Facebook, and Google—to examine how new and emerging social media apps, platforms, and capabilities can be used to support emergency notification and response, and provide greater value to the public. Many private-sector social media companies have recognized the potential of their products to support disaster response and begun developing tools and capabilities for this express purpose. This task force can exchange ideas and capability requirements, while building awareness of ways that Federal, state, and local governments can leverage social media. The task force should publish its findings in a report on best practices.

4.2 FEMA and the Federal Communications Commission should work with social media providers to integrate social media platforms into FEMA's Integrated Public Alert and Warning System (IPAWS), enabling social media websites and apps to push public emergency alerts from state and local emergency managers directly to registered users through a trusted system. Agreements with social media providers can be modeled after the existing Wireless Emergency Alert system, in which participating wireless carriers send authorized alerts to cell phones based on geographic location, broadcast from cell towers in the designated emergency zone. Social

media alerts could be issued based on geographic position (through cell phone apps) and IP address locations (through web browsers) without requiring opt-in from users. Authorized state and local emergency managers use IPAWS to rapidly send verified alerts through traditional and non-traditional platforms, including TV and radio broadcasts, e-mail, cell phones, and local sirens or light boards. Expanding this service to include agreements with social media providers can broaden the reach of emergency alerts, providing a verified, unchanged social media message from emergency management agencies that reaches beyond the agency's existing social media followers.

4.3 FEMA non-disaster preparedness funding to state, local, tribal, and territorial emergency management agencies should require all recipient agencies to designate and train specific personnel to use the IPAWS system. IPAWS provides a trusted system for emergency messaging that reaches broad platforms with customized geographic targeting, but users must first be authorized and trained to effectively use the system prior to an event. This requirement will encourage broader registration in the system, ensuring capabilities are in place prior to a major event.

4.4 FEMA and the DHS Science and Technology Directorate (S&T) should work through the State, Local, Tribal, and Territorial Government Coordinating Council (SLTTGCC) to develop a conference or webinar series for emergency managers on innovative social media use and best practices in state and local emergency management, including social media successes in recent large-scale disasters. These conferences/webinars will also provide a platform for emergency managers to share lessons learned directly with peers. FEMA should leverage existing social media resources or guides from the National Emergency Management Association (NEMA) and Emergency Management Assistance Compact mission-ready packages where possible. The best practices conference series can also examine how city and state agencies are successfully using two-way communications through non-emergency 311 apps and websites to gather critical information, photos, and videos during an event and communicate to citizens using a single trusted platform, similar to the FEMA app and Disaster Reporter feature. As an outcome of the conference series, the SLTTGCC should develop a process to capture lessons learned on social media use during disasters and leverage individuals from leading public organizations to train others in municipal and state governments, NGOs, and lifeline sector owners and operators on best practices and new ideas.

Recommendation 5. The Secretary of Homeland Security, working with heads of appropriate Federal agencies, should launch a cross-agency team within 60 days to develop solutions to site access, waiver, and permit barriers during disaster response and begin implementing solutions within one year.

In this recommendation, the Council reaffirms and calls attention to the recommendations in its 2009 *Framework for Dealing with Disasters and Related Interdependencies* study that calls for DHS to work with Federal and regional government partners and lifeline sector owners and operators to streamline fleet movement, communications, and critical site access for lifeline sector response crews.

Removing these barriers offers one of the best opportunities to speed disaster response and recovery after a major event. Difficulty in efficiently moving large fleets across multiple states, gaining waivers for Federal and state regulations, complying with laws that govern information sharing and pricing in the petroleum sector, and gaining response crew access to restricted areas to begin repairs all significantly delayed service restoration in the immediate aftermath of Superstorm Sandy. These recurring,

intractable issues affect all regions and require Federal leadership to engage cross-sector and multi-jurisdictional partners to develop solutions. To implement this recommendation, the Council recommends the following steps:

5.1 DHS's Office of Infrastructure Protection and FEMA should collaborate with state and local government officials and owners and operators to develop a commonly applied process or system to credential lifeline sector owners and operators and grant them access to disaster areas. This affirms a prior NIAC recommendation (Recommendation B1A in *Framework for Dealing with Disasters*). Whether implemented regionally or nationally, DHS should develop a strategy and resources to communicate the new process or system to owners and operators and state and local law enforcement, who typically secure disaster zone access points and allow or deny access to owners and operators. DHS should consider that large-scale events require mutual aid assistance from well beyond the affected region, making national interoperability for credentialing solutions a requirement. DHS may consider supporting a pilot credentialing system or access protocols within a region before it is rolled out to other regions.

5.2 DHS should work with state and local government and infrastructure owners and operators to catalog the waivers and permits commonly required during a variety of disaster scenarios (e.g., hurricanes, earthquakes, pandemics, and accidents or attacks) and develop a streamlined process for rapidly issuing those permits and waivers at the Federal, state, and local level. Owners and operators initiate a time-consuming waiver process that is nearly identical for recurring scenarios, and a streamlined process could reduce critical response time spent on waivers, especially during non-weather events that cannot be anticipated. Owners and operators should identify existing waiver impediments based on their experience and communicate them to government partners during this process. DHS should provide resources to maintain a shared database of the permit/waiver catalogue and all processes developed.

5.3 DHS should work with the transportation, energy, and other lifeline sector regulators to identify actions that will expedite waivers and remove impediments to fleet movement, including driver-hour limitations, road and weight restriction, port access restrictions, toll crossing processes, and others. When moving fleets across multiple states, crews face different permit requirements and restrictions for every state; different toll booth payment methods and processes for every region; and Federal driver-hour limits that can add additional delays. DHS should work with state, local, tribal, and territorial governments to develop a streamlined process to remove state requirements in an emergency or issue permits several days prior to a disaster (and prior to disaster declarations) to enable response crews to pre-stage, and to develop and communicate a rapid process for fleet crews to move through all state tolls. In addition, DHS should request that Congress consider legislation authorizing the Federal waiver of Federal and state restrictions on the interstate movement of lifeline sector response fleets during very large-scale disasters.

Recommendation 6. The President should direct the Council of Economic Advisors and the Office of Science and Technology Policy to work with Federal agencies to create a strong and enduring value proposition for investment in resilient lifeline infrastructures — and their underlying physical and cyber assets, systems, functions, and networks — and accelerate the adoption of innovative technologies in major infrastructure projects.

Strategies that "bake" resilience into the design and construction of physical and cyber structures—the

wires, pipes, roads, and rails that connect our communities—offer one of the best opportunities to reduce long-term risks to regions. Although the long-term benefits of these intelligent infrastructures far outweigh the costs, significant barriers to investment exist due to outdated frameworks for evaluating projects and ineffective financing and investment strategies for advanced technology projects.

To implement this recommendation, the Council recommends the following steps:

6.1 Within one year, the Department of Energy, in conjunction with the Council of Economic Advisors and the White House Office of Science and Technology, should complete a pilot analysis of the value proposition for investment in physical and cyber grid modernization and recommend any incentives or alternative mechanisms for cost recovery that may be needed to encourage long-term investment in the modernization of all lifeline infrastructures. The analysis should identify not only where advanced technologies can avoid direct costs of infrastructure damage and loss of service, but where resilience upgrades address long-term societal needs such as climate change adaptation. By providing the value proposition at a regional level, this effort will reduce owner/operator uncertainty around the actual return on investment of advanced technologies, and build state and local government support for utility investments that deliver value in non-disaster time as well as during disaster response. Using the electricity sector as the vanguard, all lifeline sector SSAs should work with their sector partners to establish the value proposition for investment and financing in other critical sectors.

- As part of this analysis, DOE should work with owners, operators, and state and local governments to help establish the value proposition for investment in grid modernization that 1) integrates the private-sector business case with long-term resilience and societal objectives, and 2) reevaluates the current utility cost recovery framework for long-term investments in resilient infrastructure. Recent studies, including those by the White House and the GridWise Alliance, underscore the need for continued investment in grid modernization and resilience to mitigate the increasing costs of power outages due to severe weather, estimated at $18 billion to $33 billion per year. To improve electric grid resilience, investments are needed for cost-effective hardening, advanced control and intelligent grid management systems, and energy storage and microgrid capabilities that together improve flexibility, situational awareness, and operator response to all hazards.

6.2 The President should direct the National Oceanic and Atmospheric Administration (NOAA) and appropriate Federal agencies to determine how existing weather and climate forecasting models and methodologies can be used to better communicate both long-term and short-term predictions of severe weather events, enabling private, state, and local partners to fully understand potential dangers and make informed decisions that manage risk in planning and preparing for disasters. The Federal government has a clear role to play in leveraging its world-class expertise to develop more sophisticated forecasting, planning, and modeling that accurately assesses future risk to inform industry design standards and infrastructure investments in preparation for potentially larger, different, and more frequent storms or natural disasters. With a more accurate understanding of model forecasts and data, owners and operators can reduce uncertainty regarding future risks and strengthen the value proposition for investment.

6.3 DHS should work through Federal research organizations, academic institutions, and the national laboratories to develop Applied Centers of Excellence for Infrastructure Resilience to provide an operating environment to test and validate innovative technologies and processes to build resilience into new large-scale infrastructure projects, integrate next-generation R&D, and

share results with other designers in other regions. Innovative technologies that can improve the resilience and security of our nation's infrastructure are emerging from national laboratories, universities, and technology developers. However, many of these innovations have not been tested in a real-world environment that can validate their performance. Applied Centers of Excellence for Infrastructure Resilience, modeled after the Port Authority of New York and New Jersey Center, would convene relevant stakeholders (owners and operators, technology developers, designers, and engineers) to test technological applications and processes in a rigorous operational environment to determine their readiness. As major infrastructure upgrades are implemented, the Centers can collect and share lessons learned that can be applied to future infrastructure projects and provide input into industry design standards as they are updated. Funding could be provided through a combination of Federal agencies with lifeline sector responsibilities and industry cost-share. Working with the Applied Centers of Excellence, DHS should provide the data and analysis that communicates the value proposition for private-sector investment to both lifeline sector CEOs and their customers and stakeholders. In doing so, the Applied Centers of Excellence can raise awareness of new capabilities as they are being tested, and speed commercialization of technologies as they enter the market.

Next Steps

These recommendations form a comprehensive strategy for the government to improve regional resilience. To move out with this strategy, the Council recommends that the government immediately implement the foundational recommendation of creating meaningful partnerships with senior executives in the lifeline sectors by pursuing the following next steps.

- **Implement senior executive partnerships in the lifeline sectors (Recommendation 1.1).** To build or reinforce CEO- or decisionmaker-level partnerships in the other lifeline sectors, the heads of the relevant Sector-Specific Agencies should convene a meeting with sector CEOs to address high-priority risks to the sector's infrastructure. In the Transportation Sector, the government has tasked the Council with a new study to examine resilience in the Transportation Sector that will include exploration of the creation of a cross-modal CEO-level partnership with Federal leaders.
- **Identify the highest priority cross-sector risks affecting national security and resilience (Recommendation 1.3).** In parallel with the sector studies, the government should task the Council to identify the highest priority cross-sector dependencies of each of the lifeline sectors that could impact national security and resilience. These priorities would be integrated into a report to the President, with recommendations on how to mitigate these risks.

Appendix A: Acknowledgements

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Appendix B: Study Approach

This study was borne out of a growing recognition that strengthening the resilience of individual regions helps build a more resilient nation. As regional infrastructures and economies become more interconnected, disasters can more easily spread across communities and reach a scale that requires national involvement. Our study seeks to better understand how to leverage the combined capabilities of private, Federal, state, local, territorial, and tribal partners to meet regional security and resilience needs. We developed this understanding by examining regional interdependencies and impacts in a large-scale disaster, identifying best practices and lessons learned, and determining how the Federal government can best support a regional approach to building resilience.

This study builds on previous NIAC studies that examine critical infrastructure resilience. These include the 2009 *Framework for Dealing with Disasters and Related Interdependencies*, which examined the nation's ability to respond to and recover from a major disaster with prolonged loss of critical services; and the 2010 *Optimization of Resources for Mitigating Infrastructure Disruptions*, which recommended community-level assessment of infrastructure interdependencies and the adoption of national planning and analysis lessons learned to regional and community-level systems. In addition, we built upon the findings and recommendations of the Council's 2009 *Critical Infrastructure Resilience* study, which examined how to best integrate resilience and protection into a comprehensive risk management strategy, and its 2010 *Framework for Establishing Critical Infrastructure Goals*, which provided a foundation for understanding how resilience is implemented within national infrastructures.

Charge to the NIAC

On April 17, 2012, the Administration tasked the Council to perform a study to examine how regions can become more resilient in the face of increasing risks and infrastructure interdependencies. The study would specifically:

- Build on prior Council studies and incorporate a strong element of regionalization of resilience.
- Focus on the complex, interconnected regions in the Northeastern United States.
- Examine the highly interdependent lifeline sectors (energy, water, transportation, and communications) in the Northeast to gain insights that would be applicable to other regions in the United States.
- Involve Council members who have experience and expertise in one of more of the regions or sectors of interest.

The Council launched this study and by forming the Regional Resilience Working Group, consisting of Council members who have expertise in several critical infrastructure sectors, including electricity, communications, transportation, water, commercial facilities, defense industrial base, financial services, and information technology (see Appendix A for a list of members).

Objectives and Scope

This study examines the challenges that regions face in improving resilience and recommends steps the Federal government should take to help regions become more resilient. To frame this topic, the Working Group established the following objectives:

- **Best Practices:** Identify the characteristics that make a region resilient and the steps that can be taken by critical infrastructure owners and operators; Federal, state, and local government; and the private sector to improve resilience within the region.
- **Process Improvements:** Determine how public and private critical infrastructure partners can work together to improve regional resilience.
- **Federal Role:** Recommend how Federal government capabilities and resources can help accomplish resilience goals to address any gaps and help regions become more resilient.

Regional Resilience Study Approach

The Working Group gathered information and data from a rich variety of sources including focused interviews and an extensive literature review. It collected and analyzed data from the following sources:

- Interviews with 37 individuals representing state and local emergency managers, regional security and resilience organizations, national experts on resilience and disaster response, owners and operators of critical infrastructure, experts from industry and academia, non-profit groups, and Federal agencies that were critical in the response to Superstorm Sandy
- Insights from State, Local, Tribal, and Territorial Government Coordinating Council studies
- More than 350 documents and sources, including:
    - Reports and studies from Federal, state, and local governments; Congressional committees; non-profit organizations; regional resilience consortia, and academic institutions
    - Hundreds of news articles, journal articles, and media advisories
    - Videos, presentations, conference proceedings, and Congressional testimonies
    - Official government documents, including national plans, policy directives, and executive orders
- Webinars and conferences with regional government and critical infrastructure representatives on barriers to rapid disaster response

To gain real-world insights, the Working Group formed a Study Group in February 2013 to examine the impacts of Superstorm Sandy on the resilience of the lifeline sectors in Philadelphia and the Northeastern states, including impacts from New York to Washington, D.C. The Study Group did not attempt to recount all the events, impacts, and actions. Instead, it focused on the distinctive features of Sandy that led to unanticipated impacts to lifeline infrastructures and the actions taken by regional stakeholders—owners and operators, state and local government, and non-profit groups—to minimize the impact of the disaster. A detailed account of sector-specific and cross-sector learnings and Study Group findings from Superstorm Sandy is presented in Appendix D.

Appendix C: Briefing Summaries of Federal Agencies and Resilience Experts

To gain additional insight into its case study on Superstorm Sandy response, the Regional Resilience Working Group interviewed representatives from key Federal agencies representing lifeline sectors and emergency response, along with nationally recognized experts on regional resilience. Federal representatives briefed the Working Group on highlights of agency response and key lessons learned during Superstorm Sandy, as well as how those lessons will inform future regional resilience efforts. Regional resilience experts briefed the Working Group on resilience strategies and areas for improvement. Summaries of these briefings are provided here.

U.S. Department of Energy

Interviewee: William Bryan, Deputy Assistant Secretary of Infrastructure Security & Energy Restoration, Office of Electricity Delivery and Energy Reliability

The U.S. Department of Energy (DOE) has three key roles in emergency response, during both national disasters declared under the Stafford Act, and for regional disasters involving the energy infrastructure:

- Reliability: Taking steps before an event to make systems are more reliable, including R&D.
- Survivability: Taking action to ensure assets and critical components survive. For example, hardening critical choke points within systems or protecting substations from flooding.
- Resilience: Ensuring a rapid response and recovery. If the first two areas are addressed correctly, ensuring resilience is easier to accomplish.

Strengths, Challenges, and Lessons Learned from DOE's Response

- Energy sector response was marked by extensive Federal and private sector coordination. The President and Secretary of Energy met with electricity sector CEOs during their regular conference calls, and the Federal Emergency FEMA and DOE established an Energy Resilience Task Force with utility representation to coordinate response. Federal and industry partners spearheaded a mutual aid response of more than 70,000 workers.
- Legislative and regulatory challenges: Regulations slowed the movement of fuel and resources across state lines, which have widely differing state regulations, despite the rapid issuance of waivers as needed. In particular, anti-gouging laws were a deterrent for sourcing fuel from areas outside the affected region due to high transportation costs that might excessively raise fuel prices.
- Federal situational awareness challenges: Federal officials did not have good visibility into the levels and locations of fuel resources as disruptions grew and cascaded. Because Federal partners had difficulty identifying bottlenecks in fuel supply and delivery, they could not effectively offer assistance. DOE identified the need for a communication plan with fuel suppliers to comply with anti-trust laws, which limit information sharing, while ensuring situational awareness.
    - Social media emerged as an occasionally effective tool in helping to track fuel resources, but it also presents challenges, and information provided by social media is difficult to vet and validate.

- Community-level response challenges: Local communities need better access to information and power restoration estimates so they can effectively plan for fuel, food, and shelter. Not enough information was being supplied to the public about what was being done to address problems.
    - Communities need to better define their critical assets and nodes to help with appropriate prioritization of resources and power restoration efforts. However, local law enforcement typically considered electricity sector utility crews to be emergency responders following Sandy, which allowed them access to restricted areas and gave them priority when utility trucks needed fuel.
    - Communities must take an individualized approach to building resilience that reflects the weather patterns and other specific risks that they face.
    - Following a disaster, power may be restored to a neighborhood but residents may not be able to return home until electricians or pipe-fitters repair damage. Moving forward, mutual assistance for electricians and pipe-fitters may speed community recovery.

Areas for Improvement and Planned Actions

- DOE is considering permanently locating personnel in each FEMA region to better assist during events that may not be declared national disasters, but have wide impacts on the electricity system.
- DOE's White House Innovation Fellow is working to develop an interactive social media application for smart devices that allows citizens to send geo-located pictures of damage to utilities during a disaster event. It will assist utilities by providing another avenue for determining where trees are down, and where problems are located.
- More efforts are needed to educate the public and communities to better prepare for events.
- The department is working with DHS's Science and Technology Directorate to continue R&D investments for technologies that will build resilience into the grid.
- Federal partners will continue working closely with industry to identify and remove regulatory and legislative barriers to effective response, and develop technology or process solutions to existing challenges.

Department of Homeland Security, Federal Emergency Management Agency

Interviewee: Kathleen Fox, Director of the National Preparedness Assessment Division

Response efforts during Sandy showed a maturation of Federal Emergency Management Agency (FEMA) processes in the seven years since Hurricane Katrina: moving from a "pull" system that waits for resource requests from states to a system that "pushes" resources and capabilities out in advance of anticipated needs. FEMA acknowledged more work needs to be done as it prepares for larger, more complex disasters in the future.

FEMA evaluated response strengths and areas for improvement in four priority areas for FEMA: ensuring unity of effort across the Federal response; being survivor-centric; fostering unity of effort across the whole community; and developing an agile, professional, emergency management workforce.

Strengths and Lessons Learned from FEMA's Response

- To ensure unity of effort across the Federal response, FEMA:
    - Utilized expedited disaster declarations to move Federal aid into an area before the storm made landfall.
    - Used an online crisis management system to support resource requests in the field, maintain situational awareness, and track assistance delivered to survivors.
- To be survivor-centric, FEMA:
    - Implemented the Sheltering and Temporary Essential Power (STEP) program to pay for emergency repairs for electricity, heat, and hot water, allowing survivors to stay in or return to their homes. In an area such as New York City with dense population and limited supply of unused housing options, this sped up the return to normalcy and prevented the need to stay in shelters.
    - Used geospatial data analysis to identify and assist survivors in finding shelter if they could not return to their homes. The analysis included information from high watermark sensors, inundation levels, and road closure information. FEMA also increased the total amount of rental assistance available to eligible survivors to take into account the high rental costs in New York City.
    - Instituted a rapid National Flood Insurance Program claims process authorizing partial payments of up to $30,000 to cover repairs when action was necessary to protect health and safety.
    - Developed the Check Your Home mobile application and web portal that allowed survivors to view aerial imagery of their homes and know how it fared during the storm.
- To foster unity of effort across the whole community, FEMA:
    - Deployed a FEMA Innovation Team, a multi-sector, cross-functional group made up of non-profits, volunteer groups, businesses, and government, to creatively solve survivors' problems.
    - Activated the National Business Operations Center to facilitate two-way information sharing between public- and private-sector stakeholders.
    - Coordinated with faith-based and voluntary organizations.
- To deliver an agile, professional emergency management workforce, FEMA:
    - Completed the largest and most diverse personnel deployments in FEMA history, including nearly 10,000 FEMA personnel.

Areas for Improvement and Planned Actions

- Areas for improvement in ensuring a unity of effort across the Federal response:
    - Integrating Federal senior leader coordination and communications into response and recovery operations. There were challenges with accurately, clearly, and quickly communicating senior leaders' decisions to those responsible for implementing them.
    - Coordinating Emergency Support Functions (ESFs) and Recovery Support Functions (RSFs). It was the first time the two functions worked together. By not drawing upon the capabilities of supporting departments and agencies, the ESF coordinating agencies limited the Federal government's ability to help state and local jurisdictions respond quickly to complex problems. A department-centric approach and gaps in personnel recovery experience affected some RSFs' ability to provide coordinated assistance to communities.

- Areas for improvement in being survivor-centric:
    - Meeting survivors' needs during initial interactions through community relations, disaster recovery centers, and FEMA call centers. Following Sandy, disaster recovery centers did not always provide consistent services and call centers did not always have the staff or technology needed to keep pace with survivors' requests for information.
    - Ensuring all survivors have equal access to services by clarifying roles and responsibilities related to disability integration and equal rights.
    - Reducing the complexity of the Public Assistance program by implementing the alternative procedures to approve PA projects included in the Sandy Recovery Improvement Act of 2013.
- Areas for improvement in fostering unity of effort across the whole community:
    - Coordinating among states, localities, and tribes was challenging because New York City and New York State did not jointly develop resource requests or priorities before sending them to the Federal government. As a Federal agency, FEMA is set up to work with the state.
    - Sandy was the first time a tribal affairs liaison was activated under NRCC. The Sandy Recovery Improvement Act of 2013 allows tribes, as sovereign nations, to make emergency and disaster declaration requests directly to the President.
- Areas for improvement in delivering an agile, professional emergency management workforce:
    - Ensuring a qualified disaster workforce by utilizing the FEMA Qualification System that defines the training, experience, and demonstrated performance required to become credentialed in each of the disaster workforce positions. FQS was in progress during Sandy response and recovery.
    - Preparing to deploy the entire workforce under an efficient and clear process.
    - Supporting deployed personnel by securing lodging and equipping personnel.
    - Ensuring continuity of operations by balancing large deployments with the need to maintain steady-state operations.
- A Continuous Improvement Working Group is charged with coordinating and monitoring recommendations resulting from FEMA's after-action review. FEMA is also working with state and local communities by asking them to assess their current capabilities. The exercise starts a dialogue about risk and also helps FEMA to understand the type of assistance the community could need if there is an emergency. FEMA has found that successful community response starts with building relationships with stakeholders and industries within a community. Communities that spend time and resources to improve and strengthen their plans tend to be better prepared and fare better during an event.

U.S. Environmental Protection Agency

Interviewee: Dave Travers, Water Security Division Director

The U.S. Environmental Protection Agency (EPA) has primary emergency support function responsibility for the water sector and considers water to be a lifeline sector because whole communities cannot function without it. Access to water impacts other critical sectors outside of drinking water and wastewater treatment; hospitals, firefighters, and businesses all require water to provide basic services and for minimum operation. Despite its importance, water is often not seen as a priority when responding to an emergency at the local or Federal level and is given a secondary status. There is a lack

of understanding about the economic, public health, environmental impacts that can happen as a result of disruptions in the sector.

Lessons Learned from EPA's Response

- The water sector is extremely dependent on electricity. A power outage can cause a water system to lose pressure, allowing inflow and contamination. Other impacts include loss of water delivery and the ability to treat water.
- Ensuring consistent power generation to water systems remains a challenge. Some water systems did not have connections to receive generators, while others faced limited or no access to fuel supply during Sandy.
- There are ongoing generator maintenance issues, as generators are used so infrequently that problems may not be discovered until a disaster.

Areas for Improvement and Planned Actions

- Representation at Emergency Operation Centers—Staging a water sector representative at local and state EOCs can improve coordination for water sector utility response and resource allocation following an event.
- Ensuring water systems are aware of the availability of interstate assistance—In general, water sector utilities have not developed Emergency Management Assistance Compact resource packages and cost estimates. This is mainly due to a lack of understanding about EMACs capabilities for water sector requests.
- Consistent application of the National Response Framework—When the procedures are not applied consistently, it can lead to duplication of mission assignments under emergency support functions.
- Ensuring water crews have access to their own systems during an emergency—Water utility crews have reported being denied or prevented from accessing sites by emergency management and law enforcement agencies, slowing the ability to restore services.
- Improving situational awareness—Water system operational status information has been limited and sometimes delayed resulting in inconsistent situational awareness.
- Local interdependency workshops could help illustrate the importance of water as a lifeline sector and should be encouraged by the Federal government. As water systems work to become more robust, preparing for impacts from climate change should be integrated as part of an all-hazards response, especially as part of long-term planning.

Regional Resilience Expert Briefings

Stephen Flynn

Professor of Political Science, Director of the Center for Resilience Studies
Northeastern University

Key Insights on Regional Resilience

- A threat-centric approach to assessing and prioritizing critical infrastructure risk is flawed. Timely and accurate intelligence will always be limited, and by the time a threat is known, the window of opportunity to build in safeguards is likely closed.
- A resilience-centric approach ensures critical functions and services in the context of disruption. It focuses on mapping the infrastructure, the design boundaries, and governance systems; identifying critical functions; testing loss of those functions against a worst-case scenario; and adopting features, processes, and protocols that reduce the risk of disruption or speed recovery.
- Understanding infrastructure threat is still important, but resilience helps drive down threat in a more inclusive way by limiting both an attacker's capability to take out a certain infrastructure, and the extent of the consequences if they do.

Opportunities for Improvement

- A regional approach to infrastructure resilience is more effective than a national, sector-by-sector approach, because systems tend to be regional in scope, and a regional focus provides granularity and the ability to see interdependencies across sectors that are often lost at a higher level.
- A cross-sector approach enables sectors to improve their own resilience by addressing interdependencies. It requires bringing sectors together, asking the users what the consequences are of not having a service or function available, then working together to ensure continuity of critical functions, either by having users pay more for priority service or become an advocate to policymakers and regulatory boards.
- When infrastructure breaks is a good time to think about how it was designed and rebuild stronger. Owners and operators are now seeing federal support to make improvements during system repairs after large events, not simply replace in-kind.
- Regional partnerships require a neutral convener, such as universities, non-profit organizations, or national laboratories. When infrastructure systems cover multiple states and counties, it's very difficult for any one of those government representatives to convene all stakeholders.

Thad Allen

Executive Vice President
Booz Allen Hamilton
Admiral (ret.), U.S. Coast Guard

Insights on Regional Resilience

- Approaching resilience at the regional level is the best way to achieve it. Critical infrastructure within each community and region is diverse; the types, density, and risks of each sector differ, which necessitates a customized approach.
- As regions grow in density of population and density of infrastructure, they are experiencing increasing complexity from the interaction of the natural environment and the built environment, and greater consequences from events.
- Resilience is equivalent to a healthy immune system—it enables you to withstand an illness, without knowing what the specific threat may be ahead of an attack.
- Relationships are the key to a resilient community or region. They create a unity of effort in response, and almost any activity that builds these relationships contributes to community resilience.
    - The challenge is identifying and understanding the capabilities of all non-governmental stakeholders, and finding a value proposition to bring them together before an event.
- There will never be a major catastrophic event in this country that won't involve public participation. Proactively communicating information creates transparency and credibility, which is required in today's social media environment.
    - Any organizations leading a complex operation involving the public that does not take social media into account and proactively deal with it will have the entire reality of the situation created for them, often by someone who may not be knowledgeable or consequential. The organization's voice will be drowned out, or worse, silence will be taken as withholding information.

Opportunities for Improvement

- Resilience responsibilities often get delegated to the middle of organizations, but resource allocations get made at the executive level. Resilience requires an integrated, strategic approach led by CEOs.
    - A culture of resilience is needed in which each stakeholder understands that resilience is an organization-wide responsibility.
- Incident command systems that manage event response must include better representation of the private sector, non-governmental organizations, and faith-based organizations. They bring resources, passion, commitment, and the emotional glue that is necessary for resilience.
- Written strategies have dates with a short shelf-life. It is better to act with strategic intent, which embeds a common direction into every decision.
    - At the federal level, that means bringing federal programs and strategies down to the regional level and customizing them to that region.

Dane Egli

Senior Advisor, National Security Strategies
Johns Hopkins University Applied Physics Laboratory

Insights on Regional Resilience

- Critical infrastructure security and resilience is a public good (because it is non-rivalrous and non-exclusionary) and society expects it to be there. As a common pool resource—much like clean water or air—it cannot be achieved when managed in an ad-hoc fashion.
    - Resilience is currently led by independent action in a highly interdependent environment. If each stakeholder acts only to protect their assets, it leads to inefficiencies and hidden gaps.
    - Even after an event, key lessons learned are often collected in silos, which dilutes their potential effectiveness.
- Case studies reveal that highly interconnected systems and regions depend heavily on the lifeline infrastructures and have tightly woven interdependencies.
- The key to resilience (before and after an event) is bringing groups together across sectors and regions to address common risks and critical interdependencies.
    - Communities and regions need a reputable, neutral convening authority that can bring interconnected stakeholders together. Universities and non-profit organizations can serve this role.

Opportunities for Improvement

- Functional resilience requires a transformative, forward-thinking approach that focuses on building resilient designs rather than simply repairing and rebuilding. It uses large-scale optimization in a resource-scarce environment so that can accept some level of degradation and accept it in a graceful manner.
- To understand risk, communities and regions must start by mapping the functions, services, and assets that each sector in that region depends upon. When subjected to a hypothetical disaster, the resulting risk maps will help reveal hidden risks for each sector and critical points of failure that require greater attention.
    - This identifies the areas of most acute consequence for a region, and may reveal risks that are not immediately apparent to one sector.
    - A national strategy for developing risk maps and operationalizing the process are needed.

