National Survey of US Public Transit Agency Experience with and Response to Extreme Weather Events

Report of Survey Findings

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Executive Summary

Extreme weather events pose serious challenges public transit systems. They disrupt transit operations, impair service quality, increase threats to public safety, and damage infrastructure. This report presents findings from a June 2016 national survey of public transit agencies in the United States to understand what types of extreme weather transit agencies are experiencing, what risks are associated with extreme events and how they are responding or preparing for them.

The survey collected data from approximately 900 transit professionals who work in planning, operation, maintenance, and engineering in 273 transit agencies in the U.S. Survey items captured data on recent experiences with extreme weather events, perception of weather risks to the local transit system, assessment of the agency's capacity and challenges in dealing with weather risks, and organizational responses and adaption to extreme weather events and potential climate risks. A total of 352 individuals representing 197 transit agencies responded to the survey (41% response rate) resulting in a rich and unique dataset on extreme weather and transit.

This report provides a descriptive summary and assessment of aggregate survey responses. Findings are presented in four parts: recent experience with extreme weather; perception of weather and climatic risks; assessment of organizational priority, capacity and challenge of managing extreme weather; organizational responses and adaptation to extreme weather events. Sections are summarized briefly here, while more detail is presented in the full report.

Recent experience of transit agencies with extreme weather

- Nationwide, respondents report that severe rainstorms/thunderstorms are the most frequent type of extreme weather event transit agencies recently experienced. Other frequent extreme weather include extreme cold, extreme high winds and extreme heat. Region-specific hazards – hurricanes and tides/storm surges – rank the least frequent types of extreme weather.

- Extreme snow storms are have caused the most severe impacts while flooding has the second greatest impact on transit agencies.

- The most common consequence of extreme weather to transit agencies are significant delays in transit service, followed by temporary shutdowns and damage to vehicles or equipment.

- More than half of the respondents indicated that their agencies had used re-routing or partial closures of some routes due to extreme weather. Approximately one third of all respondents indicated their agencies had closed services at some transit stations or at the system level in response to severe weather events.

Transit professionals perceptions of weather and climatic risks

- Respondents' perception of future weather risks are heavily influenced by their recent experiences with extreme weather events: severe rainstorms/thunderstorms impose the

greatest risk, followed by extreme high winds, extreme heat wave, extreme snow storms and cold temperatures.

- Transit professionals in the U.S. recognize that extreme weather events are occurring more frequently and becoming more severe. They are aware of and concerned with the impacts imposed by extreme weather on transit operation and infrastructure, and they recognize need for transit agencies to prepare for extreme weather in advance.

Assessment of transit organization priority, capacity and challenges of extreme weather

- Among all types of public safety risks, extreme weather was ranked second highest, after accidents and/or collisions.

- Respondents indicated moderate-to-high level of confidence with coping with extreme weather events. Many believe their agencies possess adequate weather information, internal expertise/staff, and adequate emergency plans. They are positive about their prior efforts to cope with extreme weather events, and optimistic about their agency's capacity to respond to these events in the future.

- Access to financial resources was reported to be the greatest challenge to preparation for extreme weather.

Transit organization responses and adaptations to extreme weather events

- Overall, transit agencies are more likely to adopt generic risk-mitigating strategies (e.g., information technology, investing in back-up power supplies) so that their benefits can be maximized under various emergency situations.

  o A majority of responding agencies have adopted an emergency management strategy to address extreme weather: hired professionals in charge of emergency responses; developed emergency plans; conducted safety training; and engaged in external coordination or collaboration activities.

  o While numerous agencies have begun to conduct assessment of vulnerability to extreme weather risks, few have adopted *ex ante* risk-mitigating strategies such as asset protection and infrastructure retrofitting.

  o The vast majority of transit agencies use their own websites and social media tools to communicate with transit riders during extreme weather events.

- A large majority of US transit agencies use specific protocols to coordinate responses to weather across multiple departments: emergency government agencies, local government departments, and other local transit agencies during extreme weather events.