Richard Reed

Vice President, Preparedness and Resilience Strategy
American Red Cross

Insights on Regional Resilience

- National resilience is the output of community resilience; it has to start at the community level.
- Pre-event training of response personnel becomes critical at the local and community level. The problems during a disaster in Oklahoma are different from the problems in New Jersey. Having the capacity at the local level to address specific issues and concerns is critically important. The Red Cross pre-event presence at the local level creates an advantage.
- The Red Cross has greater flexibility than the Federal government on how they can engage with during a disasters, and can often mobilize faster.
    - The Red Cross has strong relationships with complementary non-profits to support a coordinated response and use resources more effectively. For example, the Red Cross might procure food, which is prepared by another non-profit with food preparation capacity, and then served by the Red Cross. Multi-Agency Resource Centers provide a good model for bringing together the strength and expertise of multiple non-profits.
    - It can leverage international support from Canada and Mexico more easily.
    - It can support state and local disasters that do not rise to the level of the Stafford Act.
- The Red Cross's Digital Operations Center now tracks and responds to social media posts to better locate and respond to survivor needs. During Sandy, operators responded directly to the public's tweets for help or information, and could alert state emergency management centers and FEMA of actionable information.

Opportunities for Improvement

- The majority of disaster events are not "black swan" events. There's a pattern of likelihood for events in each region, and few are completely unpredictable. The challenge is getting better at preparing for these events.
- The Red Cross is focusing on convincing partners in industry that they need to be more active in disaster recovery *before* an event.
    - Red Cross's Ready When the Time Comes program works with companies to train their employees in disaster preparedness, making them prepared and community-aware resources that can be deployed locally during a disaster.

Appendix D: Case Study on Superstorm Sandy

Superstorm Sandy, the combination of a massive hurricane followed by a Nor'easter, caused extensive damage over a wide geographic footprint, and offered a case study to examine impacts within a region and discern lessons learned and implications for improving resilience in any region and for any hazard. The National Infrastructure Advisory Council's Working Group on Regional Resilience formed a Study Group in February 2013 to conduct this case study of regional resilience, based on the experience with Superstorm Sandy and centered in the Philadelphia metro area and surrounding region. This included southeastern Pennsylvania, New Jersey, and New York City, and considered impacts from New York to Washington, D.C. The Working Group directed the Study Group to give special attention to the resilience of the lifeline sectors of energy (electricity and oil and natural gas), water, transportation, and telecommunication, which are vital to the continued operation of critical regional services that could risk human health and safety if disrupted or not restored promptly. The Study Group used the lessons learned that were gained during the planning and response phase of Superstorm Sandy to offer insights on how regions could improve resilience and reduce risks for all types of hazards by addressing near- and long-term infrastructure needs.

Exhibit 18. Task to the Study Group

The NIAC Working Group members requested the Study Group to conduct a case study examining the planning, coordination, and response for Superstorm Sandy as it applies to the Philadelphia region and lifeline sectors in neighboring regions to:

- Understand the regional impact on the lifeline sectors, including impacts on other critical infrastructures, state and local governments, communities, and private industry owners and operators.
- Identify failure mechanisms between interdependent sectors and gaps in regional resilience.

Scope

To accomplish this task, the study focused on the following definitions and lines of inquiry:

- The study examined how Superstorm Sandy placed stress on one or more of the lifeline sectors beyond current planning conditions.
    - The lifeline sectors were defined for the purpose of this study as oil and natural gas, electricity, water (potable water and wastewater), transportation (rail, aviation, highway, and public transit), and communications (including the supporting information technology backbone).
- The study examined the impact of physical and cyber disruptions from Superstorm Sandy on critical infrastructures, including impacts due to aging infrastructure.
- The Philadelphia study region included portions of Pennsylvania, New Jersey, Delaware, and Maryland.
    - Lifeline impacts of Superstorm Sandy were also examined in great detail in the adjoining region, including New York and Connecticut, and considered across the impacted area stretching from New York to Washington, D.C.

Approach

The study was conducted by a Study Group of 13 members (see Appendix A) representing the following:

- Energy/Electricity
- Energy/Oil and Natural Gas
- Transportation/Rail
- Transportation/Aviation
- Transportation/Highway Motor Carrier
- Transportation/Public Transit
- Water
- Communications
- State government
- City government

Each member had direct experience with emergency management operations or managing and overseeing critical infrastructure decisions. Their collective experience provided the main source of information and insight for this study.

While the Study Group closely examined Superstorm Sandy, it did not attempt to recount all the events, impacts, actions, and specific lessons learned. These accounts are well documented in news stories, after-action reports, and special studies, which can be found among this report's references in Appendix H. Instead, the Study Group focused on the distinctive features of Sandy that led to unanticipated impacts to lifeline infrastructures and the actions taken by regional stakeholders—owners and operators, state and local government, and non-profit groups—to minimize the magnitude and duration of the disaster. To gather this information, the Study Group drew upon information and data from several sources, including:

- Seven panel discussions with emergency managers and leaders from the lifeline sectors, state and local government, and non-profit groups
- Interviews with key leaders and experts involved in the response to Sandy
- Published reports, data, news stories, and in-process studies on both the impacts of Superstorm Sandy and the resilience investments it initiated
- Study Group member experience and expertise

The Study Group also conducted a one-day facilitated meeting to identify key findings and its conclusions for regional resilience based on all information and data collected throughout the study.

Overview of Superstorm Sandy

In many ways, Superstorm Sandy was an exceptional event. It began as a massive hurricane that produced record flooding from New York to Delaware, triggering extensive power outages, critical fuel shortages, and the largest mass transit disruption in the region's history. It was followed seven days later by a Nor'easter that hit much of the same region just as substantial recovery efforts were under way. Owners and operators of lifeline sectors and their government and non-profit partners faced unprecedented challenges that were met with novel and bold response and coordination.

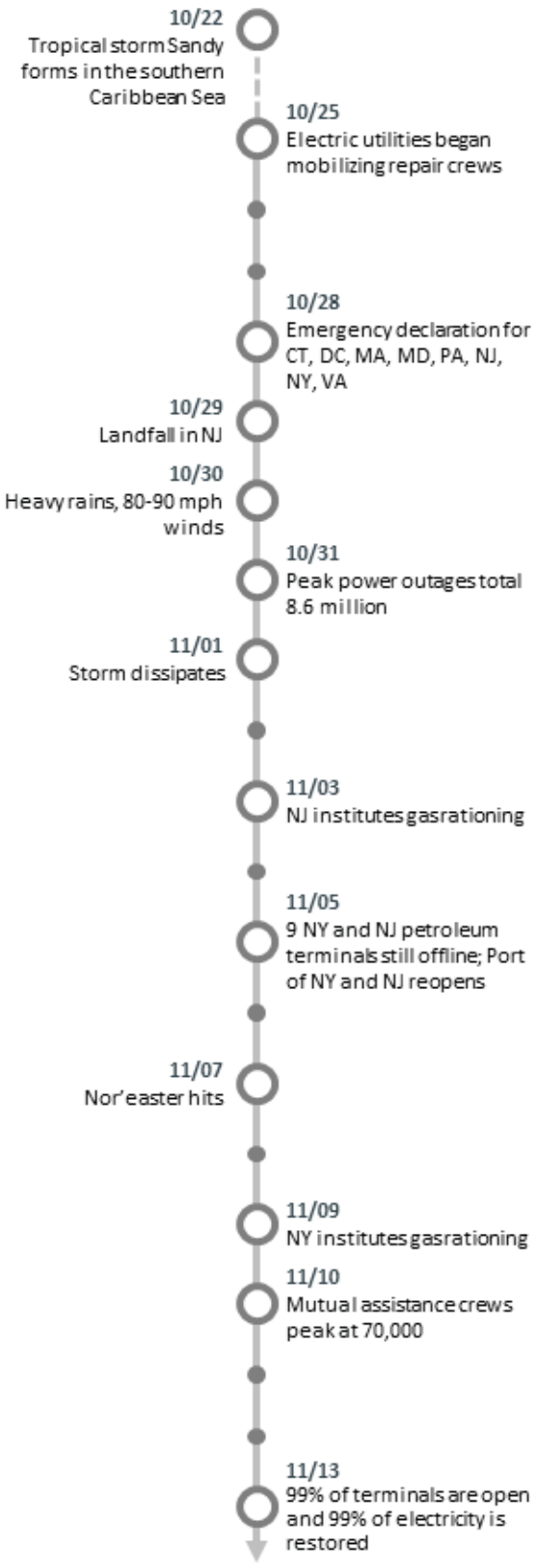
Hurricane Sandy made landfall in the United States on Oct. 29, 2012 near Atlantic City, NJ as a post-tropical cyclone. For the next three days, heavy rains, 80–90 mph winds, and storm surges battered the East Coast as the storm drove inland toward Pennsylvania, causing massive flooding, widespread power outages, and severe damage to homes and infrastructure. At its peak, hurricane-force winds extended 175 miles from the center of the storm and tropical storm-force winds extended 485 miles, making it

one of the largest Atlantic tropical storms ever recorded. Impacts were felt from North Carolina to Maine and as far west as Illinois. By the time the storm dissipated on Nov. 1, peak power outages totaled 8.6 million, damage estimates exceeded $60 billion, and 117 people had lost their lives (New York City 2013b; DOE 2013a)).

While parts of Maryland, Delaware, and Pennsylvania experienced notable storm impacts, the majority of Sandy's destruction was concentrated in New Jersey and New York. National Oceanic and Atmospheric Administration (NOAA) storm predictions issued prior to the storm were accurate, but their dense presentation and unclear communication prevented residents and asset owners from fully grasping the potential impact of the impending storm (NOAA 2013a and 2013b). Along the Jersey shore and up into Hoboken, more than 72,000 homes and businesses were damaged and severe flooding left people stranded in their homes waiting for rescue teams in boats. Atlantic City's famous boardwalk was ripped apart due to powerful waves and winds. New York City, which paradoxically received as little as ½ inch of rain in parts, was inundated by seawater that surged over Lower Manhattan's seawalls and highways and into low-lying streets, inundating tunnels, subway stations, and the electrical system that powers Wall Street. Battery Park registered a record-high storm tide of 13.88 feet and waves in New York Harbor reached a record 32.5 feet. Flooding exceeded FEMA's 100-year flood maps (last updated more than 20 years ago) by 53 percent citywide, and in some parts of the region was called a 300-year flood by the Army Corps of Engineers (New York City 2013a and 2013b). Coastal towns such as Red Hook and Breezy Point, as well as Staten Island and Long Island, were overwhelmed by storm surges and powerful waves, and damage to transportation infrastructure cut them off from the rest of the city.

As volunteer responders descended upon the hardest hit areas to aid residents and crews began to restore energy, water, communications, and transportation services, a Nor'easter swept into the affected region with strong winds, rain and snow, and coastal flooding on Nov. 7—just one week later. The heavy, wet snow blanketed the already damaged area, snapping storm-weakened trees and downing power lines, tacking an additional 200,000 people onto the list of more than 500,000 already without power in near-freezing temperatures (DOE 2013a). This

Exhibit 19. Superstorm Sandy Timeline



second blow hampered recovery efforts, making it more difficult to restore normalcy to the region.

The unprecedented nature of Superstorm Sandy was due to a confluence of factors. After evolving into a Category 1 hurricane in the Caribbean and traveling north off the U.S. East Coast, Sandy made a sharp turn toward the northwest toward the coast of New Jersey. This unusual path made the storm surge much worse for New Jersey and New York, as a cyclone's strongest winds and highest storm surge are to the front and right of its circulation. Additionally, the storm evolved atypically as a tropical cyclone merging with an intense, near-record low pressure system, causing it to dramatically increase in size before landfall (NOAA 2013a). Combined with a full moon that made high tides 20 percent higher than normal at the time it made landfall and the Nor'easter snow that followed less than a week later, Sandy had indeed become the "perfect storm" so widely forecasted. At the time of this report, more than a year after the storm, key lifeline sectors are still being repaired and returned to full capacity, and coastal homes and communities are still being rebuilt and recovered.

The successes and challenges of Superstorm Sandy are captured in the following sections of this case study, and examined for broad lessons learned and implications for resilience to all regional hazards, including events beyond storms. What follows are five lifeline sector-specific reviews and two cross-cutting reviews that each examine:

- Highlights of planning, response, and recovery
- Response, recovery, and interdependency challenges
- Sector-specific lessons learned
- Implications for resilience
- Opportunities for improvement based on the resilience implications

These seven reviews draw upon many information sources and the expertise and insights of Study Group members.

Oil and Natural Gas

Superstorm Sandy underscored the region's high dependency on gasoline and diesel fuel to power backup generators and fuel vehicles needed for restorations efforts. The combined strength and scope of the storm produced wind and flooding that caused widespread damage to terminals, pipelines, storage facilities, and truck racks from wind and flooding. Many marine terminals, refineries, and supply and distribution terminals in the region shut down due to either damage, lack of power, or both. Electrical components including control systems, switching gear, and vapor recovery units sustained flooding damage, and repairs required both time and technical expertise. Marine terminals, if operational, were still unable to receive product from barges due to debris in the New York Harbor. In addition, the northern leg of the Colonial Pipeline, which delivers as much as 15% of the region's fuel from Gulf Coast refineries, was shut down due to lack of power and the subsequent inability to receive its product at offline terminals.

An estimated 60%–65% of service stations lost power in New York and New Jersey and could not provide fuel to repair fleets or the public. As power was restored to service stations, many were unable to get fuel delivered to their station. Backup generators at many critical facilities in other sectors had limited storage capacity, typically only a 24-hour supply of fuel, thus creating a large demand on distributors as restoration stretched on.

The natural gas distribution system was devastated on New Jersey's barrier islands and took eight weeks to restore, a lengthy process that included individual home safety inspections. However, damage and disruption was not widespread in the region, and natural gas supplies even supported cogeneration at some critical sites that kept the power on. This review thus focuses mostly on petroleum industry impacts and actions during Superstorm Sandy.

Exhibit 20. Oil and Natural Gas Sector Highlights

- Superstorm Sandy exposed risks within the sector that were not understood by dependent critical sectors and government officials, due in part to their limited understanding of sector operations, distribution, marketing, and regulations.
- Without power, even well stocked gasoline service stations were unable to pump fuel to customers. Emergency managers struggled to determine which stations had both fuel and power.
- Stakeholders sought out alternative fuel supplies by leveraging distributor relationships with other fuel suppliers in nearby regions; seeking regulatory waivers; and tapping electricity restoration crews from non-impacted states to bring their own fuel tankers.
- Refineries and supply terminals that lost power also had major water damage to primary switch gear and other critical electrical components that delayed restoration long after power was restored.
- Many critical dependent sites limited to 24 hours of fuel storage required repeated daily refueling runs for generators. Regulations on fuel storage create disincentives to store greater supplies.
- Anti-gouging laws discouraged suppliers and distributors from bringing in fuel from other regions at higher costs, as the resulting price increase might give the appearance of gouging. Antitrust laws and SEC Regulation Full Disclosure (FD) place limits on sharing market-sensitive supply information, which compromised situational awareness.

Exhibit 21. Critical Elements of the NJ, NY & Northeast Fuel Supply Chain

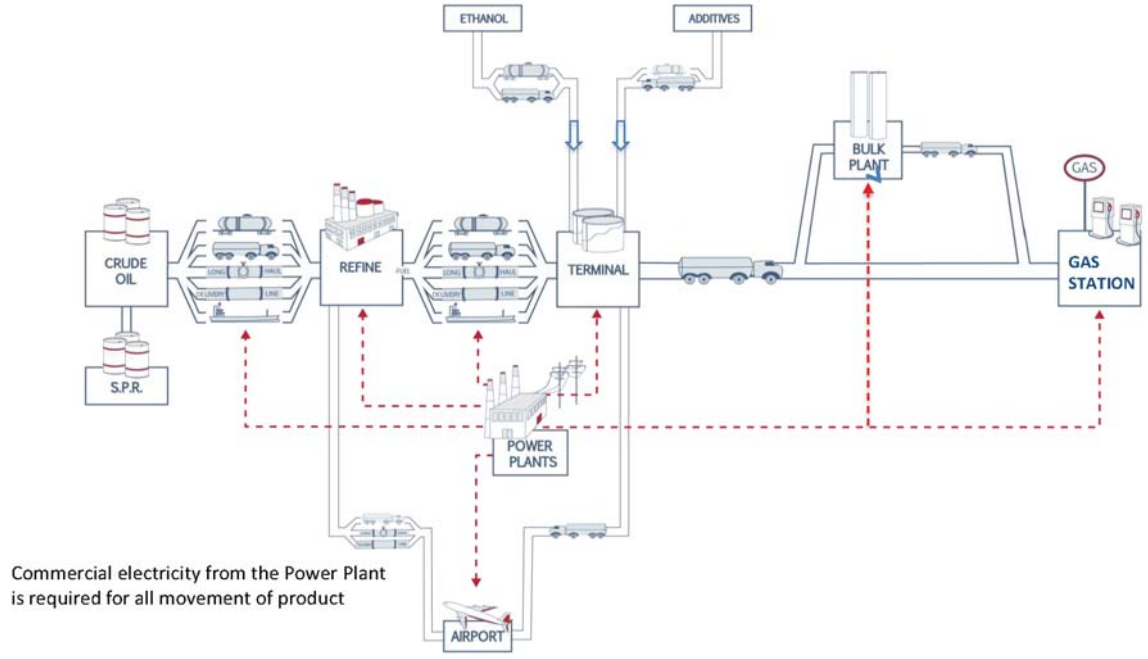


Diagram courtesy of the American Petroleum Institute. Used with express permission.

Highlights of Planning, Response, and Recovery

Although some assets on the eastern seaboard suffered significant damage, owners and operators and their government counterparts acted swiftly to remove barriers and maintain fuel availability.

Mature business continuity plans and advance coordination aided recovery efforts.
Owners and operators took the following steps to support continued operation of assets critical for business:

- Transferred operations to control systems and operation centers outside of the impacted areas.
- Evacuated personnel and key resources in the line of the storm and brought in personnel and equipment from unaffected regions to assist with repair and recovery.
- Worked with city or county government officials ahead of the storm to coordinate entry control procedures that would grant access to authorized repair crews to restart refineries, terminals, or pipelines.

City and state agencies also fueled vehicles and generators prior to the storm and some established an independent fuel supply. For example, New York City set up a fueling station at Floyd Bennett Field for city vehicles.

Owners and operators tapped alternative fuel supplies to supplement the local supply chain.
With 25% of the region's fuel-making capacity offline due to lack of power or damage from the storm surge, fuel distributors brought in supplies from outside the damage zone:

- Restoration crews coming from non-impacted states, upon hearing about local fuel shortages, brought their own fuel tankers to support the restoration efforts.

- At the direction of the president, the Department of Defense loaned ultra-low sulfur diesel from the Northeast Home Heating Oil Reserve for the first time since its creation.

Temporary regulatory waivers provided flexibility to use non-standard fuel sources.
Federal, state, and local officials issued a host of temporary waivers to increase fuel accessibility, including the following:

- Lifted U.S. Environmental Protection Agency (EPA) fuel specifications for sulfur content requirements in ultra-low sulfur diesel fuel and ethanol requirements for reformulated gasoline.
- Removed New York City-specific fuel transportation restrictions and required use of ultra-low sulfur #2 oil for heating.
- Suspended the Jones Act to allow tankers from foreign countries to supply fuel from refineries in the Gulf of Mexico.
- Allowed residential heating oil delivery vehicles to re-fuel commercial facilities, which allowed fuel suppliers to better serve critical infrastructure sites.

See "A Closer Look: Petroleum Regulations and Waivers during Superstorm Sandy" at the end of the Oil and Natural Gas section for further details.

Gas rationing suppressed public demand.
Throughout New Jersey, gas shortages caused long lines to form for many days following the storm. Governor Chris Christie instituted an odd-even gas rationing system based on license plate numbers—last used in the 1970s—to help alleviate overcrowding at gas stations while stretching supply. This was later adopted by New York City.

Daily conference calls between government officials and owners and operators and the co-location of key officials greatly improved cross-sector situational awareness.

- In daily calls led by the New Jersey Office of Homeland Security, emergency managers and owners and operators received updates on restoration across the region and coordinated a more effective response. Senior Department of Energy officials led and participated in coordination calls to facilitate power restoration to affected terminals and refineries.
- The New Jersey Regional Operations Intelligence Center (ROIC) invited representatives from the Fuel Merchants Association of New Jersey, which represents the state's petroleum marketing industry, into the state EOC, enabling state officials to coordinate fuel requests from other critical sectors.

New Jersey's recent regional exercise and drill simulated widespread petroleum distribution losses and prepared the sector for some Sandy challenges.

- The "Running on Empty" exercise with New Jersey's infrastructure bureau and regional owners and operators in 2011 presaged the petroleum disruptions the sector actually faced in Sandy. Petroleum owners and operators were not caught off guard.

Response, Recovery, and Interdependency Challenges

Severe petroleum disruptions during Superstorm Sandy underscored the sector's strong dependence on electricity—to receive, refine, pump, and distribute fuel supplies from terminals to service stations—and on the transportation sector—which oversees the pipelines, tankers, barges, railroad tank cars, and trucks used to distribute fuel supplies to customers.

Heavily damaged refineries and terminals and extensive commercial power outages caused disruptions throughout the supply chain—from pipelines and refiners to suppliers and distributors—that other sectors did not anticipate.

- Power outages to pipeline pumps and fuel terminals that could then no longer accept fuel forced the northern part of the Colonial Pipeline to shut down, effectively cutting the region off from a 2.4 million barrel per day supply of petroleum.
- Without power, several refineries were unable to refine fuel for the region, receive fuel, or access their existing supply of fuel for supply and distribution.
- While refineries and supply terminals were initially offline due to a lack of power, many also suffered major water damage to primary switch gear and other internal electrical components that delayed operations long after power was restored. As of Nov. 5, nine terminals in New York and New Jersey were still offline due to damages sustained. The second largest refinery in the region, with a 238,000-barrel-a-day capacity, was not able to begin restart until Nov. 20, more than three weeks after it shut down in preparation for the storm.
- Without commercial power, well-stocked gasoline service stations were unable to pump fuel to customers. Service stations with power quickly depleted resources as demand rose, and suppliers experiencing power outages or infrastructure damage could not refuel them.

Limited visibility into regional fuel supplies made it difficult for owners and operators, government officials, and dependent sectors to assess the problem and prioritize response.

State emergency managers and other critical sectors lacked insight into the status of all links in the supply chain and the significance of disruptions, which complicated decision-making.

- Though fuel scarcity resulted from distribution issues, not supply shortages, public emergency managers had limited visibility into supply levels in refineries and storage terminals due to anti-trust laws and disclosure regulations, making it difficult to assess whether widespread shortages existed or determine where fuel could be moved once power was restored.
- Emergency managers and repair crews had no centralized way to determine which stations had electricity, backup generators, or fuel to pump. Restoration crews wasted time searching for operational service stations.
- Fuel distributors had trouble determining which suppliers had fuel and where. Trucks often waited at terminals only to be told they had no allocation when their turn came.

State and local governments lacked full understanding of petroleum operations and restoration needs.

- In Superstorm Sandy and past events, owners and operators spent critical response time educating government partners on how the sector markets, distributes, and transfers ownership of fuel. A lack of understanding of the sector's operations and market restrictions delayed coordination on solutions.
- Government officials in some cases attempted to allocate or prioritize fuel resources.
- As repeatedly experienced in past disasters, recovery crews in this and other sectors faced difficulty obtaining re-entry into damaged zones to restore critical services.

Fuel shortages triggered cascading disruptions to critical sectors and delayed recovery.

- Other critical sectors, especially emergency services, healthcare, and other lifeline sectors, depended heavily upon fuel for both backup generation and for repair fleet vehicles.

State and Federal regulations inhibited information sharing and limited fuel supply shipments from outside the region.

Fuel refiners, suppliers, and distributors faced state and Federal regulations that created obstacles to sharing supply information and sourcing fuel from outside the region. While waivers were quickly issued for certain regulations, others are not easily waived and further exacerbated the disruption:

- **Antitrust laws**, which place limits on market-sensitive information sharing and competitive conduct, restricted the owners'/operators' ability to share information regarding their fuel supplies with government partners and other companies.
- **SEC Regulation Fair Disclosure** states that any material nonpublic information that a petroleum company discloses to another entity must also then be disclosed publicly—making petroleum companies reluctant to share sensitive supply status and operations information with state emergency managers and other sectors.
- **Anti-gouging laws**, established by the state, prohibit a service station from excessively raising the price of fuel (10% above normal prices in New Jersey; in New York, "unconscionably extreme" increases are barred). This discouraged suppliers and distributors from bringing in fuel from other regions, as the increased transportation costs and subsequent fuel price increases would risk the appearance of price gouging.
- **Uniform Commercial Codes**, adopted by all 50 states, dictate that refineries and distributors cannot discriminate among customers and must first meet their contractual obligations. As a result, operators cannot redirect fuel deliveries unless stated in existing contracts.

Oil and Natural Gas Sector Lessons Learned

1. **State and local regulations designed to protect consumers often delay the ability to procure, deliver, and prioritize fuel supplies during a major disruption**. Excellent Federal, state, and local coordination both before and during the storm swiftly delivered waivers in many cases. But sometimes the waiver process or lack of waivers significantly delayed restoration of fuel deliveries in the region. See A Closer Look: Petroleum Regulations and Waivers during Superstorm Sandy for more information at the end of this section.
2. **Superstorm Sandy exposed risks in the petroleum industry that were not understood by other critical sectors and state and local government**. Limited understanding of sector operations, distribution, marketing, and regulations at the state and local level complicated situational awareness and made it difficult to assess and address supply chain breakdowns.
    - Some believe that petroleum facility owners and operators have complete decision-making control on where fuel is delivered, when in fact they are bound by regulations and contracts.
3. **More accurate real-time information on the types of products and supply levels in petroleum fuels systems would allow** Federal, state, and local energy officials to better address potential shortages during a disaster. The American Petroleum Institute has begun developing educational materials for state and local emergency managers and government officials. See also Electricity Sector Resilience Implications #4.
4. **Regulations on atmospheric (above-ground) fuel storage are not well understood and create potential disincentives for critical sites in other sectors to store excess emergency fuel**. Growing expectations for uninterrupted electricity created high demand for reliable backup generation, yet fuel reserves typically max out at 24-hour supplies, even at critical sites. Safer underground storage is costly and raises environmental considerations.

5. **Hundreds of independent and privately owned service stations had insufficient backup generation**, contributing to limited supply for emergency responders, repair crews, and the public. Despite being stocked with fuel, service stations without electricity often did not have reliable backup power to pump fuel. State and local government officials scrambled to supply limited emergency generators to stations, and connecting them was not seamless.
6. **Interdependencies between the electricity and fuel sectors highlighted the need for increased cross-sector communication** and coordination with public emergency managers. It became critical for fuel refiners and suppliers to communicate their electricity outage issues back to a central location, where they could be tagged with priority by state authorities and electricity repair crews. Daily conference calls with Federal energy officials and industry CEOs facilitated this coordination.
    - Fuel owners and operators need to work with emergency management officials and electricity owners and operators to determine in advance where they fall in the prioritization of service restoration, enabling them to plan accordingly.
7. **Large petroleum companies successfully applied experience from previous storms and hurricane-prone regions** (such as the Gulf Coast) during Superstorm Sandy. National companies share lessons learned across their facilities, and provide personnel and expertise from outside the region to assist during restoration.
    - A distributor who successfully built a relationship with a Philadelphia supplier (outside its normal operating region) was able to successfully use that relationship to source fuel for critical customers during Superstorm Sandy. In a prior storm, the same distributor lacked this relationship and had been cut off while trying to pre-stock critical customers with fuel.
    - Several companies donated thousands of gallons of fuel to critical infrastructure during Sandy.

Implications for Resilience

Petroleum companies have identified actions they can take based on lessons from Superstorm Sandy that will increase sector resilience in the face of a growing risk environment.

8. **Joint regional exercises with state and local government and critical sectors are one of the best mechanisms to identify gaps and interdependencies**, reinforce relationships, and address regional planning challenges for resilience. Joint exercises help to build muscle memory for response and institutionalize key relationships.
    - **Fuel distributors should build relationships with suppliers in adjoining regions** to help source alternative fuel supplies during fuel disruptions. Executive involvement in fuel distribution decisions during emergency events (while maintaining contractual obligations) can improve restoration and minimize cascading disruptions.
    - Owners and operators can reinforce to government and other sector officials their responsibility to ensure they have prepositioned an adequate fuel supply for critical operations before the storm.
9. **A comprehensive review of all Federal, state, and local regulations can** identify barriers to rapid recovery and restoration in the oil and natural gas sub-sector and enable security partners to remove them.
10. Government and industry partners can draw upon successful waiver processes during Superstorm Sandy **to streamline a waiver request and issuing process** for a variety of all-hazards events.

11. **Public emergency managers require new tools to better monitor real-time fuel availability and storage levels at all points in the supply chain**. An examination of what tools and personnel resources could improve real-time information sharing and situational awareness at the regional and Federal level can improve disaster response, while working within existing limitations on information sharing required by regulation.
    - Government officials should work with owners and operators to determine the best individuals within the company (such as public relations officials) to interface with, and communicate information needs so that those representatives can better source that information within the company.
12. Owners and operators in the electricity and oil and natural gas sub-sectors, working with Federal and state governments, should **fully identify regional interdependencies to better communicate restoration processes and priorities**. This will enable coordinated restoration and enable fuel owners and operators to plan restoration efforts in light of power restoration plans.
13. **Near-term and long-term investments will harden infrastructure and standardize equipment to improve flexibility.** Industry standards for installing transfer switches or other systems needed to accept backup power at oil terminals, pipelines, and service stations can speed the connection of emergency generators to critical facilities.
    - Despite the increased regulations it may prompt, state and locally identified critical infrastructure operations and assets that require uninterrupted power must pre-position anticipated fuel storage needs beyond 24 hours of generation capacity to ensure resilience.
    - Military trucks and commercial trucks are currently not fitted with the same hardware, which limits the National Guard's ability to quickly provide additional resources.
    - Petroleum facility owners and operators may consider elevating and relocating critical electronic equipment and control rooms. Marine terminals, which are particularly vulnerable to flooding, may require flood protection upgrades.

Opportunities for Improvement

- Review, refine, and streamline the process for issuing fuels waivers to owners and operators so fuel can be sourced and delivered in alternative ways.
- Public-private cooperation to design technologies and processes to measure and report real-time information on fuel supplies.
- Incentives for government and privately owned critical sites with back-up generation capabilities to pre-position and store more than 24 hours of fuel.
- Encouragement for service stations to integrate quick-connect capabilities for emergency generators, and support states to maintain an inventory of emergency generators for dispatch during an event.
- Assistance in educating state and local officials and other sectors about oil and natural gas sub-sector operations.

A Closer Look: Petroleum Regulations and Waivers during Superstorm Sandy

During Superstorm Sandy, residents and recovery teams struggled to acquire fuel, particularly petroleum products such as gasoline and diesel. In large part, this shortage resulted from the direct hit Sandy delivered to the petroleum terminals and refineries in the New Jersey and Staten Island areas. Widespread power outages and damaged transportation arteries also made fuel production and distribution difficult. When the petroleum industry tried to work around these complications to get fuel to those who needed it, the laws and regulations that govern petroleum often prevented them from reaching a solution. To help alleviate this issue, Federal and state agencies issued a number of petroleum waivers during Sandy and the recovery process.

Exhibit 22. Federal and State Agencies Regulating ONG Activities

Federal Regulatory Bodies

- Department of Defense
- Department of Homeland Security
- Department of Transportation
- Environmental Protection Agency
- Federal Energy Regulatory Commission

State Regulatory Bodies

- State government energy offices, represented by the National Association of State Energy Officials (NASEO)
- State public utility commissions, represented by the National Association of Regulatory Utility Commissioners (NARUC)
- Governors' offices and state legislators, represented by the National Governors Association (NGA) Center for Best Practices and the National Conference of State Legislatures (NCSL)
- State and local emergency management agencies, represented by the National Emergency Management Association (NEMA) and first responders
- Local governments and associations that represent them, such as the Public Technology Institute (PTI)
- Energy Emergency Assurance Coordinators (EEAC)

(U.S. DHS and DOE 2010)

Petroleum Infrastructure and Regulations

The petroleum portion of the energy sector includes the production, transportation, and storage of crude oil; processing of crude oil into petroleum products; transmission, distribution, and storage of petroleum products; and sophisticated control systems to coordinate storage and transportation.[2] The entire petroleum supply chain is heavily regulated by both the Federal government and individual states, with the Federal government generally regulating health, safety, and environment factors, and the states regulating petroleum operations within their jurisdictions. Under normal conditions, these regulations are harmonized through collaboration between the Environmental Protection Agency, the Department of Energy, and the Interstate Oil and Gas Compact Commission.[3]

Federal Health, Safety, and Environmental Laws and Regulations

According to ConocoPhillips, the following Federal regulations apply to all oil and natural gas activities (ConocoPhillips 2012):

- **Clean Air Act**: Regulates air emissions from engines, processing equipment and other sources associated with production.
- **Clean Water Act**: Regulates produced water and storm water runoff. Regulates facilities with a reasonable potential to discharge oil to navigable waters.

[2] "A Closer Look" draws heavily upon the following sources: DHS and DOE 2010; American Petroleum Institute nd.b; and ConocoPhillips 2012. Other sources are identified in notes throughout the text.

[3] The Interstate Oil and Gas Compact Commission serves as the collective voice of member State governors on oil and gas issues and advocates states' rights to govern petroleum resources within their borders; IOGCC 2103.

- **Endangered Species Act**: Covers endangered or threatened species and their habitats.
- **Emergency Planning and Community Right-to-Know Act**: Requires operators to report chemicals stored and used above certain quantities and to submit material safety data sheets to emergency responders.
- **Environmental Response, Compensation and Liability Act**: Requires operators to report releases of certain chemicals in excess of established threshold levels.
- **Federal Land Policy and Management Act**: Establishes guidelines for the management, protection, development and enhancement of public lands.
- **National Environmental Policy Act**: Provides guidelines for environmental analysis on Federal lands and minerals and established the Council on Environmental Quality.
- **Occupational Safety and Health Act**: Requires information disclosure about chemicals used at every site.
- **Safe Drinking Water Act**: Sets standards for disposal of flowback and produced water.
- **Toxic Substance Control Act**: Requires operators to report information on a chemical's production, use, exposure and risk.

Exhibit 23. Emergency Support Function 12 (ESF 12): Energy

ESF 12 is intended to facilitate the restoration of damaged energy systems and components when activated by the Secretary of Homeland Security for incidents requiring a coordinated Federal response. When activated, the designated agency directing ESF 12 has the following scope of responsibility:

- Collect, evaluate, and share information on energy system damage and estimations on the impact of energy system outages within affected areas
- Provide information concerning the energy restoration process such as projected schedules, percent completion of restoration, and geographic information on the restoration
- Facilitate the restoration of energy systems through legal authorities and waivers
- Provide technical expertise to the utilities, conduct field assessments, and assist government and private-sector stakeholders to overcome challenges in restoring the energy system

State, tribal, and local governments have primary responsibility for prioritizing the restoration of energy facilities. Restoration of normal operations at energy facilities is the responsibility of the facility owners.

Federal and State Antitrust Laws

The petroleum industry is also subject to Federal and State antitrust laws, which place limits on information sharing within the petroleum industry, forbid anti-competitive conduct, and cannot be waived (American Petroleum Institute nd.b). The three core Federal antitrust laws include (FTC 2013):

- **Sherman Act**: Outlaws "every contract, combination, or conspiracy in restraint of trade," and any "monopolization, attempted monopolization, or conspiracy or combination to monopolize."
- **Clayton Act**: Prohibits mergers and acquisitions where the effect "may be substantially to lessen competition, or to tend to create a monopoly."
- **Federal Trade Commission Act**: Bans "unfair methods of competition" and "unfair or deceptive acts and practices." The Robinson/Patman Act amends the Clayton Act to ban certain discriminatory prices, services, and allowances in dealings between merchants.

Regulation Fair Disclosure

The Securities and Exchange Commission (SEC) in August 2000 adopted Regulation FD (Fair Disclosure) to address the selective disclosure of information by publicly traded companies. Regulation FD provides that when an issuer discloses material nonpublic information to certain individuals or entities—generally, securities market professionals and holders of the issuer's securities who may trade on the

basis of the information—the issuer must make public disclosure of that information (U.S. Securities and Exchange Commission 2004).

Although Regulation FD was intended to preserve the integrity of capital markets by restricting insider trading, there has been considerable backlash from publicly traded companies as to its interpretation and implications. The SEC addressed many of these concerns in its Final Rule on Regulation FD, effective October 2000 (U.S. Securities and Exchange Commission 2001). However, many issues remain unclear and industry may be reluctant to provide privileged information to government in situations where the disclosure might be faulted by the SEC.

National Security Authorities

The petroleum industry is also subject to laws providing the Federal government with national security authorities over energy in case of emergencies. These include (DHS and DOE 2010):

- **Defense Production Act (DPA)**: Delegates the Secretaries of Energy and Commerce under the President's authority to require the priority performance of contracts or orders relating to materials (including energy sources), equipment, or services, including transportation, or to issue allocation orders, as necessary or appropriate for the national defense or to maximize domestic energy supplies.[4]
- **Robert T. Stafford Disaster Relief and Emergency Assistance Act**: Authorizes FEMA, following a presidential declaration of emergency or major disaster, to provide assistance and require other Federal agencies to provide resources and personnel to support state and local emergency and disaster assistance efforts.
- **Merchant Marine Act of 1920 ("Jones Act"):** Directs the Secretary of Homeland Security to waive the provisions requiring the use of U.S.-flag, U.S.-built, and U.S.-crewed vessels in coastwise trade, upon the request of the Secretary of Defense. Interagency procedures have been established to expedite actions on Jones Act waiver requests during a petroleum supply disruption.
- **Ports and Waterways Safety Act**: Authorizes the Secretary of Transportation to establish vessel traffic systems for ports, harbors, and other navigable waters and control vessel traffic in areas determined to be hazardous (e.g., because of reduced visibility, adverse weather, or vessel congestion).
- **Energy Policy and Conservation Act**: Specifies that, in order to be eligible for financial assistance to assist in the development and implementation of an energy conservation plan, a state must submit to the Secretary of Energy an energy emergency planning program for an energy supply disruption that is consistent with applicable Federal and state law. The contingency plan "shall include an implementation strategy or strategies (including regional coordination) for dealing with energy emergencies."

Waivers Issued During Superstorm Sandy

On October 26 (three days before Sandy hit the New Jersey shore), DOE's Office of Electricity Delivery and Energy Reliability (OE) was designated the Federal Sector-Specific Agency directing Emergency Support Function 12 (ESF-12) activities for the energy sector under the National Response Framework (FEMA 2012). As a result, OE began issuing its *Hurricane Sandy Situation Report* on October 28. At that time, refineries and utility companies were carefully monitoring the storm and utilities were preparing

[4] "National defense" is defined in DPA to include "emergency preparedness activities conducted pursuant to title VI of the Robert T. Stafford Disaster Relief and Emergency Act and critical infrastructure protection and assurance."

for the hurricane by pre-positioning supplies, securing workers, and requesting mutual assistance support to restore power after the storm made landfall (DOE 2012b).

Department of Transportation Waivers

On October 28, the Department of Transportation's Federal Motor Carrier Safety Administration (FMCSA) issued a Declaration of Regional Emergency Notice, stating: [5]

- "The emergency exemption is issued as a result of extreme weather conditions, shortages, and interruptions in the availability and/or delivery and repair of services and property throughout the States affected in the Eastern Region to include the following: Connecticut, Delaware, the District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia and West Virginia. It is effective beginning October 29, 2012.
- "This declaration of emergency provides relief for commercial motor vehicles operations while providing these emergency materials and services to customers in the above mentioned states during the emergency. This exemption applies only to those operations providing direct assistance to the emergency relief effort. Direct assistance terminates when a driver or commercial motor vehicle is used in interstate commerce to transport cargo or provide services not destined for the emergency relief effort or when the motor carrier operation dispatches such driver or vehicle to another location to begin operations in furtherance of commerce" (FMCSA 2012b).

The FMCSA also issued the following waivers via the Hurricane Sandy Information Center on its webpage:
"Due to the damages caused by Hurricane Sandy FMCSA is coordinating with Federal agencies and states on emergency declarations, waivers, exemptions, special permits, tolls and other temporary authorizations related to relief efforts in your state. Trucks bringing fuel to the impacted region must follow different state regulations. The team will coordinate information on a variety of waivers to ensure each state is on the same page on key regulatory issues that should be addressed to assist the flow of petroleum products to affected states, including:

- Driver Hours-of-Service
- Oversize and Overweight
- Low Sulfur Diesel Waivers
- Toll Waivers
- Vehicle Registration Waiver (International Registration Plan — IRP)
- Fuel Tax Waiver (International Fuel Tax Authority — IFTA)" (Federal Motor Carrier Safety Administration 2013)

A month prior to Sandy, DOT's Federal Highway Commission issued guidance on Section 1511 of the Moving Ahead for Progress in the 21st Century Act (MAP-21) that was also put in place during the storm. The guidance extends the states' authority to issue special permits to vehicles with divisible loads (e.g., relief supplies) during a Presidentially-declared emergency or major disaster under the Stafford Act (Federal Highway Administration 2013). These permits help alleviate the strict Federal oversize and weight limits placed on vehicles using the Interstate system to expedite the delivery of relief supplies to areas in need.

[5] For a complete listing and links to Federal and State motor-carrier related waivers and exemptions during Sandy, please see FMCSA "Hurricane Sandy Relief Efforts - Declarations, Waivers, Exemptions & Permits."

EPA Fuel-Related Waivers

In the event of a fuel supply emergency, only EPA[6], with the concurrence of the Department of Energy, may temporarily waive a fuel or fuel additive requirement if doing so will alleviate the fuel supply emergency.[7] Clean Air Act Section 211(c)(4)(C), which authorizes fuels waivers, specifies the criteria for granting a fuels waiver, and the conditions that must be included in a fuels waiver (see Exhibit 24). A fuels waiver can be issued only when the criteria specified in the Clean Air Act have been met. In general, these criteria allow a fuels waiver only to address a temporary emergency fuel supply shortage that exists throughout a state or region that was caused by an unusual situation, such as fuel shortages as a result of the extensive hurricane damage to refineries and pipelines.

The Clean Air Act includes a range of requirements for motor vehicle fuel depending on location (rural vs. urban) or time of year (e.g., the volatility of gasoline is controlled each year during the high ozone season of June 1st through September 15th). As a result, EPA may grant a waiver to allow use of a fuel that normally is not allowed in a particular time period or geographic area.

The process for obtaining a fuel waiver from EPA involves many steps. Except in unusual or emergency circumstances, a formal request for a fuels waiver must be made by, or on behalf of, the Governor of an affected state after consultation with EPA. The first point of contact for a state government to obtain information about a fuels waiver request is the EPA Air Enforcement Division or the Transportation and Regional Programs Division. Outside of normal business hours, the point of contact is the EPA Emergency Operations Center. EPA requests that it be contacted as soon as it appears that there may be a fuel supply shortage to allow them to provide guidance to the affected state regarding a possible fuel waiver request, and to begin an assessment of the possible fuel supply shortage in coordination with the Department of Energy.

After this assessment, EPA requires the Governor of the affected state or territory to issue a formal written request for a fuels waiver under the direction of the EPA Administrator. The request should describe how the fuels waiver criteria specified in Clean Air Act have been met, including the following:

- The nature of the Act of God or other event that caused the shortage
- An explanation of why the shortage was not foreseeable and could not have been prevented by prudent planning on the part of the suppliers of the fuel
- The type of fuel for which a shortage exists
- The geographic area that is affected
- The effect of the shortage on fuel supplies, such as the number of gasoline stations that are, or are expected to be, out of fuel
- The expected duration of the shortage
- The specific nature of the waiver being requested, including the duration, the geographic area, and the alternative fuel that would be allowed

[6] State fuels programs that are part of a State Implementation Plan (SIP) are Federally enforceable, and the requirements cannot be waived unless waivers are issued by both EPA and the state.
[7] This explanation borrows from U.S. EPA, "Fuel Waivers."

Exhibit 24. Criteria and Conditions for Fuels Waivers Specified in Clean Air Act Section 211(c)(4)(C)

(ii) The Administrator may temporarily waive a control or prohibition respecting the use of a fuel or fuel additive ... if, after consultation with, and concurrence by, the Secretary of Energy, the Administrator determines that--

(I) extreme and unusual fuel or fuel additive supply circumstances exist in a State or region of the Nation which prevent the distribution of an adequate supply of the fuel or fuel additive to consumers;

(II) such extreme and unusual fuel and fuel additive supply circumstances are the result of a natural disaster, an Act of God, a pipeline or refinery equipment failure, or another event that could not reasonably have been foreseen or prevented and not the lack of prudent planning on the part of the suppliers of the fuel or fuel additive to such State or region; and

(III) it is in the public interest to grant the waiver (for example, when a waiver is necessary to meet projected temporary shortfalls in the supply of the fuel or fuel additive in a State or region of the Nation which cannot otherwise be compensated for).

(iii) If the Administrator makes the determinations required under clause (ii), such a temporary extreme and unusual fuel and fuel additive supply circumstances waiver shall be permitted only if--

(I) the waiver applies to the smallest geographic area necessary to address the extreme and unusual fuel and fuel additive supply circumstances;

(II) the waiver is effective for a period of 20 calendar days or, if the Administrator determines that a shorter waiver period is adequate, for the shortest practicable time period necessary to permit the correction of the extreme and unusual fuel and fuel additive supply circumstances and to mitigate impact on air quality;

(III) the waiver permits a transitional period, the exact duration of which shall be determined by the Administrator (but which shall be for the shortest practicable period), after the termination of the temporary waiver to permit wholesalers and retailers to blend down their wholesale and retail inventory;

(IV) the waiver applies to all persons in the motor fuel distribution system; and

(V) the Administrator has given public notice to all parties in the motor fuel distribution system, and local and State regulators, in the State or region to be covered by the waiver.

During Sandy, state governments worked with EPA to issue the following waivers:

- October 31 – EPA Administrator issued an "October 2012 Fuel Waiver Concerning Connecticut, Delaware, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Virginia, Mississippi, Alabama, Georgia, Tennessee, South Carolina, North Carolina, and the District of Columbia" which waived Federal reformulated gasoline (RFG) requirements in Designated RFG Covered Areas (Jackson 2012a).
- October 31 – EPA waived requirements for use of Ultra Low Sulfur Diesel fuel, and to instead allow the use of high sulfur heating oil, in certain generators and pumps used for emergency purposes in New Jersey (Jackson 2012b).
- On November 1 – EPA waived the requirement for use of Ultra Low Sulfur Diesel in emergency response vehicles in New Jersey (Jackson 2012c). Related, on November 3, in response to shortages of clean diesel fuel caused by Hurricane Sandy, the IRS waived tax penalties when dyed diesel fuel is sold for use or used highway, and for the use of diesel fuel that does not meet EPA sulfur requirements, in New York, New Jersey and Pennsylvania (IRS 2012a).
- On November 2 – EPA waived the requirement for use of Ultra Low Sulfur Diesel in emergency response vehicles and equipment in the five boroughs of New York City and Nassau, Suffolk, Rockland and Westchester counties in New York, and in the Commonwealth of Pennsylvania (Jackson 2012d).
- On November 16 – EPA extended the multi-state waiver of RFG requirements in NY and NJ, and the waiver of diesel fuel requirements in NY and NJ (Jackson 2012e). Related, on November 20, in response to continuing shortages of clean diesel fuel caused by Hurricane Sandy, the IRS waived tax penalties when dyed diesel fuel is sold for use or used highway, and for the use of

diesel fuel that does not meet EPA sulfur requirements, in New York and New Jersey (IRS 2012b).

Waivers Issued During Superstorm Sandy by Component of Petroleum Industry

Facility	Waiver
Gas Stations	**Federal and State** • **Fuel specs** (RFG, ASTM, ULSD) **State and Local** • **Air quality** – Vapor recovery • **Pump labeling** – State and local governments generally require that gasoline stations place labels on their pumps disclosing gasoline ingredients, especially ethanol and methanol (Fultz 1988). The labeling waiver was issued by individual states and communities because cleaner gasoline and diesel was unavailable, while conventional fuel sometimes was.
Ports, Barge/ Shipping	**DHS** • Merchant Marine Act of 1920 ("Jones Act") – Certain provisions of the Jones Act **States** • **Vapor recovery regulations** – Part of the implementation of the Clean Air Act, vapor recovery is the process of recovering the vapors of gasoline or other fuels, so that they do not escape into the atmosphere in order to reduce noxious and potentially explosive fumes and pollution.[8]

Pipelines	**EPA**
	• Fuel specs for RFG and ULSD
	States
	• Fuel specs
	• **Air quality** regulations for:
	  ○ **Vapor containment units** – Part of vapor recovery system (see above)
	  ○ **Startup emission** – Part of EPA's requirement for states to improve startup, shutdown, and malfunction air emission provisions under the Clean Air Act (Beveridge and Diamond 2013).

Terminals	**EPA** • Fuel specs for RFG and ULSD **IRS and State Revenue** • Dyed diesel • Motor fuel tax exemption • Fuel merchant importer waiver **States** • **Gasoline fuel specs for ASTM** – The American Society for Testing and Materials (ASTM) D4814-13 specification describes various characteristics of automotive fuels for use over a wide range of operating conditions. It provides for a variation of the volatility and water tolerance of automotive fuel in accordance with seasonal climatic changes at the locality where the fuel is used (ASTM n.d.). • **Gasoline fuel specs for RVP** – Reid vapor pressure (RVP) is a common measure of gasoline volatility. EPA regulates the vapor pressure of gasoline sold at retail stations during the summer ozone season (June 1 to September 15) to reduce evaporative emissions from gasoline that contribute to ground-level ozone and to diminish the effects of ozone-related

[8] Each State is required by EPA to set up its own plan for implementing Federal Clean Air Act requirements; this is called a State Implementation Plan or SIP. EPA sets national standards, requirements or guidelines that the State then incorporates into State statute or administrative code. Once a requirement is established through State law, the State submits that to EPA in a SIP. Each State's SIP goes through a Federal approval, making those rules Federally enforceable. See, for example, Wisconsin Department of Natural Resources 2012.

Facility	**Waiver**

	health problems (EPA 2013b). States and counties can have their own RVP standards (EPA 2010).
	• **Home heating oil sulfur and biodiesel mandates** – In response to an EPA effort to reduce the sulfur content of diesel fuels, many states and local governments in the Northeast began proactively adopting higher biodiesel blends or low sulfur diesel (Amerigreen 2011).
	• **Air quality** regulations for:
	  ○ Vapor recovery
	  ○ Containment units
	  ○ **No Action Assurance (NAA)** – EPA and state emission standards for Hazardous Air Pollutants from industrial, commercial, and institutional boilers, including HVAC systems. NAA refers to non-enforcement of regulations at the agency's discretion, usually until a final rule has been set (Giles 2012).

Trucking	**Department of Transportation**

	• **Declaration of Regional Emergency** – DOT's Federal Motor Carrier Safety Administration (FMCSA), under Title 49 CFR Part 390.23, issued a Declaration of Regional Emergency Notice on October 28, 2012.
	• FMCSA coordinating with Federal agencies and states on emergency declarations, waivers, exemptions, special permits, tolls and other temporary authorizations related the flow of petroleum products to affected states, including:
	  ○ Driver Hours-of-Service
	  ○ Oversize and Overweight
	  ○ Low Sulfur Diesel Waivers
	  ○ **Toll** Waivers
	  ○ **Vehicle Registration** Waiver (International Registration Plan -- IRP)
	  ○ **Fuel Tax** Waiver (International Fuel Tax Authority -- IFTA)" (Federal Motor Carrier Safety Administration 2013).
	• **DOT-SP 15752** – DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA) issued a Special Permit on November 7, 2012, authorizing "the transportation in commerce of certain hazardous materials in support of the recovery and relief in response to Hurricane Sandy" (Pipeline and Hazardous Materials Safety Administration 2012).

	States
	• Weight limits • Importer/exporter license • Commercial truck registration • Interstate fuel taxes (IFTA and IRP)
Refineries	**EPA**
	• **Fuel specs for reformulated gasoline (RFG)** – RFG is gasoline blended to burn more cleanly than conventional gasoline and to reduce smog-forming and toxic pollutants. The RFG program was mandated by Congress in the 1990 Clean Air Act amendments (EPA 2013c). • **Fuel specs for Ultra Low Sulfur Diesel (ULSD)** – The cleaner diesel fuel program reduces sulfur content, creating immediate health benefits and allowing engine manufacturers to begin using advanced emissions control systems. The diesel program regulations are located in 40 CFR Part 80 subpart I (EPA 2013d).
	States (with EPA and IRS)
	States impacted by Sandy also waived some of their fuel specs, after being so authorized by EPA and IRS

Electricity

Superstorm Sandy caused massive electricity outages that affected 21 states from North Carolina to Maine. Though much of the damage was concentrated in New York and New Jersey, Sandy's impact was extensive:

- Nearly 10 million customers lost electric power during the storm, with a peak outage of about 8.6 million on October 30 and 31, and the Nor'easter's second attack created additional outages on a compromised infrastructure that further prolonged recovery.
- In New Jersey, Public Service Electric and Gas Company (PSE&G) lost 2 million out of its 2.2 million total customers at the highest point. PECO, which supplies electricity to Philadelphia and the surrounding areas, experienced record-breaking outages: 850,000 of the 1.6 million customers lost power as the storm hit, though the majority was restored within 24 hours as Philadelphia experienced limited damage and no flooding.
- The Long Island Power Authority lost 90% of its customers during the storm. Though line and pole damage from tree limbs and wind was widespread, it was substation and switching equipment flooding and extensive saltwater damage that made Sandy unique and substantially delayed restoration. Even underground lines sustained damage from flooding.
- ConEdison lost 975,000 of its 3.3 million customers during Sandy, and flooding at ConEd's East Manhattan substation cut power to about 250,000 customers for five days, creating a notably dark skyline and new nickname for the Manhattan neighborhood below 39th Street: SoPo, or South of Power.

Exhibit 25. Electricity Sector Highlights

- The storm sent water surging over flood barriers and into low-lying areas where many plant assets are located, inundating substations and causing significant damage.
- Electricity sector response was marked by unprecedented industry and government coordination headed by senior leadership. A Senior Assessment Team of government executives worked in the field to directly troubleshoot key issues, while a first-of-a-kind Federal Energy Restoration Task Force was created specifically to streamline power restoration and fuel availability. Electric utility CEOs participated in daily conference calls with EEI and DOE senior leadership.
- Electricity sector representatives were embedded in Federal, regional, and state EOCs, many for the first time. An EEI representative was headquartered at FEMA for 10 days during the response.
- The sector mobilized 70,000 utility personnel from 80 utilities across the nation—the largest dispatch of mutual aid in the U.S. electric system. DOE engaged three power marketing administrations to assist investor-owned utilities for the first time, and airlifted their Federal resources into hard-hit areas.
- Multi-state fleet movement to support mutual aid was slowed by uncoordinated permitting, waiver, and toll movement processes.
- The large force of responders meant that fuel requirements for utility crews increased dramatically while fuel shortages worsened.
- As utilities and regions better prepare for large storms, the cost and difficulty to secure mutual aid resources rises. For unpredictable storms, utilities now have to start earlier and cast a wider net to get the resources they need.

Exhibit 26. Example Electricity Grid Structure

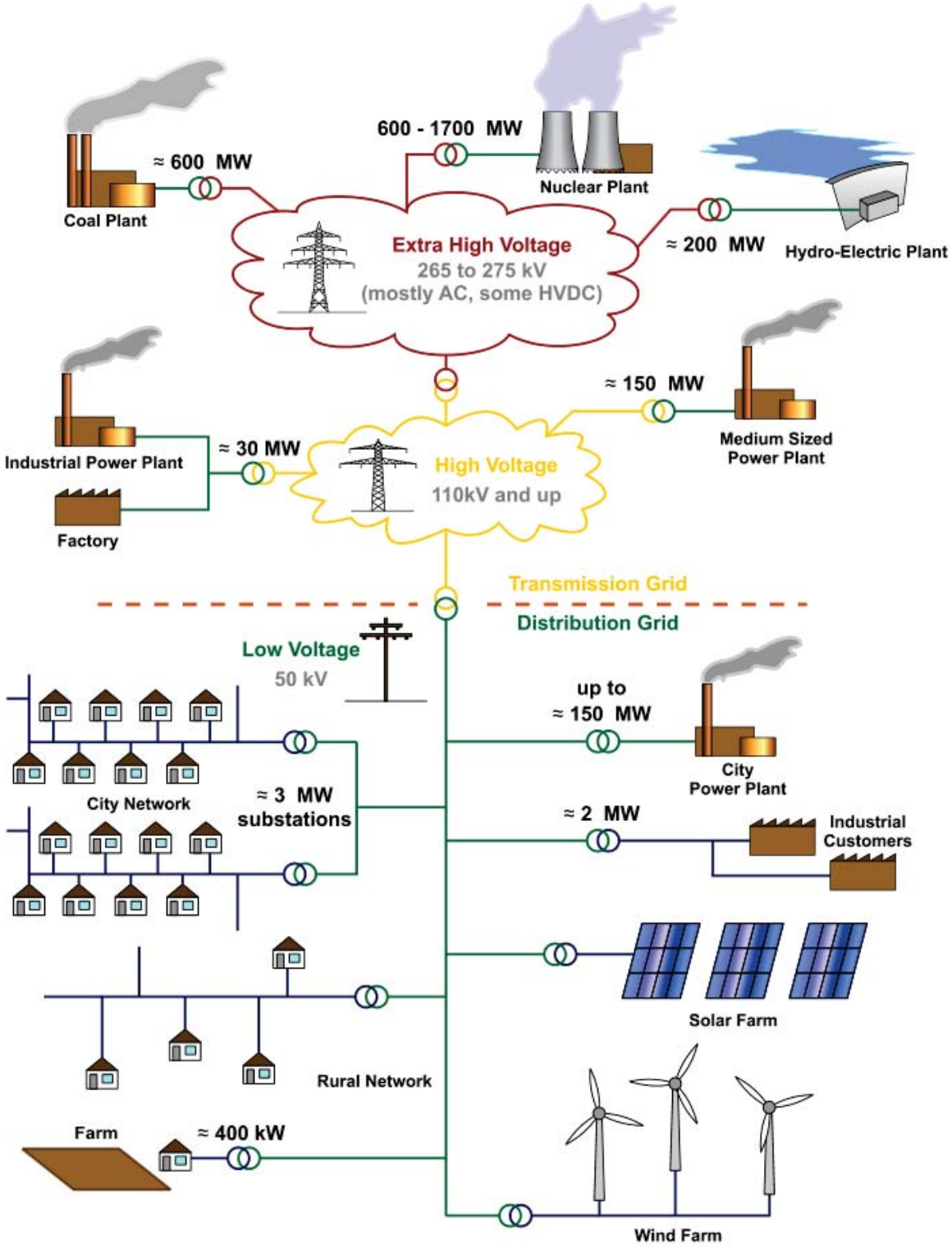


Diagram via Creative Commons.

Highlights of Planning, Response, and Recovery

Despite significant damage, an unprecedented response effort and extensive and coordination helped to speed electricity restoration in the region.

The sector mobilized the largest dispatch in history of mutual aid in the U.S. electric system.
About 70,000 utility personnel from 80 utilities across the nation assisted in recovery from Sandy. Despite significant damage, workers restored electricity to 99% of customers within two weeks. (By comparison, New York and New Jersey took 6-7 days to restore 95% of customers after Irene the prior year, but they experienced half the number of outages.) Utilities began mobilizing crews as early as five days before the storm made landfall in New Jersey. Almost every Edison Electric Institute (EEI) mutual assistance group was activated. Some utilities, however, faced challenges in bringing non-unionized repair crews on board. DOE engaged three power marketing administrations (Bonneville, Western Area, and Southwestern) to provide 235 personnel and roughly 200 pieces of equipment. It was the first time the Western Area or Southwestern Power Administration had provided mutual aid to investor-owned utilities through DOE's ESF-12 response, and the Department of Defense airlifted their equipment into the impacted region.

Task forces of senior Federal personnel increased public-private coordination and cut through red tape.
President Obama's "zero tolerance for red tape" was a catalyst for unprecedented senior-level engagement and public-private coordination.

- The president sent a Senior Assessment Team of government executives into the field to directly address and coordinate response on electricity sector issues. Members included the deputy FEMA administrator, a DOE deputy assistant secretary, a flag officer from U.S. Northern Command, and White House personnel.
- A first-of-a-kind Energy Restoration Task Force at FEMA's National Response Coordination Center (NRCC) specifically supported power restoration and fuel availability.
- Electric utility CEOs participated in daily coordination conference calls with EEI representatives and DOE senior leadership to improve situational awareness and facilitate resource deployment.
- Agencies such as DOE, DOT, and EPA worked directly with utility owners and operators, trade associations, and state officials to expedite waivers enabling repair crews to cross state lines and transport heavy equipment through disaster areas.

Utility personnel in some parts of New Jersey were classified as emergency responders for the first time.
This enabled electric utility personnel to jump to the head of fuel lines and removed access barriers to disaster areas for restoration crews.

The sector shut off power to critical equipment in the days before the storm to limit damage.
Utilities moved equipment out of flood zones, where possible, and preemptively shut down power to some stations to avoid critical equipment damage during anticipated flooding.

Recent regional investments in redundant and hardened assets within the electric *transmission* system limited Sandy's impacts; the storm mainly damaged the electric *distribution* system.
Transmission system impacts resulted mostly from loss of load as regional utilities quickly dropped from thousands of megawatts of load to merely hundreds. Utilities were in daily communication with the regional transmission organization, PJM, to coordinate and ensure sufficient voltage to bring back large lines.

Exhibit 27. A First in Response: Electricity Representation in the National Response Coordination Center

At President Obama's request, the Edison Electric Institute for the first time staged a representative at the FEMA NRCC for 10 days during Superstorm Sandy response. EEI represents 70% of the electricity delivered in the United States and plays a key role in convening senior-level personnel from investor-owned utility members and other trade organizations.

Direct, senior-level coordination enabled resource and asset movement that would not have otherwise been possible. Traditionally FEMA would be coordinating with individual utilities, without an established working relationship, to meet individual needs. The embedded EEI representative became a point-person that worked directly with representatives of FEMA, DOE, DHS, DOT, and DOD to achieve significant coordination successes, including:

- Military airlifting of resources and personnel from the West Coast power administrations to hard-hit areas on the East Coast.
- Working with U.S. Army Corps of Engineers to source sufficient pumps, generators, fuel, and heavy-duty fans to pump out and dry substations.
- Matching workforce expertise in mutual aid crews to primary needs of utilities.
- Obtaining the necessary permits, waivers, and lodging resources to move and house thousands of mutual aid personnel.
- Identifying and directing fleet crews to available fuel resources as fuel disruptions worsened.
- Sharing first-hand knowledge of electricity sector operations and restoration processes for FEMA and other agency personnel who could then better coordinate response in other lifeline sectors.