National Survey of US Public Transit Agency Experience with and Response to Extreme Weather Events

1. 2016 National Survey of Public Transit Agencies

1.1 Introduction

Extreme weather events pose a serious challenge to public transit systems. Not only do they disrupt transit operation, impair service quality, and cause additional safety threats, but they also damage infrastructure and impose stress on the state of good repair. As demonstrated by Hurricane Sandy and other recent weather-related disasters, the weather impact on transit can have significant ramifications for regional mobility and functioning of economic systems, given increased reliance on transit systems for access to jobs and other services. How to effectively manage the risks of extreme weather is a question that constantly concerns transit managers. This issue has become increasingly urgent with the likely increase the frequency and intensity of extreme weather events, such as floods, heat waves, tropical cyclones and severe storms. While many transit agencies have long experience coping with weather disruptions, they are confronted with the new challenge of identifying and developing appropriate long-term adaptation strategies to address greater risk and uncertainty associated with extreme weather.

This report presents data from a national survey of transit agencies in the United States to better understand the extent to which public transit systems experience extreme weather and to examine how they respond to and prepare for these challenges. The survey posed a variety of questions to transit personnel in planning, operation, maintenance, and engineering asking about:
- recent experience with extreme weather events;
- impacts of extreme weather on agency operations;
- perceptions about the risks and concerns related to extreme weather;
- strategies and approaches used to manage and adapt to extreme weather risks;
- perceptions of agency capacity to address extreme weather;
- key challenges that weather disruptions create for transit agencies.

The report is presented in three main sections. Section 1 provides an introduction to the study, survey design and methodology. Section 2 presents basic characteristics of the respondents including agency characteristics and respondent demographics. Section 3 presents descriptive statistics in four parts: recent experience with extreme weather; perception of weather and climatic risks; assessment of organizational priority, capacity and challenge of managing extreme weather; organizational responses and adaptation to extreme weather events. The executive summary provide a recap of the findings.

1.2 Survey Methodology and Administration

The aim of the study was to provide the first comprehensive national-level survey of transit risks and responses related to extreme weather. As a first step, it was critical to ensure that the sample

frame is representative of the national population of relevant transit agencies. From the National Transit Database (NTD) the research team selected all major fixed-route transit agencies operating bus or/and rail transit services in metropolitan areas across the United States with an annual fare revenue of at least 1 million dollars in 2013. As a result, smaller agencies which have few vehicles in operation and generally do not report their operating data to NTD are excluded from the study. The final sample frame includes 273 transit agencies.

The study recognized that the perspectives and experiences of transit agencies is not monolithic and that responses would likely vary depending upon the professional background and position of the survey participant. Therefore, the study identified managers or leaders of five major departments in each agency: operations, maintenance, service planning, strategic planning, and engineering. The study used a multimethod approach to collect individual names and contact information including publicly available online listings, telephone calls to agencies and Freedom of Information Act requests. Although not all agencies had personnel with each of the five positions, particularly the smaller agencies, the three-month process resulted in a final sample frame of 892 respondents.

As part of the survey development process, the study conducted formal interviews with individuals in planning, engineering, communications and finance from a purposive sample of four transit agencies in four different parts of the United States. Interviews were conducted primarily by telephone, but some were conducted on site visits. Interviews questions asked about experiences with extreme weather events, perceptions about future weather risks, collaboration with other agencies, organizational capacity and limitations, among other items. See Appendix 2 for the interview protocol. Overall, the interviews served to increase the research team's knowledge about how extreme weather affects transit agencies. The knowledge gained helped to further identify and articulate many of the questions in the survey instrument (see Appendix 3).