Response, Recovery, and Interdependency Challenges

Electric power provides a backbone of recovery in all other sectors. The electricity sector also depends heavily on the oil and natural gas and transportation sectors to resume service. Power restoration entirely halts without gasoline and diesel to fuel utility fleet vehicles. Utilities work with the transportation sector at the state and local level to coordinate de-energizing lines and debris removal to clear roads and provide access to areas where repairs are needed. Electric utilities also rely on communications networks to operate control systems and communicate with components and equipment at substations. Many utilities have begun investing in their own fiber to reduce dependencies on public networks. Superstorm Sandy overwhelmed the capabilities of electric utility owners and operators and highlighted key interdependency challenges.

Unprecedented flooding and damage surpassed flood barriers and exceeded utility expectations. Despite accurate weather predictions from NOAA, many owners and operators across multiple industries did not understand the full implications of the predicted surge. The storm surge came at high tide, sending 14 feet of water over flood barriers and into low-lying areas where many plant assets are located. PSE&G, for example, lost 31 substations to water inundation. Heavy debris, including downed trees, destroyed buildings, and displaced sand, created safety hazards that slowed response times and required coordination with the National Guard and state transportation agencies to speed removal.

Multi-state fleet movement to support mutual aid was slowed by uncoordinated permitting, waiver, and toll movement processes.
See "Delays in fleet movements slowed response and recovery of the lifeline sectors" in the Transportation section for further details.

Fuel requirements for utility crews increased dramatically while fuel shortages worsened.
For example, PSE&G utility crews typically consume 15,000 gallons of fuel per day, but that requirement jumped to 75,000 gallons per day during Sandy response. The utility also used 120 buses to shuttle crew members back and forth from job sites, further increasing needs.

Limited lodging for large numbers of out-of-state repair crews created a logistics challenge.
A limited supply of hotel rooms—due to both power outages and an increase in displaced citizens—created a lodging shortage for restoration crews from outside the area. Utilities were hesitant to house restoration crews working 18-hour shifts in tent cities. In some cases, they worked with nearby hotels to prioritize power restoration in exchange for guaranteed rooms for repair crews. When mutual aid workers for PECO finished restoring power in Pennsylvania, they began assisting utilities in New Jersey, but were advised to keep the hotel rooms they had in the Philadelphia area and commute two hours to New Jersey because lodging was limited.

Rate recovery for resilience investments is a political challenge, even after large storms.
Although public and political support is high for resilience investments in the immediate aftermath of a storm, that sentiment can quickly fade as time passes and rate hikes are discussed. Utilities need a clear cost-benefit case for resilience improvements in proposals to public utility boards.

Excellent preparation across a large area of potential storm impact ended up complicating mutual aid response.
Utilities built on lessons learned from Hurricane Irene, but found that preparation for forecasted events becomes harder and more expensive as the sector gets better at it. Utilities in the storm's path requested mutual aid resources several days prior to the storm to ensure they were staged throughout the region before the storm hit, yet found their typical partners outside the region could not give resources. As the storm moved up the East Coast, utilities in the South retained repair crews as a precaution until the storm passed them. Utilities also had to pay contract repair crews to stay within the region and refuse offers from other facilities up and down the East Coast. As the storm progressed, state regulations or declarations from public officials prevented utilities from releasing idle crews to other harder-hit areas in the region until all damage and every outage in the state was addressed.

Increased demand for accurate restoration estimates creates a communication challenge for utilities.
In the last decade, electric utilities developed advanced algorithms that give an estimated time to restoration (ETR) based on a one-fault problem, which gives a highly accurate prediction for routine outages. However, storm events create multi-fault situations that make the first-fault ETR accurate for some of the population, but not all. The only alternative, the global ETR for entire system restoration, provides an imprecise estimate that limits decision-making. At PECO, for example, the first-fault ETR predicted that 630,000 customers would be restored by Nov. 1; 550,000 customers were restored as predicted, and the remaining 80,000 were affected by secondary faults that the ETR system could not accurately account for. Giving customers the global ETR of seven days, however, could have created high demand on hotel rooms and shelter space that was unnecessary for more than 85% of affected customers. Without an accurate sense of when power will be restored, communities cannot plan response effectively; however, with insufficient understanding of utility operations, customers and public leaders increasingly demand highly detailed ETRs that utilities cannot meet.

Because of size, weight, cost, or technology age, replacement components may be difficult to source and deliver.
Temporary patches enabled by regulatory waivers often only offer a solution until emergency declarations are lifted. In addition, critical components such as transformers are prohibitively expensive for individual utilities to maintain as spares and have long lead times for emergency replacements.

Electricity Sector Lessons Learned

1. **Senior leadership and executive engagement substantially streamlined coordination and removed regulatory and jurisdictional red tape**. Initial reviews of new senior task forces indicate that effective coordination, resource movement, and communications would not have occurred without such high-level engagement.
2. **A multi-pronged communications approach** engaging customers, government agencies and leaders, and the media increases public confidence and helps dependent sectors make better restoration and recovery decisions. Utilities engaged government leaders and customers before the event to prepare them for outage expectations, and used a variety of social media outlets to provide continuous real-time updates directly to stakeholders.
3. **Priority sites for restoration are not the same for every event.** The time of year, weather conditions, and location and type of event can create new "priority sites" for electricity restoration. Sandy preceded the 2012 presidential election by only a week, making polling locations a high priority for restoration by Nov. 6. In Philadelphia, PECO scrambled to make a list of exact polling locations in the city and integrate them into the restoration planning process. As fuel shortages worsened in New York and New Jersey, gas stations became critical sites that supported restoration for multiple other sectors and critical facilities.
4. To better inform restoration priorities, **owners and operators need up-to-date information from emergency managers on which sites they consider critical**, why, and what level of backup power each critical site has. When every circuit is a priority, no circuit is a priority. Before an event, utilities need a list of sites that emergency managers consider critical to the region, downstream impacts of power loss to each site, and an estimate of how long each site can operate on its backup power.
5. **For unpredictable storms, utilities now have to start earlier and cast a wider net to get the resources they need** from partners outside the storm's path. As a result, owners and operators must make preparation decisions and mutual aid requests several days prior to the storm, when its strength and impact area can change dramatically. Regulated utilities must justify the significant costs of preparation when damage is not as severe as originally predicted.
6. **Designating electricity restoration crews as emergency responders** significantly improved their access to resources and necessary sites, reducing response delays.

Implications for Resilience

1. **Electric utilities recognize an opportunity to strengthen critical energy infrastructure and accelerate grid modernization** to improve flexibility and capabilities following Superstorm Sandy.
    - PSE&G proposed a $3.9 billion effort over the next 10 years to the New Jersey Board of Public Utilities for infrastructure investments that include: hardening more than 40 stations against storm surges by raising them, installing better protections, or relocating them; strengthening distribution lines; creating redundancy and advanced loop

schemes; investing in 100% private communications fiber (from 50%); deploying smart grid technologies to better monitor system operations and coordinate repairs; and increasing automation and control throughout the grid. Investments are now being negotiated with regulators, though PSE&G is going forward with the most critical upgrades before the next storm season.

- ConEdison made a $1.2 billion immediate investment post-Sandy to improve resilience for 2013's summer storm season. They are now proposing a $1 billion plan over the next four years to: build concrete flood barriers, install flood gates, and install submersible electronic equipment; redesign two underground electrical networks in NYC to enable smart grid capabilities that de-energize customers preemptively during floods and isolate outages to enable surrounding areas to retain power; and install hundreds of remote smart switches to isolate damaged equipment, among other resilience improvements.
- State standards for tree trimming would streamline pre-event protective measures and ensure universal best practices to prevent storm damage. In New Jersey, each municipality creates its own regulations regarding tree-trimming, creating a challenge for utility crews.

2. **Streamlining permit, waiver, and toll processes for fleet movement** offer some of the best opportunities to cut restoration time following an event. While crews have optimized pole and line repair processes within safety standards, a well-documented process can help repair crews recoup critical lost restoration hours to fleet movement delays. (See Transportation Sector Lesson Learned #4).
3. **Critical lifeline facilities and assets that rely heavily on electricity must maintain and resize their own backup generation to ensure continuous and reliable operations**. If a site is truly critical and highly dependent on electricity, owners and operators at that site must work with stakeholders to test and maintain backup power sources. Despite prioritization, electric utilities cannot guarantee a time to restore for any site. For example, critical hospitals frequently invest in redundant power lines from utility providers and have a backup generator for short duration outages. Sandy revealed that critical sites should have frequently tested generators and fuel supplies that enable the facility to operate without power for several days.
4. **Improved customer and stakeholder education and outreach before an event can help set expectations for restoration and recovery**. Utilities and trade associations can improve pre-event education to emergency management officials and large customers, including lifeline sector facilities, on sector processes such as pre-emptive shutdowns, damage assessment, and prioritization to increase understanding of electricity sector challenges and encourage individuals and businesses to make resilience investments.
    - Restoration challenges specific to the event should also be communicated as damage assessments are completed. In Sandy, flooded switching stations required cleaning every single circuit by hand, involving hundreds of personnel over several days before power could be restored.
5. **Joint regional exercises** offer one of the best options to identify needed improvement outside of direct experience with a disaster. See Oil and Natural Gas Resilience Implication #1.
6. **A nationwide inventory of equipment along with regional or national shared equipment programs for spare parts can help speed repairs after infrastructure damage and** share the high cost of resilience for large but critical components. A shared inventory can expedite the process of matching facilities with the right size and hookup for generators and identify gaps. For standardized components, including large transformers, shared inventory banks can reduce time spent to source and deliver parts, increase utility resilience across the region, and reduce

the risks associated with transformer replacement (including high cost, long lead time, and no U.S. manufacturing capabilities). EEI's Spare Transformer Equipment Program (STEP) can potentially be expanded or used as a model. Public and private stakeholders can also work together to standardize other components to encourage shared spares.

7. **Updated flood maps and weather prediction data, accompanied by widely accepted best practices,** will enable owners and operators to anticipate future risks and build or harden infrastructure to a best practice commensurate with risk.

Opportunities for Improvement

The following considerations are near-term opportunities to improve resilience in the electricity sector before the next disaster or large event.

- Formalization of the process for senior executive public and private engagement for resilience, including pre-event planning and post-event response.
- Removal of barriers to investment and creation of incentives for infrastructure resilience upgrades, such as equipment hardening and smart grid capabilities, in all lifeline sectors.
- A comprehensive effort at the Federal and state levels to review, refine, and streamline the process for issuing permits and waivers to the sector for multi-state fleet movement.
- Development of national guidelines and credentialing for re-entry of all crews for each of the lifeline sectors' emergency responders and utility personnel to critical sites within impacted zones.
- Provision for security to each of the identified lifeline sector repair crews during response to reduce theft and improve public safety, and examine options to provide housing facilities (on military bases or other government facilities) when other lodging options are scarce.
- Development or extension of nationwide spare parts inventories for the electricity sector and other lifeline sectors, including transportation.

Transportation

Superstorm Sandy triggered the largest mass transit disruption in U.S. history, impacting aviation, trucking, rail, auto, and public transit networks. Unprecedented flooding in subways and the tunnels between New York and New Jersey shut down access to Manhattan and created massive traffic gridlock. Power losses prevented railway signals, switches, and trains from running, and subway pump systems from functioning. The region experienced 2,000 miles of damaged or destroyed roads, 1,000 lost trucking rigs, 700 damaged cargo containers at its ports, multi-day shutdowns at major airports from flooding, and miles of damaged or completely washed away rail track. New York State alone suffered $7.3 billion in transportation-related damages.

While the largest transportation damages and disruption occurred in New York and Northern New Jersey, transportation was affected across the Eastern seaboard. Significant damage to Amtrak trains and flooding of the airfields of some of the busiest airports in the country shut down service, disrupting shipping and travel across regions. Four out of ten of the nation's transit riders had their commutes disrupted by the storm. Southeastern Pennsylvania Transportation Authority (SEPTA) service in Philadelphia was suspended for nearly two days during the storm and Regional Rail lines sustained damage and downed trees. All highways in and around Philadelphia were closed during the storm, along with the Philadelphia International Airport.

Exhibit 28. Transportation Sector Highlights

- Flooding damaged electrical and communications components and exposed new critical failure points. Most pumps lacked sufficient capacity to pump out water on backup power.
- Critical replacement parts for aging equipment were difficult to acquire, requiring Federal coordination to track down limited spares from other transit systems.
- Repair crews found that permit, toll, or weigh station delays, however minimal, can significantly delay response efforts. Repair crews relied on driver hours of service waivers and load permits for inter-state movement, which sometimes required a complex and lengthy request process.
- Many commuters relied on alternative forms of transportation, such as a large bicycle infrastructure, and rapid short-term recovery options, such as immediate ferry service. A massive bus bridge replicated disrupted train service between Manhattan and Brooklyn.
- Social media and digital communication were extensively used to communicate service changes with the public.

Highlights of Planning, Response, and Recovery

Although the transit systems of New York and New Jersey suffered significant damage, innovative response plans and actions alleviated disruptions.

Using lessons learned from previous storms, advance planning and coordination activities limited destruction and improved response coordination.

- New York City's Metropolitan Transportation Authority (MTA), the Port Authority Trans-Hudson (PATH) system, and SEPTA took proactive steps such as suspending service to avoid wind damage and protect customers, moving buses and rail cars to higher ground, and covering subway entrances and ventilation grates.

- Airport, airline, and Federal Aviation Administration (FAA) air traffic management personnel, the Transportation Security Administration (TSA), and Customs and Border Protection representatives held conference calls to plan for evolving weather conditions.

Exhibit 29. New York City's Regional Transportation Network

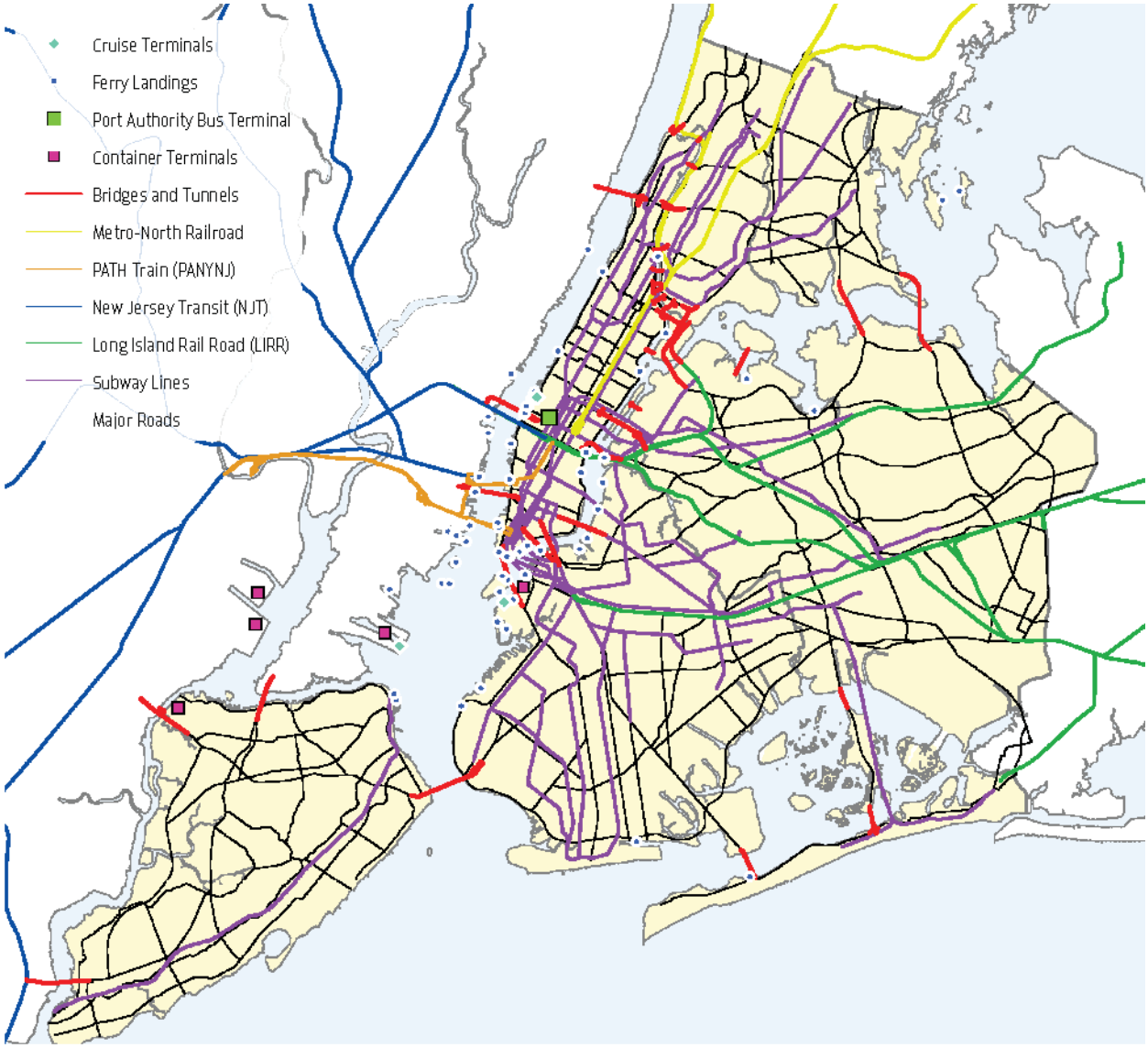


Diagram courtesy of the City of New York.

Massive bus bridges alleviated the impact of subway shutdowns.
New York's subways typically transport 5.3 million people daily. The New York Department of Transportation (NYDOT) and the MTA worked together to innovate a bus rapid transit system or "bus bridges" to replicate disrupted train service between Manhattan and Brooklyn. New temporary regulations restricted the Manhattan and Williamsburg Bridges for bus use only, regulated by the New York Police Department (NYPD). The city used 330 existing buses to transport 3,700 people per hour with three buses loading simultaneously.

Resourceful, multi-modal commuting and rapid recovery options provided needed flexibility.

- The city established emergency ferry service, including the rapid construction of new ferry landings, which are still in use for hard-hit areas, such as between Manhattan and both the Rockaways and Staten Island. Ferry usage also doubled following the storm on the East River Ferry, a recent expansion in the city's multimodal transportation network.
- A recent expansion in the city's bicycle infrastructure provided a new contingency option for commuters in Brooklyn and Queens, resulting in 30,000 bike commuters on Nov. 1—triple the typical number. The ability to get back to work quickly reduced regional economic impacts.
- Stewart International Airport, located about 70 miles from New York City (NYC), served as a logistics hub to bring in supplies for the region when LaGuardia and JFK airports were closed from flooding, even though the effort was not planned.

Transportation assets were used as warming stations and to support public safety.

Buses were used as warming stations at six locations in New York City to accommodate residents without heat, and were also used to transport residents to local shelters at night.

Social media and digital communication were extensively used to communicate with the public.

- The MTA adjusted service maps online and communicated all updates to bus, subway, commuter rail, and bridge and tunnel service via a multi-channel information push; it also posted pictures and videos of the damage to help the public comprehend the severity.
- New Jersey Transit offered free park-and-rides, shuttle buses, and ferries into Manhattan to mitigate congestion on open bridges and tunnels, and alerted customers via its website and updates on Twitter, Facebook, and the "My Transit" e-mail alert system.
- Commuters connected with other drivers and passengers through neighborhood networks, picked up strangers, and shared taxi rides using social media to help meet HOV-3 restrictions.

Transit agencies prioritized restoration of service and coordination to support other critical sectors.

Transit agencies followed restoration prioritization protocols designed to restore service first to major transit arteries and densely populated areas.

- Throughout the storm, both New York and Philadelphia ran underground trains (where possible) to transport healthcare employees and lifeline sector responders while enabling transit system assessments.
- After any storm, Philadelphia's public transit agency prioritizes restoration to the heart of the system, so that main east-west and north-south arteries can restore service immediately.
- Transit agencies give contracts for brush cutting and other cleanup to the same contractors both during disasters and normal operations, encouraging those contractors to turn down offers from private companies who may pay 2–3 times more than the city during storm recovery.
- To identify and prioritize roadway clearing, transportation agencies worked directly with county 9-1-1 operators, who coordinated dispatch of security and debris clearing crews.
- JFK airport had a fuel supply that was used to support first responders in the New York and New Jersey area.

Response, Recovery, and Interdependency Challenges

The transportation sector depended heavily on the electricity and petroleum subsectors to resume service. Switching stations and control centers required the restoration of electric power, while repair crew vehicles, buses, and aviation service vehicles all needed reliable fuel sources.

Electricity outages disabled railway signals and switches and eliminated floodwater pumping systems.

- The New York City subway system has its own pump system for normal drainage, but pumps do not have dedicated backup generators. Spare generators brought in could not provide sufficient power to prevent total flooding in some locations.
- Flooding closed airports in the region for days. There was more than 15 million gallons of water on the LaGuardia airfield, and five pump houses had no electricity or backup generation. Clearing flooded airfields became a large challenge.

Extensive flooding damaged critical equipment and exposed new failure points.

Unprecedented levels of flooding, exceeding historical predictions and flood barriers, sent brackish water from the Hudson River and salt water from the ocean surging into major vehicle tunnels and subway tunnels and stations throughout the area.

- Subway tunnels and depots for both subway cars and buses in New York City lacked sufficient protections against flooding and capacity to pump out water, which damaged electrical and communications components and aging systems.
- The storm surge exposed new critical failure points, such as stairwell entrances to subway tunnels and street-level gratings, which were overwhelmed by flooding.
- Once flooded tunnels were pumped, personnel had to manually clean, inspect, and repair electrical and electronic components, including signal systems, the electrified third rail, communications, pumps and vent systems, and fare gates.
- Salt water deposits corroded equipment that then could not be cleaned on site due to the potential for short circuiting or fire from the conductivity of the salt. The equipment had to be taken elsewhere or replaced entirely, a process slowed by a lack of power and fuel.

Critical replacement parts for aging equipment were difficult to acquire.

- New York's 108-year-old subway system has unique and outdated parts that require extensive time and high costs to replace, leading to longer than anticipated shutdowns.
- During repairs, MTA used more than 80% of its equipment inventory, nearly exhausting replacement supplies, while PATH had to seek replacement parts from partners including the U.S. Department of Transportation (DOT) and the Federal Transit Administration (FTA), as well as companies from as far as Louisville, KY; Pearl, MS; and Pittsburgh, PA.
- At the request of PATH, GE opened a plant in Puerto Rico specifically to manufacture replacement parts that haven't been available for years.
- Custom-designed parts on NJ Transit trains made damage difficult to repair.

Delays in fleet movements slowed response and recovery of the lifeline sectors, especially electricity.

Sectors that used mutual aid assistance from repair crews outside the affected area relied on emergency waivers of driver-hour limits and minimum rest periods, and rapid load permitting for inter-state movement to speed response and recovery.

- Repair crews found that permit, toll, or weigh station delays, however minimal, significantly delayed response efforts. For example, depending on the time of day, a two-hour delay in fleet movement can effectively delay that crew from beginning restoration work for 24–48 hours, depending on whether they can reach their subsequent destinations before hourly fatigue limits are reached.
- Crews must obtain load permits, which vary from state to state, for inter-state fleet movement. While emergency declarations may automatically lift some restrictions, state governors rarely declare states of emergency several days before an event, when mutual aid crews are first dispatched. When passing through a state, some fleets had to stop at multiple weigh stations,

even when their load had not changed. Requirements also differ for crossing a state vs. entering the state as an endpoint.
- Digital transponders to pay electronic tolls were needed in advance for every fleet vehicle. One utility fleet had to go through a cash-only toll en route to New York City, creating a delay to procure small bills and correct change for a fleet of drivers. A more efficient method of charging tolls would reduce fleet delays.
- Obtaining permits and toll transponders prior to response requires advance warning. Coordination in advance of Sandy helped smooth transit, but this prior warning would not be available for no-notice disasters.

Unexpected levels of flooding shut down airports and negated pre-emptive relocation of equipment to higher ground.

- Rail systems, which store rolling stock on high ground to avoid flood damage, saw some of these designated areas flood as well. In New Jersey, rail equipment was placed in more than 20 locations around the state based on information NJ Transit received about the likelihood of flooding and historical experience. Relocation decisions had to be made 12 hours prior to the storm and it was too late to execute a full system shutdown once flooding worsened.
- Personal automobiles in low-lying city streets were destroyed by flooding and could not be quickly moved.

Fuel shortages made the repair and refueling of transportation vehicles difficult.

- DHS informed aviation officials that nearby military bases had an ample supply fuel for airport ground vehicles, used to move employees onto planes and to service and fuel planes, but red tape prevented the public sector from providing fuel to the private sector, and the lack of fuel slowed airport service.
- Without adequate fuel, repair vehicles could not reach buses and rail system assets in need of repair, further delaying transit service restoration.

Lack of real-time or accurate information about road conditions led repair crews to avoid open roads.

- The 511 system that many states use to track road conditions and closures on Federal and state highways was rarely accurate or timely enough to be fully reliable.

Transportation Sector Lessons Learned

1. **Lessons learned from Hurricane Irene the prior year were effectively applied** during Superstorm Sandy. Rail cars and automobiles were moved to higher ground, and operators preemptively shut down electronic equipment to avoid damage. Relationships built during Irene were successfully used again during Superstorm Sandy.
2. **Aging portions of mass transit systems rely upon critical parts and equipment** that are no longer manufactured, and for which spare parts are not widely available. A scramble to locate spare parts within other agencies delayed repairs, and this problem will only become greater as remaining spare parts are depleted.
3. **Existing FEMA flood maps** and National Oceanic and Atmospheric Administration (NOAA) SLOSH (Sea, Lake, and Overland Surges from Hurricanes) maps for transportation and other critical infrastructure, and the associated failure predictions, **may no longer be accurate.** Rising sea levels, larger and more frequent storms, and altered drainage patterns due to new construction mean that flood walls may no longer be high enough, and new potential failure points may emerge.

4. **Employee coordination and communication can be hampered by transportation and communication outages.** One system paid employees round the clock to be housed on the property during and after the storm to facilitate immediate recovery. While costly, personnel protocols put in place prior to a storm ensure the availability of personnel resources.
5. The FTA's Emergency Relief Program's 24-month **deadline for spending recovery resources is too short for many transit systems to plan coordinated resilience investments** to occur alongside infrastructure repairs and hardening funded by the Relief Program. There is a missed opportunity to build resilience into infrastructure components that both did and did not break.

Implications for Resilience

1. **Streamlining waivers, permits, and toll payment** is needed to speed response and recovery following a disaster. Superstorm Sandy drew utility repair crews from states far outside the region, requiring extensive coordination across multiple states to enable smooth fleet movement. Superstorm Sandy revealed potentially innovative solutions that can be improved for future disasters. The All-Hazards Consortium is working this issue regionally and may offer best practices that can be replicated across the country.
    - **Tolls:** Nationwide or regionally consistent toll booth procedures may remove roadblocks and simplify payment processes. Electronic toll systems are moving toward universal transponders within regions. Easier options to move fleets through tolls may exist. The East Coast's EZ-Pass system has the ability to assign numerous license plates to one account, and uses photos of the license plates as a backup system to charge an account when a transponder is missing or broken. If coordinated, this process could be the primary process for charging fleet tolls for emergency fleets, avoiding the need for transponders altogether.
    - **Automated permitting:** Improved private sector access to automated permitting systems can speed fleet permits. The Pennsylvania Department of Transportation's (PennDOT) Automated Permit Routing/Analysis System (APRAS) and a similar system in New Jersey automate permit issuing to reduce processing time. New Jersey is exploring how to issue advance yearly permits for utilities that have standard equipment and loads.
    - **Centralized database for mobilization information:** Utility fleets would benefit from a centralized database that includes state/local permitting requirements, toll road and payment protocol information, and updates on where emergency declarations have been issued and which waivers are put in place as a result. Template procedures for issuing permits and waivers can also be shared in this database.
2. **Near-term and long-term investments in resilient infrastructure can better prepare for all hazards**. Transit agencies have identified system improvements, including the following:
    - Relocate key data centers outside of flood zones and build redundant or backup control centers to transfer operations if one is damaged.
    - Design reusable watertight coverings for vents and electronic equipment in the short term, and even rebuild with submersible components in the long term.
    - Engage with surrounding counties to responsibly plan drainage from new developments, such as shopping malls and parking lots, to decrease drainage around critical infrastructure.
3. N**ew modeling tools—with updated climate change and flood predictions—can help regions revise system-wide risk assessments and identify new and future failure points**. For example,

New York is re-examining the subway system using NOAA SLOSH maps to build more accurate flooding and failure predictions that consider changing street elevation and potential surge heights. This study is revealing new critical failure points, such as stairwells and entrances that caused the majority of subway tunnel flooding, where agencies can prioritize future hardening.

4. **A nationwide spare parts inventory** can help speed repairs after infrastructure damage to transportation systems. See the Electricity Sector Resilience Implication #7.
5. **FTA's Emergency Relief Program funding could be re-structured in a way that promotes well-planned resilience improvements.** Recipients are required to spend out relief funds within 24 months of receipt, making it difficult to design a coordinated plan to rebuild smarter and harden equipment, not simply repair it. It could also better enable system-wide equipment hardening, not just hardening of parts that sustained damage.

Opportunities for Improvement

- NOAA and other Federal agencies can provide updated weather data, SLOSH maps, climate change data, and guidance on performing engineering studies to help systems identify critical failure points and revise system standards and hardening for extreme weather events, storm surge, sea level rise, and seismic events. The Federal government can use results of its current climate adaptation study on seven transit agencies across the U.S. (including SEPTA) to determine the type of data transit agencies need to improve adaptability.
- The Federal Transit Administration could leverage its role in coordinating and facilitating mutual aid between transit systems to create a nationwide shared inventory of replacement components for aging systems.
- Emergency Relief Program requirements can be revised to promote not only repair, but system-wide hardening and replacement with more resilient equipment.

Communications

The communications sector comprises all cable, satellite, telephone (including 911 emergency lines), and internet services that government, emergency personnel, private businesses, and the general public rely on to communicate and obtain real-time information on a daily basis. During Superstorm Sandy, service disruptions were reported in 158 counties and 10 states stretching from Maine to Virginia, including Pennsylvania and the city of Philadelphia. At one point, approximately 25 percent of cell sites across these affected areas were out of commission and some 911 emergency call centers were disabled. All major cell service providers, including AT&T, Verizon, Sprint, and T-Mobile, reported significant disruptions and major broadband internet and cable operators, including Cablevision, Comcast, Cox, and Time Warner, also reported varying levels of disruption.

Exhibit 30. Communications Sector Highlights

- Not all cell tower sites had backup generators during Superstorm Sandy. One company reported there are generators on about half of their towers, and that those with generators have an average of 1.3 generators per site with limited sharing between providers.
- Where generators were present, fuel shortages impacted the ability to provide backup power for long periods of time to cell towers, antennas, and other radios.
- Mobile cell platforms and satellite communications vehicles successfully replicated basic service in hard-hit areas, enabling communities to support their own restoration. Network providers worked well with state governments to provide cell on wheels (COWs) and cell on light trucks (COLTs).
- Satellite communications kept incident response communications open and enabled hard-hit areas to restore basic communications more quickly. One company worked with FEMA months prior to Superstorm Sandy to prepare for such an event, and had 100 satellite terminals and Wi-Fi stations pre-staged with a first right of refusal for FEMA.
- Restoring wireless service was greatly enhanced by co-location of government and communications providers to coordinate on power, fuel sources, and debris cleaning.
- Strong relationships with state and local government officials reduced access control issues for telecommunications first responders.

In harder-hit areas like New York and New Jersey, the damage to the communications sector was even more substantial. Verizon's Vice President of National Operations Chris Levendos called it "the largest impact to our wireline infrastructure in our 100-year history" (NOVA 2013). At the peak of disruption in New York City, Long Island, and Westchester, more than half a million wired telephone lines were out of service and between 15 and 60 percent of wireless service networks were inoperable, with nearly 3,500 cell sites knocked offline. While many of these service outages were linked to commercial power outages, other issues arose from fallen trees knocking out overhead wiring; flood damage to central switching offices, customer equipment rooms, and backup generators at data centers; limited to no backup power due to damage and refueling issues; and corrosion of copper cables—even those underground—from exposure to saltwater. A Barclays' analyst estimated cleanup and repair costs for communications companies to be around $600 million in the hardest hit areas alone.

Exhibit 31. Components of the Communications System

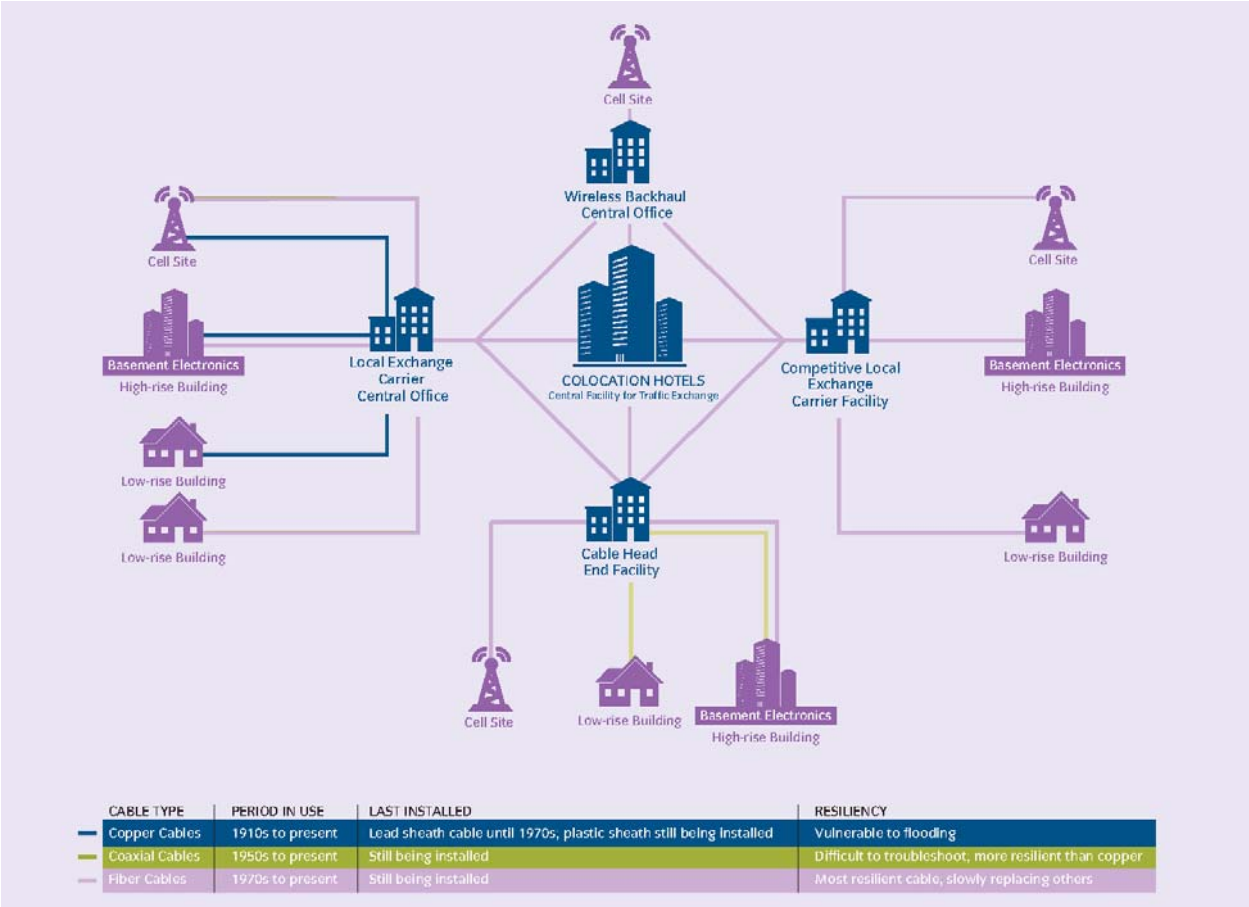


Diagram courtesy of the City of New York.

Highlights of Planning, Response, and Recovery

Despite the damage and service outages that the communications sector experienced during Superstorm Sandy, few areas reported complete outages or fully overwhelmed networks. This success is due in large part to the sector's planning, coordination, and on-the-ground response.

Staging fuel and repair equipment in advance facilitated faster restoration times.
Companies pre-staged repair trucks, extra poles, and fuel pods throughout the storm's projected path, and set up refueling stations throughout and around New York City immediately after the storm. Providers used satellite phones and obtained wireless priority service (WPS) and government emergency telecommunications service (GETS) credentials in advance.

Satellite communications experienced limited or no disruptions, maintaining critical services for incident responders and enabling harder-hit areas to restore basic communications more quickly.

- Lifeline sectors and emergency responders relied on multiple backup communication methods, including satellite phones and point-to-point radios, which greatly reduced the impact of traditional communications failures in the immediate aftermath of Sandy.

- Satellite company Hughes Network Systems started working with FEMA months prior to Superstorm Sandy to prepare for such an event. As a result, they had 100 satellite terminals and Wi-Fi stations that they pre-staged with a first right of refusal for FEMA.
- Hughes provided satellite systems to the Rockaways, which had little or no communications, and worked with Global VSAT Forum and Cisco to establish a satellite communications capability for a Habitat for Humanity command center in Breezy Point.
- The Red Cross relied on satellite communications in the immediate aftermath when cell service was unavailable and spotty.

Mobile cell platforms and satellite communications vehicles provided much-needed service to the hardest-hit areas.

- The New York State Department of Homeland Security worked with wireless providers to deploy cell on wheels (COWs) and cell on light trucks (COLTs), satellite communication vehicles, and charging stations and position them near central distribution sites and community centers.
- FEMA helped New York State troopers locate and acquire a Mobile Communications Office Vehicle (MCOV) that was able to support cellular, audio, and video communications through a satellite, with its own independent power source, to enable communications from Long Island.

Exhibit 32. FEMA's Innovation Team in Red Hook, NY

Superstorm Sandy saw the debut of FEMA's Innovation Team, a multi-sector, cross-functional group of creative problem solvers made up of government, industry, non-profit organizations, and community volunteers. The Innovation Team is designed to look at response problems from a broad perspective, rather than by agency or sector, and use its agility to quickly solve large, localized problems on the ground.

The Innovation Team reached out to networks and volunteers to restore critical needs in hard hit areas like Red Hook, NY, where one of 40 FEMA Disaster Recovery Centers had been established in the state. Using its members' personal and professional networks, the team linked up with IT volunteer organizations and skilled community volunteers to establish a mesh Wi-Fi network in a popular neighborhood courtyard and establish a satellite communications link. These connections not only enabled the community to contact family and apply for disaster assistance, but restored the community's ability to support its own response and recovery. FEMA Community Relations members and FEMA Corps volunteers went door-to-door with wireless-enabled tablets to help residents sign up for disaster assistance, educate them on available resources, and assess neighborhood needs. The Innovation Team enabled FEMA to tap into resources and expertise outside the agency and support a whole community approach to response.

Government-owned emergency alert networks maintained functionality and provided multiple avenues to communicate with the public.

- The Federal Communications Commission developed systems to send wireless emergency alerts to people in affected areas, facilitate "text-to- 911" on mobile phones, and improve location accuracy for mobile 911 so emergency personnel could quickly locate people in need.
- New York City operates its own CityNet, a network of city-owned fiber, its own wireless network, "NYCWIN," and its own 800MHz and other radio networks, which it used to issue emergency alert text messages before, during, and after Superstorm Sandy.
- Where cellular services were unavailable, point-to-point radios kept emergency responders in contact.

Internet Protocol (IP)-based and next-generation technologies, where used, increased the reliability of 911 services.

- Pike County, PA's new 911 system experienced no outages, even though it was out of primary power for almost a week. The new system employs a failsafe that links two facilities with fiber, enabling one center to take over for the other or handle overflow in mass call events.
- The City of Long Beach completely lost the ability to receive 911 calls locally, but was able to route 911 calls to Nassau County and through the Nassau County mobile command bus back to Long Beach. While fiber was more reliable, the extent of outages in some cities overwhelmed redundancies and re-routing capabilities.

Wireless service restoration was enhanced by information sharing between government and communications providers on power, availability, fuel sources, and debris cleaning.

- Communication providers held multiple daily calls with or a seat in New York State's emergency operations center and used real-time outage reporting protocols. Providers had a seat at the regional operations center in Hamilton, NJ to address two-way needs. Government officials provided front-end loaders to clear debris for network providers, who in turn provided mobile cell units to state governments.
- FEMA provided access to vehicles, used on Long Island, to gauge the coverage and strength of signals and provide outage reports to providers and state responders.
- The DHS National Coordinating Center for Telecommunications (NCC) and Information Sharing and Analysis Centers (ISACs) facilitated coordination as practiced during joint exercises at the Federal, state, and regional levels.
- Verizon trained field forces and developed protocols to communicate with municipal officials, which greatly improved coordination in New Jersey's more than 500 municipalities.

Strong relationships with state and local government officials reduced access control issues for communications first responders.

- Thanks to prior relationship-building efforts with the NCC, FEMA, and the state and local governments, providers worked with local officials prior to the storm to pre-determine access protocols to damaged areas.

Coordinated repairs of co-located assets between electric utilities and communications companies sped up restoration of both services.

- Safety concerns typically require that electric utilities remove live wires and complete repairs before communications providers repair lines on shared poles or assets. Because of the sheer magnitude of damage, this process slowed restoration times for companies such as Time Warner Cable, which worked with utilities to develop mapping software that showed where power had been turned off, clearing the way for Time Warner to begin repairs. When Time Warner reached an area first, they put the electric poles back, and vice versa, using a collective agreement.

Systems upgraded to fiber sustained less damage.

Verizon customers on fiber optic cable in lower Manhattan had their services restored immediately after the switches came back up. Verizon owns most of the fiber backhauls in the city, which also stayed up.

Response, Recovery, and Interdependency Challenges

The increasing dependence on communications by not only the general public but other critical sectors made the loss of communications a large barrier to response and recovery. Just as the communications sector relies on electricity for individual devices, antenna towers, central offices, switches, and other sophisticated equipment, the electricity sector relies on wireless communications to operate control systems and new smart grid technologies. To produce backup electricity for its essential services and efficiently repair damaged lines, communications providers also rely on the fuel and transportation sectors to reach generators at cell towers and enable repair crews to access hard-hit areas, just as these sectors rely on mobile devices to coordinate these efforts.

The loss of commercial power and subsequent lack of backup power caused service outages.

- A company that leases towers to cell service providers said that there are generators on about half of their towers, and that those with generators have an average of 1.3 generators per site with limited sharing between providers.
- Generators for cell towers are not required by law, are costly, and face some restrictions from zoning laws, clean air and water regulations, noise restrictions, hazardous material storage regulations, and Occupational Safety and Health Administration (OSHA) requirements.
- Where generators were present, fuel shortages limited the ability to provide extended backup power to cell towers, antennas, and other radios.
- Companies had to rely on their own fuel supplies and fuel networks, pulling on their national contracts to get fuel from outside the region. They experienced licensing issues, challenges to find fuel providers who could move fuel into cities, and required waivers for fuel trucks to cross state lines.
- Storm debris and flooding complicated access to generators in the field, some of which were destroyed by the storm. In some cases, local zoning laws restricted carriers from bringing in supplemental emergency generators.
- Repair crews were sometimes denied access to cell sites, which combined with fuel issues delayed expected times for restoration.

Damage to copper backhaul, overhead lines, and central offices delayed service restoration.

- The copper backhaul on which all cell towers depend was devastated by corrosion from saltwater, particularly in lower Manhattan. Following the storm, Verizon removed 150 tons of old copper cable from lower Manhattan and replaced it with 6,500 miles of fiber.
- Outside of New York City, downed trees took out overhead communications lines.
- Verizon experienced flooding of its central offices in lower Manhattan, damaging and corroding lines, switches, and servers located in subterranean rooms and lower floors. Time Warner Cable also had some impact on their hub sites that distribute services.

Communication gaps between key players made agile response difficult.

- Providers share poles and conduits with power companies, making non-coordinated responses slower and less efficient.
- Without strong relationships or prior points of contact at local carriers, the city of Long Beach struggled to individually contact carriers through 800-numbers and wasted time speaking with unknowledgeable customer support personnel, eventually flagging down a tech off the street, in a week-long attempt to secure cell on wheels. Though Verizon had an account manager assigned to Long Beach, communication breakdowns and impassable streets delayed the delivery of two COWs, which arrived within five days.

Communications Sector Lessons Learned

1. **Backup generation and fuel supplies for critical assets, especially cell towers, were insufficient to maintain reliable communications service**, a key element of coordinated response and recovery. Generators, where they existed and were operational, typically had only eight hours of fuel available. Refueling was difficult due to closed roads and fuel shortages, and some assets were not fully prepared to maintain service through extended power outages.
2. **State and local zoning restrictions, noise codes, and restrictions for hazardous materials storage discourage or sometimes prevent utilities from obtaining backup generators.** Though shared agreements with local governments have successfully created exceptions to local zoning laws for emergency generation, there is no requirement for backup generation for communications assets, and it is up to providers to seek the right permits or challenge zoning laws. Companies rarely share generators at this time.
3. **Efforts to source backup fuel from outside the region were slowed by Federal and state restrictions that prevented suppliers and distributors from crossing state lines.** Pre-issued waivers, permits, contracts or mutual aid agreements with the state could have sped this process.
4. **Mobile cell platforms and satellite communications units enabled communities to mobilize for response and recovery even when commercial power and communications services were unavailable.** Communications services are a force multiplier that enable community groups to leverage social networks to share information and support recovery. While in some cases it was difficult for mobile units to physically reach harder hit areas, pre-staging was effective. To pre-stage, states had to first request FEMA satellite resources under emergency declarations. Removing this barrier could help expedite the ability to mobilize units.
5. **Prior investment in fiber cable and undergrounding for resilience paid off.** On the same streets in lower Manhattan, tons of copper cable was corroded by saltwater, while fiber lit back up once switches came back online. Even above ground, fiber did not break as often as copper.
    - **Many providers are moving customer equipment, such as servers, switches, routers, and hubs, out of basements and into higher levels above the flood line.** Many providers who also experienced flooding in their central offices are also adjusting their layouts accordingly.
6. **Coordination between the electricity and communications sector facilitated a faster, more efficient response.** When cable companies and power providers coordinated on repairs, they were able to canvass larger areas more quickly by repairing shared poles. Communicating real-time information about outages to one another via government agencies worked well, but in some cases, gaps existed. Direct relationship building and coordination is needed.
7. **Strong relationships between service providers and state and local government improved coordination ahead of and during the event and reduced access issues.** Many companies assign individuals to coordinate with state government and public utilities commissions, and designate account managers to coordinate with cities. Representatives embedded in state and local Emergency Operations Centers (EOCs) can further improve situational awareness and coordinated restoration.

Implications for Resilience

1. **Providing sufficient backup generation, fuel services, and other capabilities to maintain at least a minimum level of voice and texting capabilities during emergencies is imperative**. Following disasters, wireless voice service and messaging is a primary method of communication

for the general public, emergency response agencies, and disaster relief organizations. Service providers and their state and local partners need to recognize the importance of communications to life safety and recovery and remove barriers to investment in redundant and backup capabilities.

- State and local emergency operations centers and 911 call centers should prioritize investment in backup and redundant connections with their local service providers.

2. **State governments and FEMA can work together ahead of events to resolve fuel transportation issues from regions outside the disaster area.** See Oil and Natural Gas Lesson Learned #1.
3. **Investment in redundant and hardened infrastructure can improve maintenance of critical functions in all hazards**.
    - Path diversity is critical. Satellite is fast, but expensive and not a cure-all. A mix of wire line, radio, cell, and satellite for critical sites provides redundancies for multiple hazards.
    - The use of fiber and undergrounding, while expensive, paid off and prevented much wider service loss and expensive damage.
    - Backup power is imperative, and enables the sector to be relatively self-reliant despite extended power loss. Providers are considering:
        i. Increasing state and local government coordination to remove barriers to adding backup generators
        ii. Investing in fuel cell generators that offer more reliable, long-term power
        iii. Developing technologies that use less power
        iv. Sharing backup power sources with other service providers
        v. Connecting to natural gas lines for supplemental power generation
    - Mobile cell platforms and satellite units are essential to life safety and recovery in areas with extended outages of critical services. Pre-staging can be improved.
4. **Cooperation, and potentially co-location, among service providers can provide network and data center redundancies.** Private companies rarely share resources, often because of collusion laws, but there is little mutual aid within a region as a result. Stakeholders can review existing regulations to identify opportunities to:
    - Share critical equipment, such as switching facilities, during an event where providers incur equipment damage.
    - Place multiple antennas on the same tower and co-locate some cell sites to provide redundancies among carriers.
    - Use a geographical information system to strategize resource co-location during planning, and enable real-time coordination of repairs.

Opportunities for Improvement

- FCC leadership can recommend or mandate best practices for backup generation or redundancies that enable a minimum level of voice and texting capabilities for the public during emergencies.
- The Federal government can recommend to state and local governments that waivers for local zoning laws be issued to communications providers for backup generation.
- FEMA can continue to serve as a coordinator and convener between communities, local governments, NGOs, and service providers, using its coordination in Red Hook, NY as a best practice.

Water

Excessive flooding from Superstorm Sandy devastated wastewater treatment plants in New York and New Jersey, sending more than 1 billion gallons of untreated or partially treated sewage into local waterways in the days following the storm. Of the 14 wastewater treatment plants operated by New York City, 10 had sewage releases, and 42 of 96 pumping stations that serve wastewater plants lost service due to damage or power outages.

In New Jersey, more than 200 million gallons of water from the tidal surge engulfed one of the largest wastewater treatment plants in the United States operated by the Passaic Valley Sewerage Commission. The 152-acre plant stood in four feet of water (with 15–30 feet of flooding in underground systems), sustained damage to critical machinery, and lost power for three days. Extensive dewatering of sewage sludge and critical repairs to bring the plant back to operation cost an estimated $200 million—about $50 million more than the commission's total annual operating budget.

Wastewater pumping stations at New Jersey's Middlesex County Utilities Authority were totally devastated, requiring a month of repairs before the system could handle all of the sewage sent to it. In Philadelphia, water utilities did not sustain damage, but had to quickly shut down valves and pipelines to preserve water pressure when electricity was lost at the Queen Lane Plant. Power was restored when the winds fell below 45 mph, just in time to avoid problems with the morning's peak water usage. Water utilities did a remarkable job maintaining potable water supply and distribution in the immediate aftermath; however, wastewater treatment utility damage presents an ongoing environmental hazard to affected regions. While immediate and short term water service losses are typically not critical, flooding of treatment plants from stormwater and tidal surges; power losses that result in pressure losses and the backflow of water in pipes that typically flow one direction; and sewage overflows due to flooding can all result in environmental damage in local waterways and lengthy treatment plant shutdowns that may delay recovery weeks after an event.

Exhibit 33. Water Sector Highlights

- Limited recognition of water and wastewater criticality resulted in service impacts that likely could have been mitigated and created "near miss" events. Utilities faced a lack of support for backup power and fuel requests from emergency managers who did not understand the cascading impacts of potential disruptions.
- Electricity restoration challenges were not well understood by water sector owners and operators. In some cases, electric utilities were unable to pinpoint outages affecting critical water assets without knowing which meter numbers and circuit numbers had lost power.
- Federal regulations restrict the use of very large, capital-intensive backup generators to emergency events, eliminating incentives for water sector owners and operators to invest in them.
- Despite credentialing efforts, water utility workers were often not considered emergency personnel, and faced difficulty in accessing critical facilities to assess and repair damage.
- Regional water utilities have strong relationships that facilitated coordination. Potable water utilities in northern New Jersey have interconnected pipelines and can provide service to another utility's customers—a feature unique to this region of the country.
- City planners and water and wastewaster owners and operators need detailed data on forecasted impacts of climate change—especially sea level rise—that could increase infrastructure risks during storm events.

Exhibit 34. The Water and Wastewater System in New York City

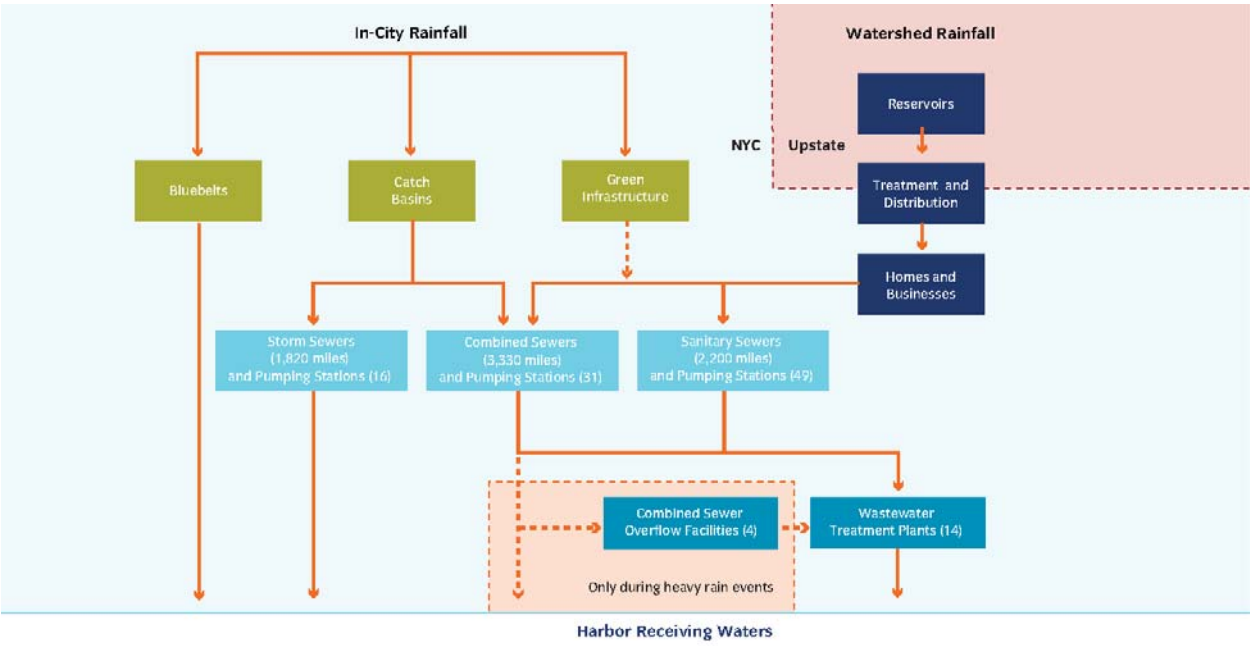


Diagram courtesy of the City of New York.

Highlights of Planning, Response, and Recovery

Multiple Water Agency Response Networks (WARNs) in nearby regions activated to provide mutual assistance to facilities in the impacted region.

When needs exceeded intrastate WARN capabilities in hard-hit states, facilities requested assistance from other state WARNs using the Emergency Management Assistance Compact (EMAC), which enables states to send personnel and resources during governor-declared states of emergency.

- Daily WARN situational awareness calls, hosted by the American Water Works Association, increased information sharing and resource requests among impacted water utilities from Florida to Maine, EMAC representatives, the U.S. Environmental Protection Agency, DHS, and the U.S. Army Corps of Engineers.
- When water and wastewater utility requests in New Jersey were not being quickly addressed, EMAC staff made direct requests to expedite deployment of generators from a Washington, D.C. water system.
- In the future, state and local emergency management officials and water utilities could benefit from a greater understanding of the EMAC capabilities to support water sector needs.

Regional water utilities have strong relationships that increased coordination during Superstorm Sandy.

Water utilities in Northern New Jersey have interconnected pipelines and can provide service to another utility's customers—a feature unique to this region of the country—which led to strong relationships and daily conference calls between regional owners and operators. Partners prepared to bring one plant, which was offline for maintenance, back online during the storm if needed.

- Because regional relationships and mutual assistance are already strong, the New Jersey WARN has not seen as much participation as other regions. Owners and operators automatically

addressed partner resource needs without a formal agreement. There is opportunity to formalize these relationships through WARN participation in the future.

Water utilities worked from emergency response checklists and plans that reinforced lessons from past events.
One utility has an ever-evolving checklist of critical personnel, roles and responsibilities, and key actions that provides the game plan personnel work from in an emergency. It is updated after each large event to enable continuous improvement.

Participation in joint regional planning and exercises prior to Superstorm Sandy increased coordination and resilience planning.
Regional water utilities in New Jersey participated in the DHS-sponsored New Jersey Exit 14 Regional Resilience Assessment Program (RRAP) the year prior to Superstorm Sandy, which provided regional hydraulic modeling and system assessments to identify vulnerabilities, interdependencies with other critical sectors, and economic and social impacts of outages in particular parts of the region. It enabled providers to identify resilience improvements that would specifically address regional risks.

Response, Recovery, and Interdependency Challenges

The water sector primarily depends on the electricity sector to run pumps that maintain pressure and prevent contamination, keep water flowing to customer taps, and process sewage to prevent wastewater from spilling untreated into waterways and flowing back through manholes and customer premises. During electricity outages, utilities need sufficient backup generation and fuel supplies to maintain pumping and treatment, preventing contamination that could cause plant shutdowns for days. There is little redundancy in water and wastewater infrastructure, much of which is more than a century old. Facilities also rely on clear roads for regular deliveries of hazardous treatment chemicals, of which they typically do not store large supplies. While bottled water can replace tap water in some cases, hospitals and other critical sites would require evacuation without steam for sterilization and water for chillers, heating, and other services.

Loss of electricity created the greatest challenge for water utilities during Superstorm Sandy, even for those equipped with backup generators, as fuel availability became an issue.
Request for generators and support to obtain fuel for backup generators was not consistently prioritized by emergency management agencies, creating significant risks for cascading consequences.
Electricity sector power restoration challenges were not well understood by water sector owners and operators.

- In Philadelphia, damage assessment and restoration was delayed by sustained high winds. The water department was unaware that electricity repair crews could not begin restoration in bucket trucks until winds dropped below 45 mph, and had to work quickly to close valves and maintain pressure throughout the system as the electricity outage proved longer than predicted.
- Electric utilities were sometimes unable to pinpoint and prioritize outages to critical water assets without knowing which meter numbers and circuit numbers had lost electricity. Water utilities scrambled to physically locate this information.

Limited recognition of water and wastewater criticality resulted in service impacts that likely could have been mitigated and created "near miss" events in which there was significant risk for critical service loss with widespread and lasting impacts.

There was limited recognition in some cases that water and wastewater utilities represent a critical lifeline sector.

- Emergency managers did not understand the cascading impacts of potential sector disruptions and de-prioritized water utility requests for backup generation and fuel support. In a Maryland county, despite utility requests for backup generation, electricity losses resulted in 25 million gallons of raw sewage being released into a local body of water.
- In Long Island, a regional hospital risked losing its water supply when one water utility generator failed and the second required maintenance. Utility requests for backup generation and fuel delivery were not considered an immediate need, despite the impending service loss and the hospital evacuation it would have required in an already hard-hit area.

Emergency support function (ESF) 3 responsibilities for the water sector are fragmented between multiple agencies in the National Response Framework.

Responsibility for water and wastewater response and recovery primarily falls under ESF-3, Public Works and Engineering, led by the U.S. Army Corps of Engineers, but with key responsibilities for the Environmental Protection Agency (EPA) and FEMA. Because no one agency manages all sector operations, water sector personnel found their needs and resource requests were sometimes triaged out of the highest priority actions during Superstorm Sandy.

Despite credentialing efforts, water utility workers were often not considered emergency personnel, and faced difficulty in accessing critical facilities to assess and repair damage.

One water utility crew had to hike through wooded trails to reach critical facilities and use back roads to bypass law enforcement barricades. Another crew recruited the National Guard to escort them through police checkpoints. Despite their tenacity, this delayed assessment and recovery.

Flooding of low-lying wastewater treatment plants caused significant damage and created treatment challenges.

During Superstorm Sandy, storm water flooded treatment plants and mixed with untreated sewage, overflowing into local waterways and low-lying streets and buildings. Wastewater treatment plants in New York and New Jersey sustained unprecedented flooding and resulting damage.

- Directed by President Obama and Gov. Christie, the U.S. Army Corps of Engineers assisted the Passaic Valley Sewerage Commission in dewatering the sewage sludge by bringing in 10 centrifuges, which each cost $30,000 per day to operate. With major damage to the plant's own sludge dewatering equipment along with other parts of their treatment process, the plant was still only partially operable two weeks after the storm.

State regulations and policies restricted assistance to privately owned water utilities.

While more than 90% of wastewater utilities in the United States are publicly owned, privately owned facilities provide identical, and equally critical, service to communities. During Superstorm Sandy, state emergency managers de-prioritized resource requests for fuel and backup generation from privately owned facilities, assuming that private utility could use their own funding and supplier relationships. This jeopardized the community served by private water utilities.

Water Sector Lessons Learned

1. **State and local government officials may lack understanding of the cascading economic and environmental impacts of operational disruptions in the water sector (especially from electricity losses) and may not appropriately prioritize water sector needs and risk mitigation activities as a result.** Past sector successes in maintaining critical water services and avoiding sewage releases means emergency managers typically do not have direct experience with large-scale loss of water and wastewater services. Because few past events have featured devastating impacts from water service loss, other critical sectors and emergency management agencies may accept risks without understanding the potential impacts. Bottled water cannot replace many services, and existing mobile bulk water units provide only 1 million gallons per day.
    - In addition, when immediate water sector needs are not met, the large service impacts may be delayed, further masking the impacts of inaction. For example, even brief losses of electricity or backup power can lead to system shutdowns that create sanitation issues and ultimately could shut the system down for a week.
2. **Federal regulations restrict the use of very large, capital-intensive backup generators to emergency events, eliminating incentives for water sector owners and operators to invest in them.** Large water and wastewater utilities require high capacity, costly generators to fully replace electricity needs. Utilities cannot recoup costs by using generators to offset peak power costs, as Federal Clean Air Act restricts large generator use to testing and emergency events. Because the next large emergency could be years or even decades away, the potential benefit is far displaced from the cost.
3. **City planners and water and wastewater owners and operators need detailed data on forecasted impacts of climate change that could increase infrastructure risks during storm events.** Over the next several decades, rising sea levels and other effects of climate change may increase the vulnerability of water and wastewater infrastructure during extreme storm events and change the landscape of U.S. waterways, where many treatment plants are closely located.
    - For example, a large wastewater treatment plant in Philadelphia operates under gravitational flows, with no effluent pump. As sea levels rise during storm surges, or over time through climate change, the treatment capacity of the plant drops and creates the potential for sewage backflow. Accurate forecasts can determine when and what infrastructure investments will be needed to keep this plant operating.