Survey development and administration occurred in three main phases: design, pre-testing and full administration. Survey design was undertaken as an iterative process, guided by both the study aims and the literature related to extreme weather, transit risk, risk management and adaptation to planning for emergencies. The survey was reviewed internally by multiple researchers at Arizona State University and University of Illinois at Chicago. Once finalized, it was coded as an online web-based survey in Sawtooth Software®. The survey was pretested on a sample of 20 individuals selected at random from the full sample frame. The pretest aimed to identify concerns about question content, clarity, and response variability as well as survey length. The pretest identified no substantial problems and the pre-test response time of approximately 30 minutes was considered long but not excessive. Following the pretest, the full survey was administered online to the remaining sample frame. The full survey opened in April 28th, 2016 and continued through June 11, 2017.

For both the pretest and the full survey, the research team sent a hard-copy notification letter to each of the respondents informing them of the survey, its aims and the reasons why they were selected. The letter requested their participation. One week after sending the hard-copy letter, respondents were invited by email to participate in the study. Each email included a link to the survey and a unique username and password. Following the initial invitation, weekly reminder emails were sent to all those who had not responded or had started but not completed the survey.

Near the end of the survey, the research team contacted non-respondents by telephone further encouraging them to participate. As required by the ASU and UIC Institutional Review Boards, all communications informed respondents of the confidentiality of their responses and the voluntary nature of the survey. Of the initial 892 individuals in the sample frame, several were removed during administration because they were either not reachable, unwilling to participate, not qualified to respond or no longer employed by the agency. During the survey replacement individuals were also identified and invited to participate. The total final effective sample size was 862.

As of June 11, 2016, we received a total of 352 responses, yielding a survey response rate of approximately 41%. Of the respondents, 297 completed the full survey (35% response rate). Of the 273 transit agencies surveyed, 197 provided at least one response (72%). Post-analysis showed no difference by size or annual fare revenue between responding agencies and non-responding agencies. Agencies were also well distributed across the US. The analysis presented in this report includes only complete survey responses.

2. Agency Descriptive Findings and Respondent Demographics

This section presents descriptive findings for the responding agencies and demographics of survey respondents.

2.1 Distribution of Responding Transit Agencies by State and Region

Depending on where they are located, transit agencies are exposed to various climate profiles and face different types of extreme weather risks. They are also exposed to different political and institutional environment that may shape their organizational priority, responsibility and strategies of addressing weather and climate risks.

FIGURE 1. RESPONDING TRANSIT AGENCIES BY REGIONS
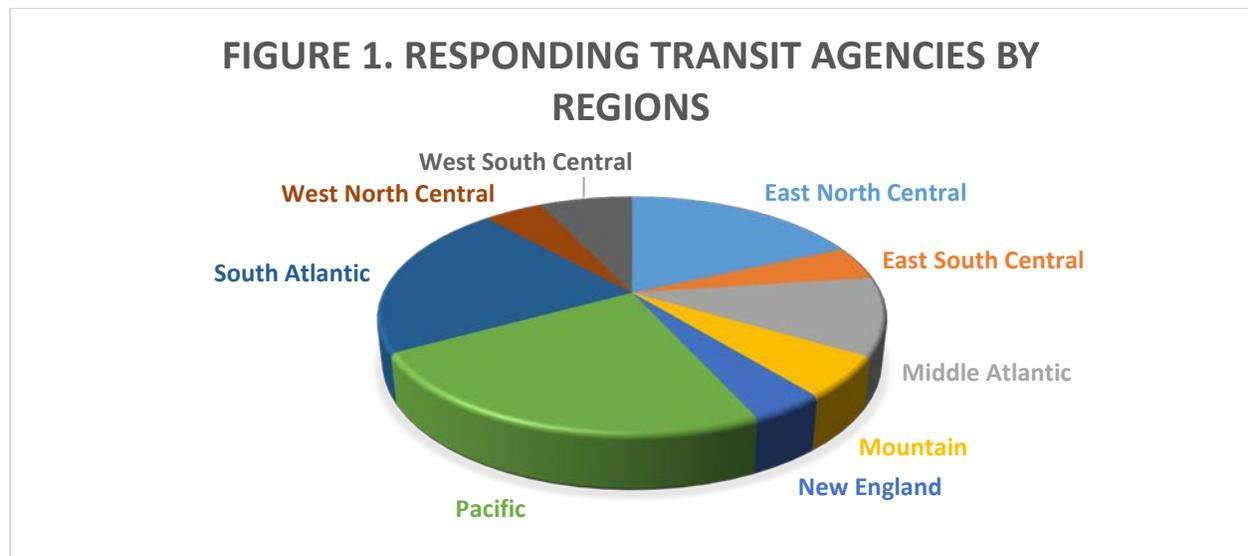
Responding agencies are distributed across the United States with 39 of the 50 states represented. Among the 11 states not represented, seven (Hawaii, Idaho, Montana, North Dakota, New Hampshire, South Dakota, and Wyoming) have no transit agencies in the population of interest. Among states, California had the most transit agencies participating in this national study, followed by Florida, Pennsylvania, Texas and Washington. Appendix 1 displays the number of responding and non-responding agencies by state.