Implications for Resilience

1. **Federal and state recognition of the water sector as a lifeline sector can elevate the priority of water sector resource requests to emergency management personnel.** NIAC originally made a similar recommendation in 2009, and many utilities still face issues from lack of understanding of prioritization of water sector needs. Doing so can support improved coordination between potable water agencies, water and wastewater utilities, and state and local emergency management officials.
    - Federal, state, and potentially local EOCs should invite water and wastewater utility representatives and WARN representatives to sit in the EOC or connect virtually to help coordinate assistance to water utilities.
2. **In each of the identified lifeline sectors, repair crews should be designated as emergency responders, given priority access to necessary resources (such as fuel), and supplied with appropriate and nationally accepted credentials to enter damaged work zones.** This could

include working with state and local governments to develop guidelines for local law enforcement who typically provide security to restricted areas in a disaster.

3. **Increasing WARN membership across the United States could provide a greater reserve of resources** to support affected systems during disasters and reduce the burden on emergency management officials. Coordination through WARNs, EMAC, and state EOCs during emergency events is improving and should continue to be a priority. Greater WARN participation will also formalize and strengthen existing relationships within the sector that contribute to rapid response and recovery.
4. **Consolidating water sector responsibilities under the National Response Framework** can facilitate a high-level view of water sector risks and better meet utility resource requests
5. **Water and wastewater utilities can work with government and energy sector partners to pursue diversified backup power strategies** for long-term commercial electricity outages.
    - A comprehensive review of regulations will identify ways to remove disincentives for water and wastewater utilities to invest in large-scale backup generation.
    - Water and power companies can examine how water utility onsite generation assets can be used to increase resilience in both sectors. The Passaic Valley Water Commission is working with FEMA and electricity providers to construct primary power capabilities onsite that benefit both sectors.
    - Utilities can standardize generator connections as infrastructure is planned and upgraded and improve fuel storage capacity.
6. **Accurate climate change forecasts will help inform infrastructure changes over the next several decades** to ensure critical facilities can continue operating at capacity as environmental conditions change. See Transportation Sector Resilience Implication #3.
7. **Regional assessments and exercises will help utilities identify large-scale infrastructure investments that address specific regional risks.** The aging water and wastewater infrastructure in the U.S. offers opportunities in the near future to begin rebuilding smarter. Regional risks—such as storms, earthquakes, and tornadoes—and specific infrastructure designs will determine the best resilience investments for each individual water utility. Regional public-private assessments and exercises can help utilities identify the best long-term investments for resilience, including backup power generation, the potential for interconnections of water and wastewater systems, water and wastewater plant redesigns, and storm water management practices that reduce the impact of flooding on the wastewater system.

Opportunities for Improvement

- Develop Federal guidelines and/or a national credentialing system for re-entry of owner and operator recovery crews and utility personnel—in this and all lifeline sectors—to restricted zones that contain critical assets.
- Initiate a comprehensive review of regulations and restrictions that may create disincentives for utilities to invest in reliable backup generation.

State and Local Government

As in all major events, state and local emergency management officials became primary coordinators during Sandy, maintaining communications with private-sector stakeholders and sharing information with partners at municipal, county, state, regional, and Federal levels. States and local governments have the sole legal authority to respond to and manage all disasters and emergencies within their jurisdiction. Federal assistance can be provided, under the provisions of the Stafford Act, only when state governors request a presidential disaster or emergency declaration and accompanying federal assistance. The storm affected 24 states and caused more than $20 billion of property damage alone along the east coast. Thirteen states requested Federal assistance through major disaster and emergency declarations. Through the Emergency Management Assistance Compact (EMAC), more than 25 states deployed 2,632 personnel and resources to the impacted region.

Exhibit 35. State and Local Government Highlights

- Multiple states, counties, and municipalities brought together public- and private-sector infrastructure liaisons under one roof in emergency operations centers to improve real-time coordination and information sharing.
- Data sharing and analytics through interoperable data platforms enabled agencies to maintain situational awareness and prioritize resources.
- State and local governments extensively used social media to communicate with the public and crowdsource information.
- Federal regulation restricting information sharing in the oil and natural gas sub-sector blinded emergency managers to the availability of fuel resources.
- Unprecedented damage and flooding overwhelmed state and local resources and delayed the ability to restore critical services to priority sites.
- Personal relationships remained critical at the state and local level and were cited as key success factors.

State and local emergency management personnel tracked and shared data about the damage to state and local infrastructure, electricity outages, fuel disruptions, public transportation issues, public safety, and sheltering for those residents displaced from their homes. Widespread damage to homes and extended restoration times put a strain on shelter systems. New York and New Jersey instituted fuel rationing programs they had not put in place since the 1970s. Officials also worked closely with private-sector partners to issue permits and waivers, direct government resources as critical service outages worsened, and keep the public informed and engaged during the recovery process.

Highlights of Planning, Response, and Recovery

Planning, early mobilization, and coordination efforts by state and local governments helped to mitigate the effects Superstorm Sandy.

Public-sector regional relationships and organizations increased coordination, resource sharing, and situational awareness across jurisdictions.

Longstanding state-to-state mutual aid processes, known as the Emergency Management Assistance Compact (EMAC), and regional mutual aid agreements enabled emergency responders to share resources and coordinate a multi-jurisdictional response. Local, state, and regional groups instituted standing coordination calls before the storm hit and continued through recovery.

- For example, Philadelphia activates an emergency steering committee including city agencies, law enforcement and fire, National Weather Service, non-profit organizations, and key utility personnel. Regionally, five southeast Pennsylvania counties have common teams and equipment that are poised to respond to an event, and who coordinate through the state emergency operations center (EOC) and via phone and e-mail. Regional coordination also verifies that local governments are taking similar preparatory and response action to ensure consistency in emergency management efforts.
- FEMA Region 3 initiated conference calls two days before storm impact, and requested that New Jersey be integrated into the regional calls, despite it being in a different FEMA region.

Emergency managers and private utilities worked side by side to coordinate and mutually support response.

- New Jersey held pre-event conference calls with private-sector stakeholders and established a private-sector desk within the EOC to coordinate resource and information requests. Multiple states, counties, and municipalities also co-located private sector liaisons within EOCs. Officials in New Jersey had contact information for owners and operators of state- and national-level critical infrastructure and had previously issued private-sector employee identification cards to improve access for essential employees to disaster areas.
- Activating the Philadelphia EOC brought together police and fire, water, transit, and energy officials in both the public and private sectors under one roof to coordinate. Any agency that has a role in the response is requested to staff the EOC to promote information sharing, streamline decision-making, and to prioritize scarce resources.

State and local governments used social media effectively as a primary mechanism for information sharing with the public and media and as a tool to confirm information and reports following the storm.

Coordinated messages through social media and traditional channels reduced panic while keeping people inside and off the roads. Social media platforms also enabled crowdsourcing of information that agencies and the public used to support response.

- Students from Franklin High School in New Jersey crowdsourced feedback from Twitter to map which gas stations were closed or open and shared it on Google crisis maps.

Exhibit 36. Innovative Social Media Use in Philadelphia and Boston

Philadelphia's integration of social media into its OEM and 311 mobile platform showed how social media could be used to reach large populations in real time and request information from citizens to improve response. The City of Philadelphia used the new "Philly311" mobile app, launched in September 2012, to share information with the public and receive non-emergency requests from residents across the city during Superstorm Sandy. More than 400 requests were made via the app, and the @Philly311 Twitter account gained approximately 2,000 followers and sent 1,000 tweets during the storm.

The city is now exploring opportunities to better coordinate social media into the Joint Information Center, train and dedicate personnel to social media management to improve messaging frequency and relevance, and engage in social media "mutual aid" agreements with agencies in other states that provide personnel to monitor and aggregate social media inputs from followers in a disaster. The city is also exploring the use of platforms such as Google Forms with private sector providers to gather information on which grocery stores, restaurants, service stations, and key businesses are operational during an event and provide that information to the public.

Social media also proved critical in an entirely different type of event: the Boston Marathon bombing. City and transit police extensively used it to provide information on the investigation and suspects to the public; drive users to their See Something, Say Something website and app to report new information; and communicate to the public and media immediately after the event when cell phone service was extremely limited. It enabled department personnel to become trusted resources for information who would often "break" stories that the media would traditionally report first and refute rumors to reduce panic.

Counties and states with interoperable electronic information sharing and analysis capabilities faced fewer information sharing issues.

Most coordination challenges stem from lack of data or the ability to analyze it effectively. Data sharing and analytics was often the key to success, enabling agencies to widen visibility into cross-jurisdictional impacts, improve outreach to affected populations, prioritize resources, and maintain a consistent message.

- For example, municipalities and counties in Pennsylvania, as well as many surrounding states, use Knowledge Center incident management software to maintain situational awareness. Information is transmitted automatically to the state and also visible at the state and local levels.

States and municipalities with underground fuel storage and sufficient backup generation encountered fewer delays.

- Despite the associated cost and regulatory requirements, some municipalities have invested in underground fuel storage, which supplied emergency response vehicles and reduced the impact of fuel disruptions. However, fuel availability for personal vehicles and home generators remained a challenge.

Response, Recovery, and Interdependency Challenges

The size and scope of Superstorm Sandy and extent of damage increased the need for cooperation both within and across county and state lines. The need for up-to-date, reliable data became increasingly important as state and local government responders coordinated resources across wide geographical areas and modified response plans in real time to address unanticipated consequences of the storm.

Federal regulation restricting information sharing in the oil and natural gas sub-sector blinded emergency managers to the availability of fuel resources and causes of disruptions.

- New Jersey emergency managers did not have good visibility into petroleum availability throughout the region, whether there was an overall petroleum shortage, levels of supply at gas stations or terminals, and which service stations had fuel but no electricity, or vice versa.
- Emergency officials worked creatively with the communications and financial services sector to identify working service stations. By analyzing which stations were accessing internet and credit card systems, they could pinpoint those that likely had power and were pumping fuel.

Misconceptions about the role of state and local government existed in both the private sector and the public it serves.

- In some cases, private sector partners believed there was a master "prioritizor" in the state EOC, when in fact emergency managers were working across agencies to coordinate the deployment of public resources based on constantly changing private-sector restoration estimates.
- The public holds a misconception that the state not only regulates but can direct the resources of electric utilities after an event and is responsible for restoration.

Widespread damage and flooding taxed debris removal crews, overwhelmed backup generation resources, and negated pre-determined restoration priorities.

- Generators were scarce, required refueling every 24 hours, and often had to be shared and transported between sites while road access was still a challenge. Some generators were designed for minimal use, were old, or had not been well-maintained, leading to burnout and increased resource requests.
- Debris removal crews were in short supply relative to the damage incurred.
- Most state and local emergency managers had worked with electric utilities to pre-determine restoration priorities, but many were served by flooded electrical distribution stations that required days to pump, dry, and clean. This required re-shuffling of priorities and increased communication with power companies.
- When the Port of New York and New Jersey shut down for four days, all cargo sat offshore or was diverted to other ports. Norfolk's port was running at 185% capacity to handle overage. States also began discussing shipping sewage to other regions for processing when water treatment plant capabilities were compromised.

Ad hoc volunteer groups lacked defined roles and responsibilities, making coordination difficult.

- Although social media helped to enable ad hoc volunteer groups to assist in disaster recovery efforts, it was difficult to coordinate with these groups because they did not have a clear understanding of roles and responsibilities.

State and Local Government Lessons Learned

1. **Economic/operational interdependencies and disaster impacts do not recognize jurisdictional boundaries, requiring fluid regional coordination during catastrophic events**. The scale and scope of the storm took many responders by surprise and required a new level of cross-jurisdictional and cross-sector coordination. In some cases, private sector partners were better at working across state lines than public officials, in part due to legal and regulatory constraints, whether perceived or real.
2. **Personal relationships remained critical at the state and local level and were cited as key success factors for coordination.** When traditional communication channels are compromised,

agencies used personal cell phone numbers and e-mail addresses to communicate. Creative problem-solving also stemmed from working directly with stakeholder contacts. It is important to ensure that, with staff turnover, these capabilities and contacts are sustained and updated.

3. **Unforeseen factors can hinder restoration efforts, rapidly alter priorities, and necessitate a flexible response.** Sandy brought to light hidden risks in some sectors. Despite milder damage in Pennsylvania, a Philadelphia potable water plant that lost power didn't anticipate that repair crews in bucket trucks couldn't deploy until winds dropped below 45 mph, delaying restoration. Sandy brought fuel vulnerabilities to the forefront, as critical operations for public and private sectors were threatened by worsening fuel shortages. Timing of the event can also result in a sudden need to shift priorities, such as polling locations that needed to be operational for the presidential election a week after the storm.
4. **States may be in the best position to consolidate and share information reported on petroleum supplies.** Because antitrust legislation prevents oil companies from sharing information on supplies with each other, state EOCs need dedicated personnel to collect and consolidate as much up-to-date information as possible on fuel supplies. Some states have developed supply disruption tracking services to provide better fuel situational awareness.

Implications for Resilience

1. **Data analytics and interoperable data exchange with key partners can improve agency response to affected populations.** State and local emergency management agencies are investing in data management platforms for EOCs that can accept information seamlessly from private sector EOC systems and improve situational awareness, decision-making, and resource management. Integrating GIS capabilities for mapping and displaying problems improves impact and outage comprehension.
2. **State and local government agencies can best harness the capabilities of social media by increasing capabilities, training, and best practices sharing**. Emergency managers who use social media before, during, and after an event can establish their agency as a trusted information source and better control and respond to rumors. Increasing training and dedicated personnel for social media and improving social media policies are necessitated by growing public use of and reliance on social media as a primary communication source. The volume of information often requires constant attention.
3. **Joint public and private exercises at the regional level and improved partner outreach in non-emergencies offer one of the best opportunities to prepare for unprecedented events in regions**. They also provide the basis for regional vulnerability assessments and coordinated planning for resilience.
    - Between-event coordination and education helps to manage turnover and improve understanding of partner operations. In New York City's OEM, new employees get a ConEdison 101 course, and they work with ConEdison to provide its new employees with an OEM 101 course.
    - New Jersey's infrastructure bureau has sponsored multiple exercises since 2010 for lifeline infrastructure owners and operators. One exercise, "Running on Empty," presaged the petroleum disruptions that occurred during Sandy.
    - Exercises also offer the opportunity to define the specific roles and responsibilities of state and Federal government agencies during an emergency to limit unnecessary duplication of efforts and enable a more effective response.
4. **Building community capacity to shelter-in-place and withstand longer power and critical service outages can decrease the strain on state and local resources and improve recovery**.

The public needs education on disaster preparation and consistent messaging from state and local officials to build the expectation for individuals to be self-reliant for at least 72 hours following an event with major service disruptions.

- In addition, states and municipalities need mid- to long-term displacement plans for sheltering. Long-term disasters will require shelters to operate at full capacity for longer than three to five days. Food options with a long shelf life and access to showers, laundry facilities, and special medical equipment should be considered.

5. **Best practices and information sharing across regions can help emergency managers employ lessons learned from disasters experienced elsewhere**. Prior events such as Hurricane Irene and Tropical Storm Lee provided lessons learned that helped better prepare emergency responders for Sandy. Regions further south routinely experience large and destructive hurricanes, for example, and could offer well-established best practices for storms and many other natural disasters.
6. **Develop streamlined processes for routine public-private coordination to avoid reinventing the wheel in the next disaster.** Coordination for debris removal, issuing permits and waivers, and sharing service outage information are staples of almost every major event. Where possible, they should not represent puzzles to solve each time.
    - For example, Pennsylvania emergency managers started an initiative with PECO to establish priorities for debris removal and access to certain roads to reestablish power for critical facilities. They have currently identified 25 priority one roads that will be addressed first and 45–50 additional priority two roads.
    - There are valuable opportunities to improve EMAC coordination prior to the next event. Sending needed resources can create additional challenges when the chain of command is unclear, pre-mission assignments are not established, and accommodations for fuel, food, and housing are not determined ahead of time. States must coordinate to develop a pre-scripted mission and package for deployed teams.

Opportunities for Improvement

- Support joint public-private exercises at the regional level, including multi-jurisdictional and Federal participation.
- Facilitate best practices and information sharing for multiple types of disasters across regions.
- Provide information and training resources to help state and local governments improve community capacity and disaster preparation.

Non-Profits and Community Organizations

When Superstorm Sandy hit, non-profit and community organizations and volunteers from across the country rushed to assist those in need in the hardest hit areas of New York and New Jersey:

- Traditional non-profits, like the American Red Cross and Catholic Charities, used their resources and wide-reaching networks to pre-stage equipment and provide essential services. In the weeks following the storm, the Red Cross raised $303 million, operated 32 shelters in the area, circulated more than 300 emergency response vehicles through the region, and worked with its partner the Southern Baptist Convention to serve more than 4.8 million meals and snacks.
- Local non-disaster agencies and organizations such as Portside NewYork, Friends of Firefighters, the Bowery Residents' Committee, and the Jewish Community Council of Greater Coney Island, among others, also contributed greatly to the response, utilizing their community ties to organize and carry out response efforts at the local level.
- Additionally, Superstorm Sandy saw a large number of ad hoc volunteer organizations mobilize around local needs. Occupy Sandy was formed using the social networks established during the Occupy Wall Street movement, and within the first two weeks following the storm, gathered an estimated 5,000 to 10,000 volunteers, whose nonhierarchical methods of organizing proved useful for triage and immediate support.
- Other organizations, such as Power Rockaways Resilience, Operation Breezy, and Boots on the Ground, provided vital services such as backup power and heaters and pumping and gutting homes to prevent mold growth.

Exhibit 37. Non-Profits Highlights

- Non-profit organizations replaced lifeline sector services when major providers were still performing restoration. They provided generators, transported food and water, and replaced internet and wireless communications that were indispensable in the first few days.
- Social media and online mapping technology were critical tools used to survey community need and match needs to resources and personnel. New capabilities and creative crowdsourcing enabled organizations to troubleshoot on the fly.
- However, a lack of common data tools across organizations complicated response among hundreds of volunteer organizations.
- Ad hoc volunteer organizations sprang up throughout the region to address unmet needs and improve the agility of response at the local level. Yet a lack of historical coordination with traditional disaster response organizations and state/local government hindered response.
- Ongoing education and training can help promote individual preparedness and support a whole-of-community approach to disaster recovery.

Highlights of Planning, Response, and Recovery

Non-profit and community organizations mobilized to effectively meet large needs during response and recovery in the hardest-hit areas.

Non-profit resources and networks provided lifeline sector services when major providers were unable to rapidly get services back online.

Power

- While gas generators sat idle due to the fuel shortage, Power Rockaways Resilience formed to begin delivering hand-built, shopping-cart-sized solar generators to the hardest-hit blocks of the Rockaway peninsula. This small-scale initial effort grew, and with the help of a nationwide fundraising campaign, oversaw the widespread installation of large-scale solar generators at relief centers and volunteer hubs.
- PortSide NewYork, a non-profit in Red Hook focused on waterfront issues, organized the work of a local electrician who donated his services.

Transportation of food and water

- New York's Governor Andrew Cuomo called the non-profits of New York a "critical partner" in recovery, noting that a number of them, including the National Urban League, the Coalition Against Hunger, the Metropolitan Council on Jewish Poverty, the Bowery Residents' Committee, the Grand St. Settlement, and the Henry Street Settlement, aided in the transportation of food to shelters in Manhattan.
- A non-profit program director from the Upper West Side co-founded UWSLoves, raising money from her friends to make and personally deliver more than 1,500 hot meals and more than 3,000 sandwiches in her own kitchen for those in need on the Lower East Side, Rockaway, Coney Island, and Red Hook.
- The Red Cross deployed its mobile units through New York and New Jersey communities distributing food and water. Volunteers individually called response vehicles to verify their location, which was then submitted to a blog on the Red Cross website to keep residents in hard-hit neighborhoods up to date on where food was available.

Communications and technology

- The FEMA Innovation Team rallied local community leaders, NGOs, government, volunteers, and commercial technology providers to deploy temporary disaster networks in the Rockaways, Red Hook, and Staten Island. This just-in-time communications then empowered communities to coordinate their own volunteers, aid, and donations.
- The Red Cross has a partnership with the Armed Forces Emergency Services system (HAM radio operators) that they pre-deployed as well as satellite phone kits to key chapter locations. This was key to operations in the first couple days without cell service.
- The Information Technology Disaster Resource Center (ITDRC), a vendor neutral clearinghouse for in-kind technology resources in disaster, engaged nearly 1,000 members of the New York tech community to supplement response efforts. Volunteers provided temporary communications and technology assistance (e.g., installing computers, networks, Wi-Fi infrastructure, and internet-based phones) to communities, nongovernmental organizations (NGOs), small businesses, and fire stations.
- The independent Global Disaster Immediate Response Team (DIRT) used ground-based terrestrial antennae to restore communications to hardest-hit areas quickly—an idea they came up with on the fly.
- Occupy Sandy leveraged free and open-source tools, such as Sahana Eden, to develop a technical infrastructure and disaster management system for information sharing and response support. The group used the Sahana software as a dispatch hub for communications and to log requests for assistance, print waybills with inventories and their destinations, and track requests

for disaster relief supplies like food, water, dry goods, and cleaning supplies. The software also tracked work orders for houses needing cleaning, mold remediation, etc.
- PortSide New York provided computer equipment to enable people to apply for FEMA aid.

Social media was a critical tool for organizations to survey community needs, match needs with resources and personnel, and provide rumor control.

- The Jersey Shore Hurricane News, a Facebook- and Twitter-based news platform created by a digital journalist in advance of Hurricane Irene in 2011, provided accurate news reports and crowdsourced information about food, water, gas, and shelter, and deliveries of supplies to residents, emergency responders, and community organizations. When 911 was overloaded, the New Jersey Office of Emergency Management used the platform to communicate with people requesting rescue.
- The American Red Cross' Social Engagement team used pertinent posts from its Facebook page to inform the headquarters-based Mass Care team's response and influence change in action on ground operations. In its D.C. headquarters-based social media disaster operations center, volunteers also monitored hashtags and keywords on Twitter, Facebook, and blogs to determine need and inform service delivery plans. The Red Cross also offered a Hurricane App to assist in individual recovery.
- Through social media and firefighter websites, grassroots organization Operation Breezy was able to spread the word that people were in need, resulting in volunteers coming in from around the country to help gut and pump water out of residents' homes.
- A 14-year-old girl used Facebook to found Survivors Silver Lining, which continues today to communicate needs (e.g., building supplies) and match donors with Hurricane Sandy survivors. She has also used the site to keep interest in donating alive after media attention dwindled.
- Humanity Road used social media to coordinate their own response as well as provide rumor control; using their mobile and web-based information gathering techniques, they located and responded to rumors with fact-based information via their social network.

Organizations and individuals developed online maps and mapping technology to increase the efficiency of non-profit response and recovery efforts.

- Hurricane Hackers NYC developed a map offering National Oceanic and Atmospheric Administration (NOAA) aerial imagery of affected areas with an overlay of recovery locations. By providing this information in a centralized location, they helped connect organizations working on technology projects and resources to common online resources.
- Mormon Helping Hands developed a private tasking system and map that was made available to organizations with ground teams responding to assess and resolve issues. Though its use varied, the system provided more than 90 organizations that were surveying damage and identifying resource needs with a method for capturing assessments, coordinating responses, and tracking issues through to completion, resulting in the resolution of thousands of incidents.
- Independent technology and media organizations, such as New York Public Radio, developed interactive maps using New York City's data to target or accommodate specific needs, which made them integral to the response effort. These maps extended access to the city's data, helping to alleviate some of the burden from the city's websites when online traffic surged.
- Occupy Sandy created a centralized website and a map using Google Fusion Tables embedded in their WordPress-powered website to provide information, connect individuals with resources, collect donations, and register and direct volunteers. Individuals could visit the site to register community needs and request aid (information that was used to help allocate volunteers and

other resources) and volunteers could input their information, making it easy to segment volunteers by interest and location.

Non-profits, community organizations, and government agencies coordinated well, sometimes on the fly.

- Geeks Without Bounds (GWOB) deployed with the FEMA Innovation Team, helping to bridge the formal and informal response efforts. For example, they worked with Occupy Sandy to streamline its exchanges with FEMA and other formal organizations.
- National Voluntary Organizations Active in Disaster (VOAD) membership includes 108 organizations comprising faith-based, community-based, and other nongovernmental organizations throughout the nation. Traditional non-profits like the American Red Cross and Catholic Charities worked with VOAD to help coordinate response efforts.
- In New Jersey, Catholic Charities worked very closely with Red Cross, FEMA, and local emergency management to conduct a coordinated effort.
- The Red Cross partnered with Philadelphia's emergency alert system, ReadyNotifyPA and New York's Notify NY system to encourage people to sign up for text alerts during disasters.

Non-profits and community organizations continue to play a key role in post-storm recovery and rebuilding efforts

- Catholic Charities conducted a "Social Impact Study" in Fayerville, New Jersey, through which they collected and provided quantitative and qualitative data to the city council and state to make the case for building resilience in at-risk towns.
- At its annual meeting, Philanthropy New York focused on topics related to rebuilding and resilience post-Hurricane Sandy, and invited participation from government officials, scientific experts, and other non-profits to discuss ways that all sectors can contribute to resilience.

Response, Recovery, and Interdependency Challenges

Non-profit and community organizations depend on power and communications to mobilize and coordinate responses, but because they are used to functioning in disaster situations where failures generally occur, they have developed methods for providing these services themselves, which they employed during and after Sandy. The fuel shortages, however, did greatly impact their ability to use generators and mobile response units. While well-marked vehicles were often able to skip gas lines, unmarked volunteer and rental vehicles could not.

Lack of common data and data collection tools created inefficiencies and duplicative efforts.

- Multiple organizations conducted different data collection efforts as a means to organize their responses. However, a lack of information sharing and establishment of common data points made some of these efforts redundant.
- Several entities—including government, non-profits, ad hoc and volunteer groups, and individuals—developed "crowdmaps" to provide situational awareness, resulting in a duplication of effort because groups did not collaborate or coordinate their efforts.
- Some proprietary data collection tools developed by organizations, such as the private tasking system and map for VOAD groups, were not always ideal for use in the field.
- Data collection needs sometimes went unfulfilled, due to a lack of a designated responsibilities, limited resources, and limited communication about gaps.
- Although certain agencies had access to databases with personal contact information for thousands of vulnerable residents (e.g., elderly, sick, and disabled), in some cases, legal and

technical barriers prevented the sharing of lists across agencies. Due to the lack of a consolidated and accessible information source, city agencies and community-based organizations had to conduct outreach to locate these individuals, making the task of reaching these populations both slower and more difficult.

Uncoordinated approach for reaching out to communication companies made prioritization difficult for service providers.

- Several NGOs came to communications companies looking for support on various projects, but without necessary documentation from FEMA. Communications companies needed to prioritize where they could help, and being told by multiple NGOs that their organization was the FEMA priority made it difficult for communication companies to determine their response strategy.

Conflicts between state emergency plans and city efforts prevented a more coordinated non-profit response.

- Catholic Charities experienced discrepancy between New York State's emergency operations plan, which typically informs their response, and what the city of New York carried out under the mayor's instructions. Because of this unannounced change of plan, Catholic Charities did not always know who was in charge, where to set up operations, or how to get from one place to another, among other issues.

Lack of communication and coordination among traditional non-profit organizations and spontaneous volunteer organizations hindered some response efforts.

- Although ad hoc and volunteer groups played a significant role in response and recovery efforts and were empowered by social media to organize, collect, and share information and resources, they also found it difficult to organize and engage with traditional response stakeholders.
- Newly formed volunteer and ad hoc groups were sometimes unfamiliar with the logistics of delivering resources and long-term recovery efforts and did not know the roles and responsibilities of local and Federal governments, emergency management regulatory agencies, and organizations like FEMA, Red Cross, VOAD, and others.
- The inexperience of some community organizations with the deployment and support of emergency technology hindered, rather than helped the overall response effort.
- New York City had its Spontaneous Volunteer Management Plan in place during Sandy, but implementation proved difficult, particularly due to poor communication between the groups involved. This may have prevented some volunteers from being utilized in the best possible way.
- After the initial response effort, there were a number of agencies—traditional and ad hoc—that were working to provide food to residents in need; upwards of 30,000 to 40,000 meals per day. However, there was no coordinated effort among the different feeding agencies during Sandy that enabled these organizations to maximize their resources.

The rapidly changing storm path left some resources pre-staged outside the areas in need.

- The American Red Cross strategically placed resources between Philadelphia and New Jersey based on early predictions of where the storm would hit, but were able to move them closer to New York the night before as the storm turned. However, they placed them on the coastline, which made getting them to Long Island and Manhattan difficult.

Volunteer organizations focused on rebuilding face a number of challenges that could inhibit their participation in recovery.

- Variance in building codes and requirements in the many municipalities and inconsistencies among inspectors provides substantial difficulty for non-profits and community organizations. The underlying concern is the potential future liability for volunteer agencies as well as the possibility of leaving a survivor with a rebuilt home that becomes uninsurable, leaving the homeowner with no legal recourse.
    - FEMA flood maps are being restructured, but are not yet available to individuals who must rebuild now.
    - Waivers are needed to use out-of-state contractors, and small to medium projects have great difficulty finding contractors, due to a business focus on larger, more profitable projects.

Non-Profit and Community Organization Lessons Learned

1. **Non-profits and community organizations have the ability to provide stopgap lifeline sector services**—particularly power and communications—in times of disaster.
2. **Social media proved to be a critical mobilization tool** that enabled non-profit and community organizations to be self sufficient. However, some organizations neglected to update social media pages, which frustrated users, or required the addition of a dedicated individual or team to respond to questions or comments.
3. Where used effectively, **online maps and tools for data collection and analysis aided in the efficient prioritization of response efforts.** However, in some cases, a lack of coordination between the organizations developing these tools and compiling data sets resulted in a duplication of effort. Additionally, some organizations developed maps and tools that were ineffective while still others lacked the training and technical knowledge to use them correctly.
4. **Coordinating a "whole community" approach with disaster stakeholders yielded effective responses.** The FEMA Innovation Team, for example, enabled agencies and external partners to coordinate efforts that could not have been conducted by any one organization.
5. **Ad hoc volunteer organizations improved the agility of response at the local level, but need better coordination with traditional organizations and government agencies**. Ad hoc volunteer organizations mobilized to serve unmet needs, and leveraged their community ties and personal networks to start acting immediately. Traditional response organizations have relationships with government agencies, emergency management, and other non-profit organizations that enable them to manage large-scale logistics, while ad hoc organizations innovated ways to survey and respond to needs and collect important data. Coordinating these efforts can yield a stronger response.

Implications for Resilience

1. **Non-profits and community organizations can continue to use and improve standard, open-source tools and techniques that leverage social media** to provide them with accurate, real-time situational awareness. Best practices for incorporating nonstandard technology resources and/or solutions that may be innovated on the fly should be shared across organizations. Specific ideas include the following:
    - Online maps that can integrate data from multiple sources, potentially using crowdsourcing (e.g. MapStory) and/or integration with GPS technology.

- Smart phone technology in the field to enable volunteers to take pictures of disaster assessment immediately, send it to a case work team, and put that location on the route for case work teams. Also the use of GPS to track and communicate the location of response vehicles via a publicly accessible online map or social media outlet.
- A better portal for disaster management (e.g., ReadyResponders Network) that delivers information, such as a daily situation report, to handheld devices.
- Software that can mine data like geotagged Tweets and automatically organize it into useful information to help identify resources that are available and where, and match them up with needs.

2. **Establishing standard nomenclature and a platform for data sharing could improve information exchange and streamline data collection efforts**. Having access to real-time data is critical to response efforts, but is not something that all non-profits and community organizations can spend time and resources collecting. Establishing a platform for data sharing and a common way of expressing it could help make collected data more robust and enable its cross-utilization in different response efforts. Procedures and common protocol for data and information sharing would need to be developed to ensure accuracy.
3. **Improved pre-event coordination between non-profits/community organizations and other emergency stakeholders can improve response efficiency**. For example, long before disasters occur, Catholic Charities spends time building relationships with FEMA, its partner agencies that are part of National VOAD, and community governments—relationships that have enabled the organization to move quickly and effectively in times of crisis. Improved coordination may include:
    - Enhancing the awareness of non-profit support response efforts and resources to reduce unnecessary duplication of service and effort
    - Including non-profits in city/state emergency planning and communicating changes in plans and protocols that may impact the non-profit response (i.e., avoiding the confusion surrounding New York State's plan vs. New York City's actions that occurred during Sandy)
    - Increasing collaboration between private industries and NGOs to ensure access to resources
    - Non-profits and government working together to develop a well-planned, adequately funded disaster-response system, and government establishing a fund that would be available to non-profit human services agencies in the immediate aftermath of a disaster
4. **Establishing methods for government agencies and traditional volunteer organizations to better engage ad hoc and nontraditional community organizations** can help maximize the potential of this force. This process should leverage the benefits that these diverse groups have to offer without compromising the agility that makes them so effective. Part of this effort could involve:
    - Developing efficient methods of credentialing for nontraditional partners and ad hoc volunteers
    - Providing clear information and guidance to ad hoc organizations and nontraditional organizations about government requirements, policies, procedures, and roles, as well as methods for volunteer management and disaster case management
    - Establishing processes that enable collaboration between ad hoc technology partners and government entities and implement nonstandard resources and solutions
    - Building community relationships and trust prior to the onset of a disaster

5. **Ongoing education and training at the community level will aid in promoting preparedness and familiarity with emergency response**. Examples include the Red Cross "Ready When the Time Comes" program that trains employees of large employers in disaster response; Red Cross clubs for elementary to college-age students; and the Catholic Charities Applied Institute for Disaster Excellence, which trains volunteers in disaster response best practices and government coordination. Not only does this type of training enable citizens to better provide for themselves during storms, but it enables the community to be more responsive to needs and encourages potential volunteers to act when disaster does strike.

Opportunities for Improvement

- FEMA can work to include traditional and ad hoc volunteers as an integral part of the response team and key resource, rather than consider them a liability. This enables non-profit and community organizations to do what they do best, rather than applying cumbersome policies.
- FEMA and other Federal agencies can establish funding avenues for traditional and non-traditional volunteer organizations in times of crisis, and for community education and training to increase the community's volunteer capacity.
- FEMA and other Federal agencies can support the development of open-source tools and techniques, and include social media in existing communications and technology policies and mandates.
- FEMA and other Federal agencies can help educate non-profit and community organizations on disaster coordination to enhance pre-planning efforts and relationship-building.
- FEMA can utilize data collected by non-profit and volunteer organizations (e.g., Occupy Sandy) to set up long-term recovery communities that engage volunteer organizations. This may include coordinating with city governments and developing standard operating procedures or guidelines that every organization can benefit from.

Superstorm Sandy Case Study Group Findings

Superstorm Sandy was one of the largest natural disasters to hit the Northeast states in the past 100 years and one of its deadliest, taking 117 lives and forced 776,000 people out of their homes. It produced extensive flooding that damaged lifeline infrastructures from New York to Washington, D.C. and resulted in more than $60 billion in economic losses.

Yet considering its force and geographic scope, the response to Sandy was remarkable. The storm's magnitude and duration required a level of coordination and response that the region had never seen or practiced. In most respects, the region's owners and operators, public officials, and emergency responders successfully met the unprecedented challenges they faced.

The findings and conclusions that follow are specific to the case study on Superstorm Sandy and reflect the collective judgment of the Study Group. They form a comprehensive set of best practices, process improvements, and potential enhancements to the roles of government and private-sector partners that can help enable shared improvements in regional resilience. Overall, the case study on Superstorm Sandy revealed that three strategies were most effective in successful planning, response, and recovery during Sandy:

- **Strong public-private partnerships and relationships** that were nurtured during disasters and between disasters ("blue-sky days").
- **Effective communication at all levels** aided by the careful placement and coordination of key personnel.
- **Coordinated planning and decision-making** that synchronized the actions of public and private responders.

These core strategies, described below in the Superstorm Sandy findings and conclusions, are essential to the resilience of all regions regardless of location or the risks that they face.

Despite these successes, Sandy's strength and size exposed new weaknesses in both the physical infrastructures and the processes used to plan, respond, restore, and recover from a major regional disaster. The Superstorm Sandy findings point to the successes, remaining challenges, and lessons learned from Superstorm Sandy. They include:

1. Maintaining the Continuity of the Lifeline Sectors
2. The Importance of Partnerships and Cross-Sector Coordination
3. Regional Planning, Analysis, and Risk Management
4. Impediments to Rapid Response
5. Leveraging Communications
6. Building Community Capacity

Study Group Finding 1: Maintaining the continuity of services of the lifeline sectors is paramount to regional resilience.

Sandy confirmed that the services provided by the electricity, oil and natural gas, water, communication, and transportation sectors are indispensable, highly interdependent, and essential for public safety and the recovery of other critical infrastructures, businesses, and communities. Public emergency managers are beginning to recognize lifeline infrastructure as a key functional driver of their traditional emergency services and life safety missions.

- Sandy emphasized that **prioritizing the restoration of facilities is complex, condition-specific, and often difficult to communicate.** Many partners and the public lack a full understanding of how lifeline sectors recover, the factors affecting priorities, and who is involved. For example, while electric utilities have pre-determined restoration priorities, real-time conditions change these priorities based on the location, timing, and severity of the event. Restoration decisions in one sector greatly affect restoration plans in other sectors and impact how public emergency managers allocate resources and equipment. Utilities have historically prioritized life safety functions and assets for police, fire, and hospital services, and are often not well informed about the location or criticality of other lifeline sector assets and systems. In addition, they face increasing demands from public agencies and other sectors to add ever more assets to their priority restoration list, diluting the true priorities. Better partner coordination and education can improve asset prioritization.
- **Damage to aging and highly specialized infrastructure posed problems in recovery** because of the difficulty in locating and procuring rare or obsolete components. The replacement of a critical component of a key transit system damaged during Sandy was unavailable because it is no longer manufactured and had to be located and shipped from another system across the country. One of the largest wastewater treatment plants in the nation required replacement components for customized parts that were difficult to quickly source.
- Sandy stressed the capabilities and assets of lifeline infrastructures over a large geographic region and exposed **hidden risks not well understood or foreseen** by emergency managers in dependent sectors and government.
    - The ability of the public and private sector to assess and manage the liquid fuel supply situation during the storm was hindered by a **lack of understanding of petroleum sector operations and regulatory restrictions**. For example, antitrust laws hampered efforts by New Jersey to obtain accurate information on terminal and retail tank storage levels among various companies. Response personnel were also unable to determine which service stations had gasoline and the ability to pump it.
    - Sandy damaged, disrupted, or disabled infrastructure assets that performed well in previous storms, including Hurricane Irene, exposing **new points of failure in critical assets and facilities and weaknesses in aging infrastructure.**
    - The **vulnerability of non-critical, administrative facilities** was revealed as a result of the large storm surge.

Study Group Finding 2: Strong public-private partnerships and cross-sector coordination were the most important success factors in preparing for and responding to Sandy.

Building and nurturing relationships, both within and between regions, were frequently cited as the most important feature of successful planning and response to Sandy. Public officials and emergency responders in New Jersey were well prepared during Sandy because of the depth of their public-private relationships built over the past three years of regular coordinated preparedness activities, including regional resilience assessments and joint exercises. When fuel became scarce, distributors and individual sectors that had strong relationships with suppliers in nearby states could more quickly source and transport fuel.

- **The active engagement of senior executives from industry and government during Sandy streamlined coordination and removed obstacles** to response and recovery that sectors had faced in the past. President Obama gave explicit orders to remove red tape, and the message trickled down. Electricity sector CEOs across the region participated in daily conference calls with senior DOE, DHS, and White House leaders to coordinate the largest movement of mutual aid resources in history. Senior-level Federal task forces were dispatched to the field with the directive to find and resolve major issues.
- **Recent experience with storms, such as Hurricane Irene in 2012, and participation in joint exercises helped government and lifeline sectors** to improve emergency response plans, flood preparations, infrastructure hardening, and communication procedures. However, it is unlikely that this level of preparation exists for disasters that this region has not yet experienced
- **Preplanning was the key to success but it is getting harder to do** because when large storms follow unpredictable paths across broad geographic areas, companies tend to implement plans earlier and hold onto resources longer, stressing mutual aid agreements. Political directives to not release repair crews to neighboring states until in-state repairs were 100% complete ignored long-standing mutual aid procedures.

Study Group Finding 3: Planning, analysis, and risk management at the regional level is essential for long-term resilience

- Critical infrastructure owners and operators in the region increasingly recognize the **need for investment in innovative infrastructure upgrades**, both in the short term and over longer time frames, to make infrastructures more resilient and protected against risks the region has not yet faced. It is **difficult to justify large capital investment in resilient infrastructure** without public support and the ability to recoup costs. Recent experience with losses from catastrophic events provides tangible evidence of the economic and public health consequences of weak infrastructures. Sandy has created a strong business case in the public and private sectors for billions of dollars of investment in infrastructure hardening and technology upgrades. However, regions will be left unprepared if past experience is the primary motivator for investments. Planners should consider a variety of operational, sustainability, social, and resilience benefits when conducting benefit/cost analyses of future infrastructure investments.
    - Public officials and infrastructure owners and operators are now challenged to **rebuild smarter, but are uncertain what level to build to** that will strengthen resilience to future risks.
- Federal funding under the Stafford Act and state **disaster funding concentrates the majority of resources on the recovery phase of a disaster**, rather than preparedness. A paradigm shift is needed in the way the nation approaches and funds regional resilience.
- **Sandy's storm surge caught many operators and public officials by surprise,** overwhelmed some critical facilities, and damaged or destroyed infrastructure. Some emergency personnel did not understand or believe storm surge predictions. Forecasts during Sandy from the National Oceanic and Atmospheric Administration (NOAA), while quite accurate, were confusing and not well understood. The storm surge, or abnormal storm-related rise of water, was predicted at 6-11 feet but came at a high tide, creating a total storm tide of up to 14 feet. Had they understood the warning language and its implications, more owners and operators would have preemptively shutdown at-risk facilities to avoid equipment damage.

Study Group Finding 4: Impediments to rapid response and recovery remain despite efforts to remove them.

- Owner and operator **inability to gain access to disaster areas** during Sandy to repair critical facilities was a major barrier to rapid recovery of the lifeline sectors. The lack of a commonly accepted credential for recovery workers across municipalities, parishes, states, and Federal jurisdictions impedes recovery. Lifeline sector repair crews were not considered emergency responders by state and local law enforcement in many cases and were routinely denied access to disaster areas containing critical assets.
- **Rapid response during Sandy was hindered by existing laws and regulations** at the Federal, state, and local level and uneven processes for receiving waivers.
- **Differences in state and local laws across regions** continue to hinder rapid recovery. In Sandy, for example, the requirement for various permits and waivers across states complicated fleet movement of emergency repair crews, while concerns about violating anti-gouging regulations prevented some service stations from procuring transportation fuel supplies from more distant regions due to higher costs that would result in higher prices for consumers.

Study Group Finding 5: Effective communications at all levels, using multiple tools and methods, was pivotal to success during Sandy.

Efforts to establish strong communication channels among public and private partners before, during, and after Sandy paid off in the lifeline sectors. It was aided by the availability of standard communication equipment such as landline, cell phones, satellite, and internet communications, which, had they failed to a greater degree, may have compromised the effectiveness of communications and coordination.

- **Co-location of key officials from lifeline sectors and public agencies in state and Federal emergency operations centers** improved communications and accelerated public-private situational awareness, coordination, prioritization, and decision-making. The inclusion of utility representatives in state EOCs and the FEMA National Response Coordinating Center, in many cases for the first time, was helpful and quickly recognized as a best practice.
- **Social media,** when leveraged effectively, became a valuable communication tool and new information stream to support situational awareness, provide notifications, and control rumors. However, this tool was only partially exploited by government agencies and lifeline owners and operators. Social media platforms are

Exhibit 38. Social Media: An Emerging Tool in All Sectors

Social media was highlighted as a game-changing tool in emergency response, and lifeline sector organizations, government agencies at all levels, and non-profit organizations are using it in new and innovative ways to support response and gather new information. Examples can be found throughout, but especially in the following sections:

- State and Local Government text box: Innovative Social Media Use in Philadelphia and Boston
- Transportation: Social media and digital communication were extensively used to communicate with the public
- Non-Profit Organizations and Community Groups: Social media was a critical tool for organizations to survey community needs, match needs with resources and personnel, and provide rumor control

rapidly evolving tools, and many users learn by trial and error. For nascent users, Sandy revealed the potential of social media as a flexible, real-time, and two-way communications tool with key stakeholders.

- Despite improvements over past storms, **situational awareness and communication of conditions continued to be a challenge** during Sandy. Growing public expectation of immediate and accurate restoration estimates challenged utilities that were dealing with unprecedented damage. While public and private utilities provided frequent impact updates to state and local emergency managers, officials often did not fully understand what damage assessments meant in terms of actual service loss, nor the true threats to some critical infrastructure (such as the loss of power and pump failures at water and wastewater facilities). States and municipalities are working to install interoperable disaster management software that can accept and better analyze real-time data directly from utilities and other agencies.

Study Group Finding 6: Regional resilience relies on the capacity of individuals and communities to strengthen local readiness and personal responsibility for short-term survival.

Sandy and other recent disasters have led at-risk communities to view themselves as survivors rather than victims and build stronger community ties and survival capabilities.

- The impacts of recent regional disasters such as Sandy are starting a **culture shift toward community readiness and personal responsibility for short-term survival**. The potential severity and wide geographic reach of storm events is raising public awareness of the need to maintain self-sufficiency immediately following a disaster. Emergency managers are also recognizing the importance of the "soft sectors" in emergency response, such as child care and housing for critical response personnel who otherwise may be unable to leave their families.
- Sandy underscored the **important role that non-profit and community groups** play in assisting communities to respond in flexible and innovative ways and execute long-term recovery from disasters. Traditional non-profit organizations also work with communities to train and prepare for disaster response, while community groups offer strong networks of individuals that can be leveraged in an event. Sandy also highlighted the important role of ad hoc volunteer organizations that formed during response to fill service gaps and respond with agility.

Superstorm Sandy Case Study Group Conclusions

The Superstorm Sandy findings highlight many of the lessons on how the Northeast states can become more resilient to large regional storms. But the Sandy experience also reveals new insights that can inform public and private partners on how to make all regions more resilient for all hazards. The Superstorm Sandy Study Group conclusions listed below attempt to identify steps that can be taken to achieve this.

Study Group Conclusion 1: Maintaining the Continuity of the Lifeline Sectors

- **State and local governments should make planning and coordination with the lifeline sectors a high priority** to help maintain continuity of service and recover rapidly during disasters. This requires a unified, long-term approach that builds relationships, mutual practices, and operational understanding that is essential during disasters. It should also include coordination among decision-makers who design and invest in new infrastructure to ensure they take advantage of resilient features. Placing representatives from the lifeline sector within state and Federal EOCs should be recognized as a best practice.
- To improve regional disaster coordination and response, public officials and infrastructure owners and operators need a **better understanding of the operations, response, and recovery processes used within the lifeline sectors**. A lack of insight into lifeline sector operations can hinder response and recovery if decision-makers do not recognize the interrelationship of restoration priorities among lifeline sectors.
- Owners and operators **conduct outreach, communication, and education up front** so partners understand key priorities and operating procedures to avoid diverting resources to partner education during an event.
- **Critical infrastructure nodes that are essential for core functions within each region should be identified through collaborative planning at the regional level, then hardened and protected**. This will require public sector leadership and support, as private service providers typically work to harden their most critical infrastructure nodes, rather than optimize resilience of all critical assets across an entire region. Government leaders can convene multiple sectors and jurisdictions to help identify where these interests overlap. Individual optimization of resilience investments in the private sector can still lead to suboptimal resource investment when viewed from a regional perspective.
    - **Pilot regions could be chosen to perform cross-sector interdependency reviews** and identify critical points of failure, opportunities to build in redundancy, and improve understanding of risks within interdependent sectors. These pilot processes can formalize and optimize a review process other regions could follow, which in turn can create a process for sharing and disseminating lessons learned.

Study Group Conclusion 2: The Importance of Partnerships and Cross-Sector Coordination

- **Regional cross-sector councils for lifeline sector companies** would help coordinate planning, response, and recovery of critical infrastructures within regions. Councils should have participation from senior executives. Institutionalizing and strengthening existing relationships requires a process-based approach that frequently engages partners in non-disaster circumstances.
- **Proactive sharing of best practices and lessons learned** from past disasters and training exercises should be encouraged within and across regions to build regional resilience. Past events and well-designed exercises often reveal key lessons and new ideas that should not be limited to the affected region alone.

- **Joint exercises are one of the most effective tools** to help regions identify interdependencies and potential gaps, prepare for catastrophic events, and build cross-sector partnerships between disasters. While losses from past events can be an effective motivator for resilience improvements, regions cannot adequately prepare for future events—especially those without precedence—without exercises that expose hidden risks and coordination challenges. Drills and exercises keep partners engaged between events, encourage knowledge transfer to mitigate employee turnover, and build "muscle memory" to make response automatic and well-coordinated.
    - **Incentives are needed** to motivate owners and operators of lifeline sectors to participate in regional exercises. In turn, greater recognition and participation from senior officials in state and Federal government are needed

Study Group Conclusion 3: Regional Planning, Analysis, and Risk Management

- There is a growing recognition among planners that **more sophisticated forecasting, planning, and modeling is needed** to accurately assess future risk and inform investments to prepare for potentially larger, different, and more frequent storms or natural disasters.
    - **New and better data** on changing weather and climate patterns, rising sea levels, and potential flood zones is needed to help regions and sectors determine how to best strengthen infrastructure for emerging risks. Owners and operators recognize the changing risk environment but cannot respond without reliable data and industry-recognized best practices for building resilience into infrastructure.
- **Incentives are needed to stimulate capital investment in innovative technologies and resilient infrastructures.** Regulated industries especially still face difficulty recouping costs and justifying to utility commissions the need for pre-emptive resilience investments.
- **A regional or national shared spare parts inventory** can help speed repairs, reduce the failure risks of components with long manufacturing lead times, and mitigate the risk of aging infrastructure that relies upon obsolete parts. Systems in adjacent regions that use interoperable parts within a sector can share the expense of maintaining reserve parts—especially for large equipment such as transformers—and help owners and operators locate rare replacement parts from systems outside the region.

Study Group Conclusion 4: Impediments to Rapid Response

- **State and Federal regulations should be reviewed** to identify and remove barriers to rapid recovery, and a process for **coordinating and streamlining of waivers** and waiver authorities is needed. A playbook of waiver processes that are activated by certain emergency declarations or impending conditions can codify lessons learned and procedures from past events and prevent owners and operators from diverting time to the same lengthy waiver request processes for each similar event.
- **National access control and credentialing is needed for lifeline sector operators to be considered emergency responders** to expedite recovery in disaster areas.

Study Group Conclusion 5: Leveraging Social Media

- **Social media represents a powerful but underdeveloped tool** for improving situational awareness for operators and communicating with the public outside traditional channels. Pioneering cities and counties can offer best practices, lessons learned, and new ideas for dynamic information sharing. Agencies, sectors, and non-profits are seeking training, dedicating more individuals to social media, and exploring new uses for two-way information sharing and crowdsourcing of information during disasters.

Study Group Conclusion 6: Building Community Capacity

- **Public education and awareness is needed to raise expectations of individual and community responsibility** in an event and build a culture of preparedness. Broad community messaging in non-disaster time is needed to cultivate this culture shift and better prepare citizens both physically and emotionally for anticipated hardships following major events. This should be accompanied by honest estimates of service outages and duration from utilities and emergency management officials.

Appendix E: Investment in U.S. Infrastructure

A cursory review of available literature enabled the NIAC to determine a very rough estimate of the order of magnitude of annual infrastructure investment in the United States. There does not appear to be an accurate or consistent method of accounting of how much is invested each year in new or upgraded infrastructure in the United States. Although no Federal agency or independent organization separately tracks such information, estimates could be compiled by drawing upon a variety of sources and normalizing the data to a common definition of infrastructure and a common year of analysis. However, conducting such an analysis was beyond the scope of the Council's study. To reach a rough estimate—enough to support a ballpark understanding of the magnitude of the nation's annual infrastructure investment—we provide a synopsis of available data and a rationalization of our estimate. Five sources—the Brookings Institution, the Council on Foreign Relations, the Cato Institute, the American Society of Civil Engineers (ASCE), and the McKinsey Global Institute—provide estimates of infrastructure investment, although each uses different data sets, definitions of infrastructure, and years of analysis. Our review of these sources suggests that **between $323 billion and $2.3 trillion is invested each year in new infrastructure in the United States. This translates to $885 million to $6.30 billion each day.**

The biggest divergence in these estimates appears to be related to 1) how infrastructure investments are defined, 2) which infrastructures are included, and 3) how private sector investments are handled. Of the five estimates examined in this analysis, four are within 15% or less of each other ($323 billion to $374 billion). By contrast, the estimate by the Cato Institute is $2.3 trillion per year and includes private sector investment, estimated at five times non-defense gross fixed investment by Federal, state, and local government. The government investment by Cato Institute is $372 billion, which tracks closely with the other sources. **Considering these five estimates, it is likely that roughly $1 billion/day or more is invested in U.S. infrastructure each day.**

Below is a brief synopsis of each estimate.

Brookings Institution

According to a 2008 report from the Brookings Institution, *An Economic Strategy for Investing in America's Infrastructure*, "in 2004, total spending on transportation was at least $210 billion, total spending on drinking water and sewerage at least $76 billion, and new capital spending on energy $78 billion" (Deshpande and Elmendorf, 2008, p. 17). **This represents, for 2004, a total of nearly $364 billion in both public and private spending for the major categories of physical infrastructure. Investment per day would be about $997 million. Over the last 50 years, gross infrastructure investment has declined as a percent of the economy, and shifted from relatively new investment to operation and maintenance** (Deshpande and Elmendorf, 2008). Net investment—gross investment minus depreciation—fell from nearly 2.5% of GDP in the 1970s/80s to around 1% in the 1990s, though estimates show it has risen in the past decades (Deshpande and Elmendorf, 2008; see Exhibit 39).

Exhibit 39. U.S. Net Public Infrastructure Spending, 1929-96

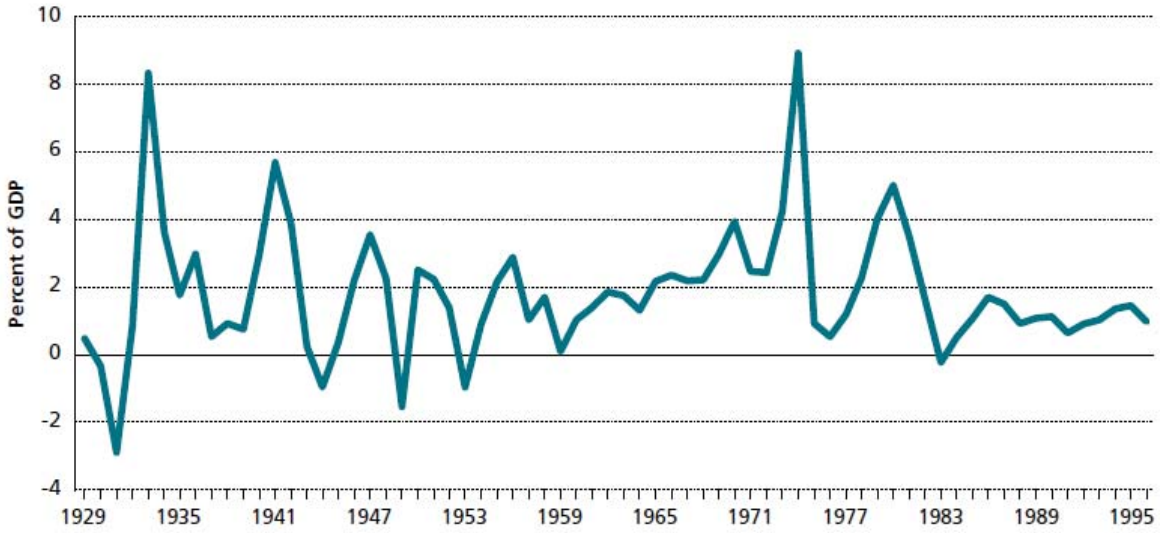


Exhibit courtesy of: Deshpande and Elmendorf, 2008 (The Brookings Institution) via Bureau of Economic Analysis 2013a
Includes highways and streets; water and sewer systems, electric and gas facilities, and airfields.

Council on Foreign Relations

The Council on Foreign Relations, in a 2012 memorandum titled "Encouraging U.S. Infrastructure Investment," states that U.S. "public infrastructure investment, at 2.4 percent of GDP, is half what it was fifty years ago" (Thomasson 2012). The recent year in question was not provided, and several other sources have cited this figure between 2008 and 2013, including The Brookings Institution in 2008 (Deshpande and Elmendorf, 2008). In 2008, real GDP was $12.88 trillion, and in 2011, real GDP was $13.44 trillion in 2005 adjusted dollars (Multipl, 2013). (GDP roughly fluctuated between these two figures during 2008-2011). **At 2.4%, that would make public infrastructure investment between about $307 billion in 2008 and about $323 billion in 2011. Investment per day would be between about $841 million and $885 million.**

Cato Institute

The Cato Institute published a study in January 2013 which compiled both private sector and public infrastructure investment in 2011. The report stated: "Most of America's infrastructure investment is provided by the private sector, not governments. Indeed, private infrastructure spending—on factories, warehouses, freight rail, pipelines, refineries, and many other items—is about four times larger than Federal, state, and local government infrastructure spending combined. If defense spending is excluded, private spending is about five times greater than government spending. [Exhibit 40, replicated her from the Cato report] shows data on gross fixed investment, which is a broad measure of infrastructure spending. In 2011 private investment was $1.818 trillion, compared to government investment of $480 billion" (Edwards 2013).

Using Cato's figures, total gross fixed investment for 2011 from both private and public sources was about $2.3 trillion dollars. Investment per day would be about $6.3 billion. However, public infrastructure investment, excluding defense, was about $372 billion in 2011, or about $1 billion per day.

Exhibit 40. Gross Fixed Investment, 2011, Billions of Dollars

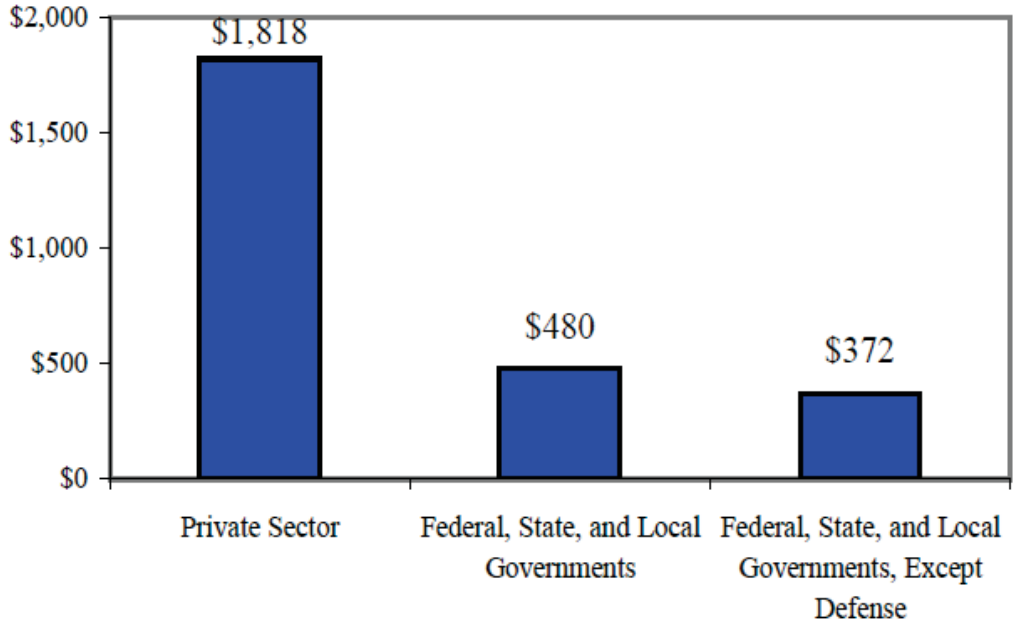


Exhibit courtesy of: Edwards 2013 (Cato Institute) via Bureau of Economic Analysis 2013b

American Society of Civil Engineers

The American Society of Civil Engineers has conducted studies known as the Failure to Act Economic Studies and an annual series known as Report Card for America's Infrastructure. These studies provide fairly specific estimates of the levels of future investment required to upgrade infrastructure for the future. They also include estimates of current levels of investment but they come from various sources and are not uniform in their infrastructure investment criteria. However, we have taken estimates for the critical infrastructure sectors for which annual investment figures were provided from the 2013 Report Card for America's Infrastructure to reach an estimate of current annual infrastructure investment.

Aviation ($3.35 billion annual infrastructure investment)

"The primary source of the FAA's [Federal Aviation Administration] capital programs and general operations is the Airport and Airway Trust Fund (Trust Fund)…. When Congress reauthorized the FAA in 2012, the AIP [Airport Improvement Program, for airports significant to national security] was authorized at $13.4 billion over four years or approximately $3.35 billion annually" (ASCE 2013, Aviation).

Bridges ($12.8 billion)

"The Federal Highway Administration estimates that to eliminate the bridge backlog by 2028, the nation would need to invest $20.5 billion annually; however, at this time only $12.8 billion is being spent annually on the nation's bridges" (ASCE 2013, Bridges)

Inland Waterways ($1 billion)

"According to the U.S. Army Corps of Engineers, maintaining existing levels of unscheduled delays on inland waterways, and not further exacerbating delays, will require more than $13 billion by 2020, while current funding levels are expected to be just $7 billion during this period" (ASCE 2013, Inland Waterways). That means, for the 7 years between 2013 and 2020, that annual inland waterways infrastructure investment will be about $1 billion.

Ports ($9+ billion)

"U.S. ports and their private sector terminal partners plan to spend more than $46 billion over the next five years on port terminal facilities, according to the American Association of Port Authorities. That equates to over $9 billion per year, of which more than one-third is spending by the port authorities themselves" (ASCE 2013, Ports).

Rail ($24.8 billion)

Freight rail investment averaged about $20 billion per year between 2009 and 2012, and Federal investment in Amtrak averages about $1.50 per American per year—or about $475 million, for a total of $20.4 billion (ASCE 2013, Rail).

Roads ($91 billion)

"While the conditions have improved in the near term, and Federal, state, and local capital investments increased to $91 billion annually, that level of investment is insufficient and still projected to result in a decline in conditions and performance in the long term" (ASCE 2013, Roads).

Transit ($52 billion)

"The expansion of transit systems in recent years has been made possible through a substantial increase in overall funding for transit – more than 36% since 2000, totaling over $52 billion from all sources in 2008" (ASCE 2013, Transit).

Schools ($10.3 billion)

"In the four years since 2008, the funding pipeline for school facilities construction has continued to slide, from a modest $16.4 billion down to a projected $10.3 billion estimated for 2012" (ASCE 2013, Schools).

Energy – Electricity ($63 billion), Oil and Natural Gos (no figures provided)

"From 2001 through 2010, annual capital investment in electricity infrastructure averaged $63 billion, including over $35 billion in generation, $8 billion in transmission, and nearly $20 billion in local distribution lines. Funding comes from a variety of sources, including government agencies, regulated utilities, private companies and developers, and nonprofit cooperatives" (ASCE 2013, Energy).

Levees (at least $415 million)

Public infrastructure investment is about $415 million annually from the USACE; no figures provided on state, local, or private investments (ASCE 2013, Levees).

Wastewater and *Drinking Water ($95 billion in 2008)*

"State and local governments incur approximately 98 percent of the capital investments annually to maintain and improve the infrastructure. In 2008, state and local governments estimated their total expenditures at $93 billion annually for wastewater and drinking water infrastructure…. Congressional

appropriations totaled approximately $10.5 billion between 2008 and 2012—about $2.1 billion annually" (ASCE 2013, Wastewater and Drinking Water). Annual infrastructure investment in 2008 was about $95 billion.

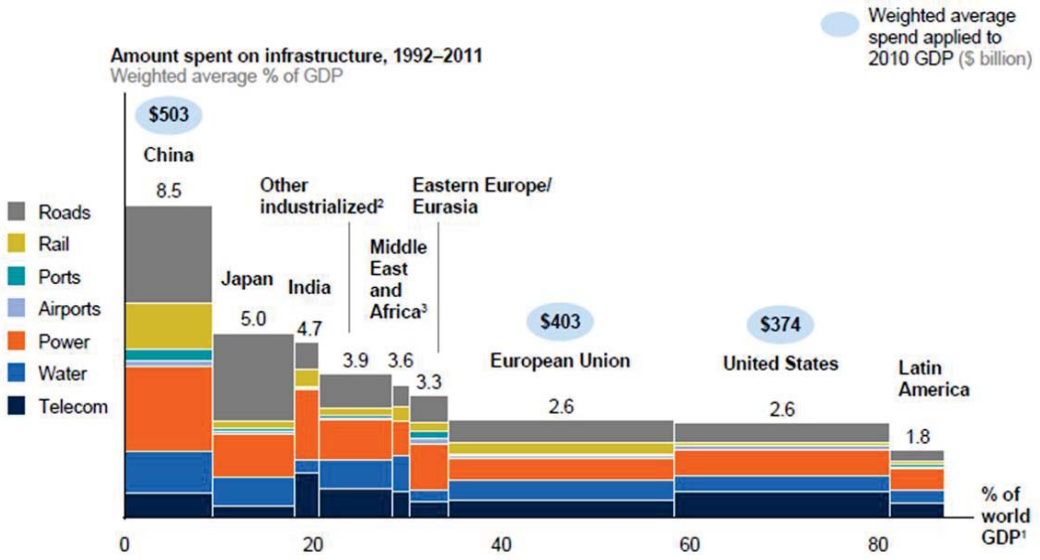
Using the ASCE figures, the annual infrastructure investment is estimated to be in excess of $363 billion, or more than $994 million each day. Because complete information was not available for all sectors, and several only provided Federal investment figures, the actual annual infrastructure investment is likely much higher.

The main purpose of the ASCE Report Card is to identify gaps in infrastructure investment. ASCE estimates that a $3.6 trillion investment in the nation's infrastructure will be needed by 2020 in order to bring the infrastructure up to a grade of "B." They estimate current likely funding of $2.0 trillion, leaving an investment gap of roughly $1.6 trillion. Roughly half of this gap ($846 billion) is in surface transportation, which is nearly 100% owned and operated by the public sector. Looking across all eleven sectors examined by ASCE, **it is estimated that about 85% of the 2020 infrastructure investment gap is for publicly owned infrastructure**.

McKinsey Global Institute

The McKinsey Global Institute (MGI) released a report in January 2013 entitled *Infrastructure Productivity: How to Save $1 trillion a Year*. Like the ASCE series, the report attempted to estimate the size of the infrastructure gap, but on a global basis. In the report, MGI estimates that the **weighted average annual spending on U.S. infrastructure from 1992 to 2011 was $374 billion, or about $1025 million per day** (McKinsey Global Institute 2013; see Exhibit 41). Infrastructures included roads, rail, ports, airports, power, water, and telecommunications.

Exhibit 41. Weighted Average Annual Spending on Infrastructure



1 Percentage of 2010 world GDP generated by the 86 countries in our analysis.
2 Australia, Canada, Croatia, Iceland, Lichtenstein, New Zealand, Norway, Singapore, South Korea, Switzerland, Taiwan (Chinese Taipei), and the United Arab Emirates.
3 Excludes unusually high port and rail data for Nigeria; including these data brings the total weighted average to 5.7 percent.
SOURCE: IHS Global Insight; GWI; IEA; ITF; McKinsey Global Institute analysis

Graphic courtesy of: McKinsey Global Institute 2013.

Appendix F: Lessons from the SLTTGCC on Regional Resilience

The Council reviewed insights from the State, Local, Tribal, and Territorial Government Coordinating Council (SLTTGCC) to examine how the national partnership engages SLTT and regional partners, and review recent work the SLTTGCC has done to inform regional resilience efforts. The SLTTGCC serves as the forum to fully integrate SLTT homeland security directors and partners as active participants in national critical infrastructure security and resilience efforts. It provides an organizational structure to coordinate across jurisdictions on state and local government critical infrastructure security and resilience guidance, strategies, and programs. SLTTGCC members and their network of SLTT alliances across the country have the jurisdiction within their states or regions to determine state and local approaches to critical infrastructure security and resilience, and to partner with private- and public-sector critical infrastructure owners and operators in each region. **This makes the SLTTGCC a key mechanism to coordinate federal resilience efforts with state and local activities in each region**.

The SLTTGCC has conducted numerous studies and published several reports that examine how SLTT governments build and sustain public-private partnerships and how they design and implement infrastructure resilience programs in their communities. The following sections review key lessons and insights from the SLTTGCC.

The Value Proposition of Regional Partnerships

In 2011, the SLTTGCC examined regional consortia across the nation to identify the value proposition for SLTT partners to join regional public-private partnership consortia. Their report, *Regional Partnerships and the Critical Infrastructure Protection and Resilience Mission*, determined that any successful partnership must offer one of the following critical benefits:

- Align critical infrastructure protection and resilience efforts to a region's common hazard or threat environment.
- Achieve a broader and holistic common operating picture of regional critical infrastructure assets and their independencies.
- Identify best practices that can be adopted in a member's own jurisdiction.
- Create new resources and funding opportunities to support regional critical infrastructure activities.
- Leverage expertise and skill sets of coalition members.
- Establish common protocols to govern interactions between owners and operators of critical infrastructure and SLTT governments.

Another SLTTGCC report, *Critical Infrastructure and Key Resources Partnerships: State Characteristics and Capabilities*, examined SLTT government-led partnership efforts to determine how they are structured and the value they provide. The majority of state programs focus on all regional issues, but take a sector-specific approach. Second in line were programs that take a cross-sector approach to multiple issues, followed by those that are formed around one specific regional issue with a cross-sector approach. No matter the design, the SLTTGCC found that sustaining an effective partnership requires that the partnership continuously demonstrate value not only to its participants (both public and private sector),

but also to the policymakers whose support may be necessary to continue the partnership (e.g. governor, state legislature, mayor). Paramount to defining value is the partnership's development and distribution of tangible and useful products, as well as increasing access to information to enable decision-making.

Some of the greatest barriers for SLTT involvement in regional organizations are time and personnel/resource barriers, and the inability to measure tangible outcomes of participation, such as resource savings, connections with the private sector, and new strategies and programs. The report concluded that many successful consortia they examined have formed in the following ways:

- Using homeland security or Urban Area Security Initiative (UASI) grants.
- Through either existing regional collaborations, or through leadership from a high-level figure.
- Following a major disruption (e.g., disaster, trade disruption) that brought the value of working together to the forefront.

SLTT Resilience Best Practices and Challenges

In 2011, the SLTTGCC examined how SLTTGCC members are leveraging their critical infrastructure partnerships and DHS Office of Infrastructure Protection tools to further advance infrastructure resilience in their regions. The study, *Landscape of State and Local Government Critical Infrastructure Resilience Activities and Recommendations*, revealed a best practice infrastructure resilience model, which includes the following four steps:

- Establish cross-sector public-private partnerships focused on the region's key lifeline sectors.
- Use those partnerships to assess each lifeline sector's interdependencies and cascading effects that could influence the sector's recovery time.
- Employ an exercise or workshop to uncover unknown sector interdependencies and test current levels of preparedness.
- Address the "outside the fence line" cascading effects on each lifeline sector that would fall to the local or state government to address through its emergency operations plan.

SLTT government resilience efforts primarily focus on four main activities: enhancing partnership development, improving emergency operations centers and integrating private-sector representatives, conducting response exercises with the private sector, and leading individual and private-sector readiness campaigns. However, SLTT governments reported that long-term incident recovery and designing resilience into the infrastructure were either not a priority or not considered under their purview.

The NIAC considered many of the challenges SLTT governments face in fostering infrastructure resilience in their communities, including the following:

- Trusted partnerships with industry and lifeline sectors take a significant amount of time and resources to establish. Owners and operators may be reluctant to share details about their restoration requirements.
- Many SLTT governments are only beginning to understand infrastructure interdependencies and cascading effects of disruptions.
- Mission responsibilities are often split between different State and local agencies, creating silos.

- Many SLTT and regional partnerships have not reached the level of maturity to transition from an infrastructure *protection* to an infrastructure *resilience* approach.

Insights from the SLTTGCC provided the NIAC with key information on resilience strategies, priorities, and needs from SLTT governments, providing direct insights from the government representatives who are responsible for forming and engaging in regional partnerships to improve national resilience.

Appendix G: Summary of Regional Resilience Organizations, Guides, and Processes

Two objectives of this study were to examine best practices and process improvements for regional resilience efforts. To gain insight into existing efforts, the Council studied two types of organizations working in regional resilience:

- Region-specific resilience consortia, non-profit organizations that bring together stakeholders to address specific cross-sector, public-private security and resilience issues in their region, exercise regional response plans, and build relationships that support disaster response.
- Cross-sector organizations and university-led initiatives that examine processes to improve regional resilience and recommend best practices and models that each region can use in building its own resilience.

The Council also examined progress from the U.S. Department of Homeland Security (DHS) Regional Resilience Assessment Program (RRAP) to understand the processes and effectiveness of multi-sector, public-private, region-specific resilience assessments.

This appendix summarizes best practices and lessons learned from these organizations, and gives a brief overview of existing models and processes that regionally based organizations have developed and piloted to assist individual regions in strengthening resilience.

DHS Regional Resilience Assessment Program

In 2009, DHS launched the Regional Resilience Assessment Program (RRAP) to analyze and assess the critical infrastructure systems, assets, and interdependencies within individual regions and identify opportunities for improvement. Recognizing the inherent individuality of regional infrastructures and risk, the RRAP projects enable regional homeland security officials and critical infrastructure partners to tailor assessments to the critical assets in their region and define opportunities to strengthen resilience. From 2009-2013, DHS conducted 35 assessments across the United States, implementing a combination of vulnerability assessments, regional analysis, and research related to the RRAP focus areas. Examples include:

- The 2009 New Jersey Exit 14 RRAP, which focused on lifeline sectors within a 10-mile radius of New Jersey Turnpike Exit 14 and service continuity during a large-scale terrorist attack
- The 2010 Atlanta Centennial Olympic Park RRAP, which focused on the security and dependencies of Atlanta's main tourist, business, and government district to inform urban design and cooperative planning.

Each year-long project helps partners identify critical cross-sector issues, operational dependencies or chokepoints, and planning and communications gaps. By offering unique opportunities for relationship building, enhanced coordination, and broader awareness among diverse interconnected stakeholders, the RRAP has catalyzed stronger and more informed public-private partnerships to tackle infrastructure security and resilience issues.

Regionally Based Resilience Capabilities and Methodologies

Dozens of regional organizations and consortia have formed across the country to solve national and region-specific security challenges and collaboratively build resilience to regional hazards. To inform its study, the NIAC examined both **region-specific consortia and the resilience models and processes developed by resilience-focused organizations** to identify common challenges and success factors for regional resilience. The study included a literature review and direct interviews with leaders from five organizations. The Council concluded that:

1. **Existing regional resilience consortia may provide best practices and lessons learned** on forming regional organizations, building public-private partnerships across sectors, conducting regional assessments and exercises, and collaboratively solving persistent regional problems.
2. **Non-profit resilience organizations have developed individual processes and models for regions to use** when building resilience that coalesce around four steps: Identify a neutral convener to lead resilience efforts and involve stakeholders early; assess and establish a baseline of regional risk; examine gaps through exercises and workshops; and develop and implement an action plan. Some of these processes are currently being piloted by U.S. regions.

The following table summarizes the region-specific consortia and regional resilience organizations the NIAC examined during this study.

Organization	Area Covered	Operating Model	Services	Notable Activities
Pacific Northwest Economic Region (PNWER) www.pnwer.org	United States: AK, ID, OR, MT, WA Canada: British Columbia, Alberta, Saskatchewan, and Yukon and Northwest Territories	Members passed legislation to form and join the organization. The board includes governors, legislators, and business leaders, and funding is provided by state/provincial governments, Federal grants, and private sponsorship.	PNWER's Center for Regional Disaster Resilience exercises infrastructure interdependencies, develops bi-annual action plans, and pilots tools and technologies for stakeholders that can apply to multiple regions.	Large-scale exercises: The Blue Cascades Exercise Series simulates large-scale disasters with impacts that cascade across the region to identify infrastructure interdependencies. The Emerald Down Exercise Series simulates full-scale cyber attacks.
All Hazards Consortium www.ahcusa.org	State-sanctioned non-profit includes DE, MD, NJ, NY, NC, PA, VA, WV, and DC	Brings together industry, universities, state homeland security and emergency management offices, and citizen leadership from across the region.	Eight working groups bring stakeholders together to plan regional multi-state workshops and summit meetings, draft white papers, and solve tactical problems in the region.	The Multi-State Fleet Movement Working Group is working to streamline waiver and permitting processes for interstate fleet movement, remove delays at toll booth crossings, and resolve fleet credentialing.

Organization	Area Covered	Operating Model	Services	Notable Activities
U.S. Resilience Project www.usresilienceproject.org	Works nationally with cross-sector owners and operators of critical infrastructure	Established to examine how private-sector best practices can be leveraged by national initiatives to increase the resilience of companies, communities, and the nation.	Aims to capture the best practices, processes, and tools from cross-sector businesses; integrate commercial best practices into national strategies and plans; and educate business and government leaders on new resilience tools.	Developed *Priorities for America's Preparedness: Best Practices from the Private Sector*, which examines existing industry best practices that could be used across sectors to better focus government resources to fill gaps.
The Infrastructure Security Partnership (TISP) www.tisp.org	2 million individuals, public agencies, and firms—trade groups, economic planners, architecture firms, standards organizations	Focuses on improving infrastructure resilience by addressing threats from a multi-hazard perspective and serving as a clearinghouse for resilience knowledge, skills, and education.	Co-founded the National Resilience Coalition to build a private-sector driven framework for national resilience that posits that State and regional risk management processes are critical to national resilience.	Developed the *Regional Disaster Resilience Guide*, a step-by-step "how-to" guide to develop an actionable plan to improve regional resilience.
Community and Regional Resilience Institute (CARRI) www.resilientus.org	Research institute started with support from the DHS Science and Technology Directorate and Oak Ridge National Lab	Formed to develop and share critical paths that any region or community may take to build its capacity to prepare for, respond to, and rapidly recover from significant disasters.	Began an 18-month effort in 2010 to create the Community Resilience System (CRS), a web-enabled process that communities can use to determine their resilience and take steps to improve.	The CRS pilot program was launched in 8 communities in 2011 with the Meridian Institute, a non-profit problem-solving organization.
American Society of Mechanical Engineers (ASME) Innovative Technologies Institute (ITI) www.asme.org	Brings together government, business, and academia to quickly work together to solve problems.	Provides market-relevant engineering and technology-based products to government, industry, and academia.	ASME-ITI created an objective business process for individual regions to build resilience with available financial and human resources.	It is piloting the Regional Resilience/ Security Analysis Process, which takes a quantitative, engineering approach to improving resilience within a region.

Keys to Successful Regional Partnerships

The following common success elements emerged from NIAC research and interviews with regional resilience organizations:

- A neutral convener is needed to bring the public and private sectors together and build trust.
    - Trust drives regional resilience by enabling information sharing and an understanding of interdependencies, which underscores resilience efforts.

- CEOs face competing priorities and need a strong business case for taking action that shows distinct benefits for their company. Regional governments too need to see an economic benefit for building resilience. Getting the right people to the table is critical.
    - Involving the private sector early in regional resilience efforts gives them ownership and ensures continued participation and implementation.
    - Successful efforts typically begin by identifying private sector needs, inviting the private sector to set the agenda and lead the effort, and working closely with supporting state representatives.
- Leadership, a clear value proposition, and a simple process drive success. Regional groups build trust over time by setting near-term targets and meeting them with tangible results.
- A resilient community or company is one in which economic growth and disaster/risk management teams are planning together.
    - Resilience isn't only about loss avoidance; it underpins growth and can be a competitive differentiator for companies *and* regions. This should be part of the value proposition for participation in joint efforts.
- Regions should focus more on their lifeline sectors and core infrastructures to better address interdependencies. Local communities often do this well, but regional coalitions may get stuck trying to address interdependencies through sector-specific efforts, which can create silos.

Regional Resilience Processes and Guides

TISP, CARRI, and ASME-ITI all provide step-by-step processes that use academic research, regional experience, and existing tools to create guides for assessing regional resilience and developing robust action plans. The NIAC concluded that:

- Regional resilience guides help commonly define regional resilience, identify the fundamental principles of regional resilience, and provide near-, medium-, and long-term recommendations for regions to develop region-specific action plans.
- Their processes are remarkably similar, and are now being piloted by community organizations. They each follow a version of this process:
    - Form a non-profit facilitating organization or coalition to lead resilience efforts.
    - Assess current resilience, typically through a baseline assessment followed by an exercise or workshop.
    - Develop a strategy for improving resilience and outline roles and responsibilities in an Action Plan.
    - Develop an implementation strategy and identify a coalition or organization to lead implementation.

Each resilience guide concluded that infrastructure interdependences are increasingly important, such that regional resilience cannot be achieved without engaging *all* stakeholders: state and local government leaders, non-profit community groups, utilities, and private businesses.

- Community resilience is intricately tied to the resilience of individual businesses and organizations that support the community, and vice versa.
- Public-private regional partnerships for resilience are essential to drive the process. Yet despite the value, participation can be a hurdle in terms of staff time, workload, and financial support for SLTT governments.

Finally, these organizations concluded that resilience improvements require significant capital, yet few models exist to channel Federal resources or shared private resources to regional partnerships or organizations. Work is needed to develop the value proposition and design funding models that direct resources toward regional efforts. A brief overview of each guide follows.

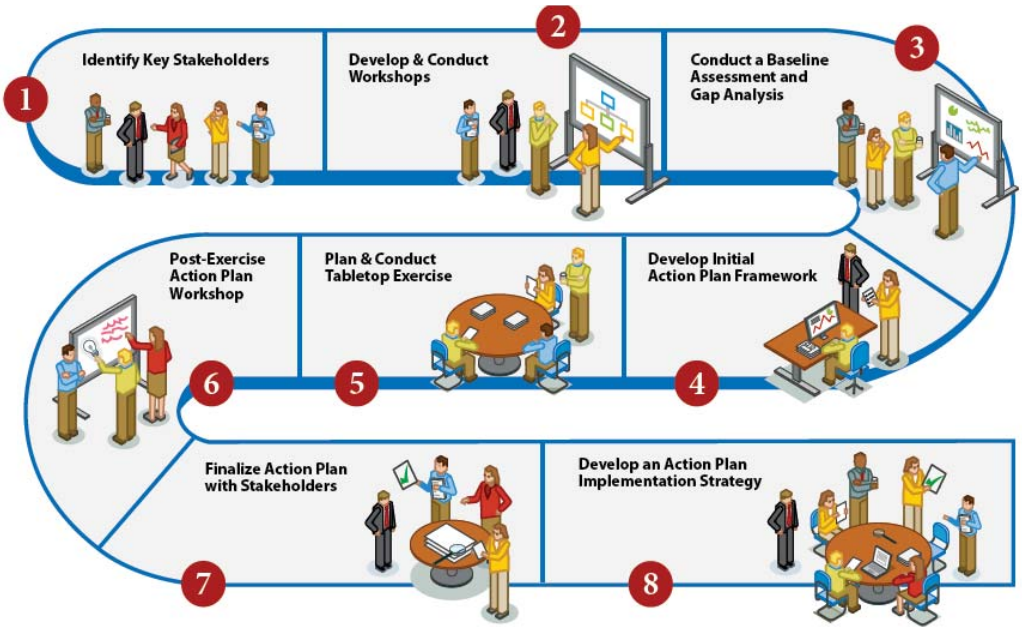
TISP Resilience Guide: Regional Disaster Resilience

More than 100 Federal, state, and local government and private sector organizations came together to develop the 2011 Regional Disaster Resilience: A Guide for Developing an Action Plan. It provides a step-by-step "how-to" guide to develop an actionable plan to improve region resilience. The guide includes:

- Near, medium, and long-term recommendations—many sector-specific—that regions can follow to develop a robust resilience Action Plan
- 14 focus areas that cover the disaster lifecycle, and a comprehensive inventory of interdependency needs, gaps, and recommendations in those areas
- A toolkit with action plan templates and assessment tools

The TISP guide offers a collaboratively developed process (see Exhibit 42) that each region can use to assess and improve resilience among all regional stakeholders.

Exhibit 42. TISP Regional Resilience Process

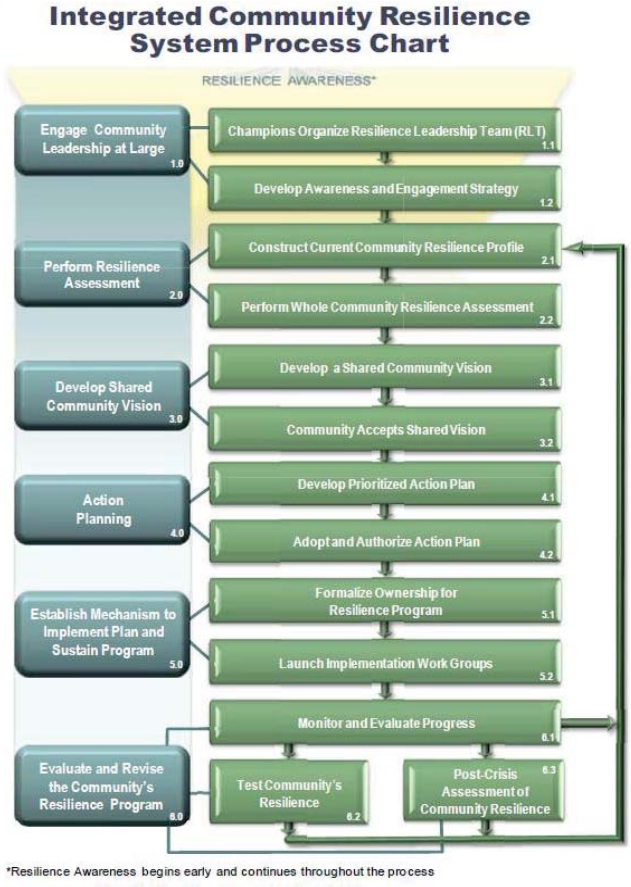


CARRI Resilience Guide: Community Resilience System

The Community Resilience System (CRS) is a six-stage process for building resilience that includes templates, checklists, and tools as well as a web-based tracking system to move through the process (see Exhibit 43). In contrast to the TISP process, CARRI's Community Resilience System focuses on smaller communities within a larger region. However, it also starts with engaging community leadership including organizing a leadership team and developing an engagement strategy. CARRI also recommends determining the current state of resilience through an assessment. The community should develop a shared vision for resilience before creating an action plan with priorities. Following plan adoption,

communities should establish a mechanism for implementation by formalizing ownership of the resilience program and launching implementation work groups. The plan should be monitored, evaluated, and revised. CARRI also advised having post-crisis assessments.

Exhibit 43. CARRI Regional Resilience Process



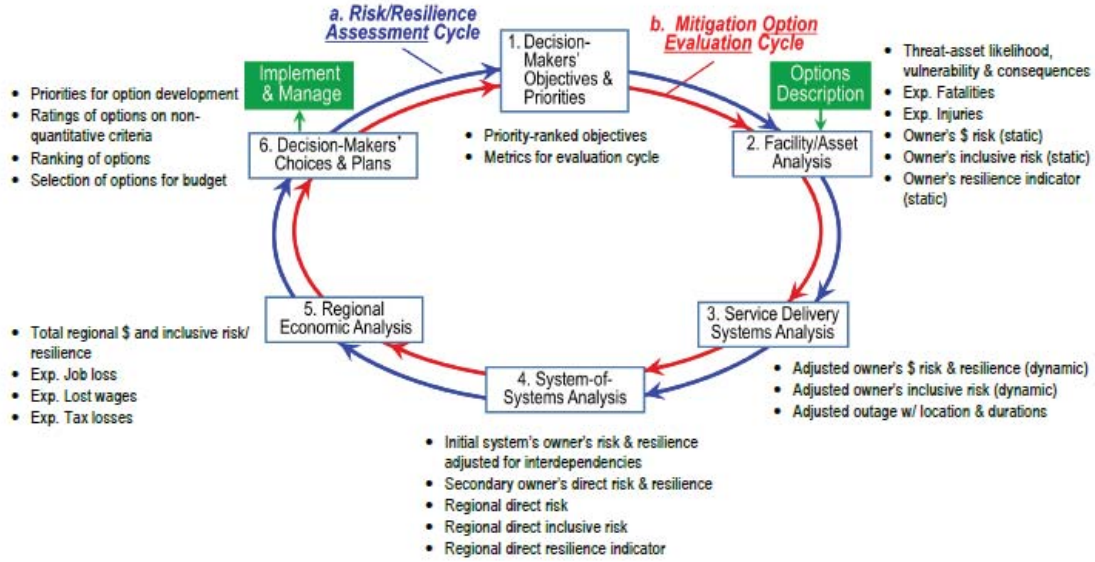
ASME-ITI Resilience Guide: Regional Resilience/Security Analysis Process (RR/SAP)

Developed under a DHS and U.S. Department of Energy contract managed by the Southeast Region Research Initiative (SERRI) of Oak Ridge National Laboratory, the process provides a quantitative, engineering approach to improving resilience (see Exhibit 44). It involves two cycles:

- Risk/Resilience Assessment Cycle—6-step cycle to:
  - Identify the most serious risk and resilience challenges facing the region and its infrastructure, public safety functions, and major industries.
  - Set a baseline for comparisons.
- Mitigation Options Evaluation Cycle—Identify new projects, programs, and/or investments to enhance the resilience, continuity, security, or other high-priority objectives.
  - Defines precisely how and how much the programs and investments would improve resilience, security, and the other criteria; what they will cost; and which would be the most valuable to the owners and to the region's citizens.

Each part of the process has been feasibility tested in four regions. The process was designed to be carried out by onsite, non-specialized, non-expert staff. However, it is still a prototype, and each phase requires additional development and field-testing.

Exhibit 44. ASME-ITI Regional Resilience/Security Analysis Process



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Appendix I: Acronym List

Acronym	Definition
AHC	All Hazards Consortium
APRAS	Automated Permit Routing/Analysis System
ASTM	American Society for Testing and Materials
CARRI	Community and Regional Resilience Institute
COLT	cell on light truck
COW	cell on wheels
CSA	combined statistical area
DHS	U.S. Department of Homeland Security
DIRT	Disaster Immediate Response Team
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DPA	Defense Production Act
EEAC	Energy Emergency Assurance Coordinators
EEI	Edison Electric Institute
EMAC	Emergency Management Assistance Compact
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
ESF	Emergency Support Function
ETR	estimated time to restoration
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FMCSA	Federal Motor Carrier Safety Administration
FTA	Federal Transit Administration
GETS	government emergency telecommunications service
GWOB	Geeks Without Bounds
IFTA	International Fuel Tax Authority
IP	Internet Protocol
IPAWS	Integrated Public Alert and Warning System
IRP	International Registration Plan
ISAC	Information Sharing and Analysis Center
ITDRC	Information Technology Disaster Resource Center
MAP-21	Moving Ahead for Progress in the 21st Century Act
MCOV	Mobile Communications Office Vehicle
MTA	Metropolitan Transportation Authority
NAA	no action assurance
NARUC	National Association of Regulatory Utility Commissioners
NASEO	National Association of State Energy Officials
NCC	National Coordinating Center for Telecommunications
NCSL	National Conference of State Legislatures
NEMA	National Emergency Management Association
NGA	National Governors Association
NGO	non-governmental organization
NIAC	National Infrastructure Advisory Council
NOAA	National Oceanic and Atmospheric Administration

Acronym	Definition
NRCC	National Response Coordination Center
NYC	New York City
NYDOT	New York Department of Transportation
NYPD	New York Police Department
OE	Office of Electricity Delivery and Energy Reliability
OEM	Office of Emergency Management
OSHA	Occupational Safety and Health Administration
PATH	Port Authority Trans-Hudson
PennDOT	Pennsylvania Department of Transportation
PHMSA	Pipeline and Hazardous Materials Safety Administration
PNWER	Pacific Northwest Economic Region
PPD-21	Presidential Policy Directive on Critical Infrastructure Security and Resilience
PSE&G	Public Service Electric and Gas Company
PTI	Public Technology Institute
RC3	Regional Consortium Coordinating Council
RFG	reformulated gasoline
ROIC	Regional Operations and Intelligence Center
RRAP	Regional Resilience Assessment Program
RSF	Recovery Support Functions
RVP	Reid Vapor Pressure
SEC	Securities and Exchange Commission
SEPTA	Southeastern Pennsylvania Transportation Authority
SLOSH	Sea, Lake, and Overland Surges from Hurricanes
STEP	Spare Transformer Equipment Program
STEP (FEMA)	Sheltering and Temporary Essential Power
TISP	The Infrastructure Security Partnership
TSA	Transportation Security Administration
USRP	U.S. Resilience Project
VOAD	Voluntary Organizations Active in Disaster
WARN	Water Agency Response Network
WPS	wireless priority service