Figure 1 displays the regional distribution of the responding agencies. The largest proportions of participating agencies are in the Pacific (24%) and South Atlantic regions (21%). Agencies from northeast and middle Atlantic account for roughly 18% and 11% of the total, respectively.

2.2   Responding Agency Characteristics

Responding transit agencies operate one or more of four types: (1) bus mass transit; (2) heavy rail (subway, elevated, or at grade); (3) light rail and commuter rail; and (4) water mass transit (e.g. ferry). Of the 197 responding agencies, the majority (74%) operate only bus services most of the remaining agencies (41) operate a combination of bus and rail or bus and water. Only 10 agencies operate exclusively rail transit services.

Table 2. Responding transit agencies by transit mode

# of Responding Agencies	Bus	Heavy Rail	Light Rail	Water
146	▓			
3		▓		
4			▓	
4	▓	▓		
3		▓	▓	
26	▓		▓	
5	▓	▓	▓	
1				▓
4		▓	▓	▓
1	▓		▓	

A majority of responding agencies are independent transit authorities (64%) with the remainder are mostly operated by city government (33%). Nearly 43% of the responding agencies contract with another organization to provide either part or all of their transit services. Average total revenue of responding agencies as reported by TRD is $51.5 million; the median revenue is $4 million.

2.2   Individual Respondent Positions, Experiences and Demographics

Survey respondents come from a variety of different job positions. Shown in Table 3, the largest percentage, nearly 28 percent, work in transit operations, while around 25% are service or strategic planners, and about 17% are in maintenance. Approximately 11% are in executive leadership positions either the Chief Executive Officers or General Managers. Fewer responses were received from transit safety managers and engineers (around 5% each).

Table 3. Participating Respondents by Positions

Positions	N	% of the respondents
Executive Leadership (CEO/GM)	29	10.51
Operation	77	27.9
Planning	68	24.64
Maintenance	46	16.67
Safety/Security	15	5.43
Engineering	14	5.07
Others	27	9.78

Job tenure statistics (Table 4) show that on average respondents have worked at their agencies for about thirteen years, seven of which have been spent in their current positions. Commensurate with their tenure, most respondents supervise a large number of employees (30 on average) indicating that the survey captures the managerial and leadership contingent in U.S. transit agencies.

Table 4. Respondents' Personal Working Experiences

Survey Items	N	Mean	Median	Std. Dev.
Number of years working at your agency	294	13.41	11	10.4
Number of years serving in your current position	294	6.72	4	6.86
Number of employees you directly supervise	291	30.08	7	98.42

Respondents have an average age of 51 they are predominantly white male (as shown in Table 5) [1,2]. Nearly 81% of the respondents are men and the majority have obtained a Bachelor, Master or other graduate degree (Table 6).

Table 5. Participating Respondents by Race

Race	N	%
White	233	80%
Asian	9	3%
African American	36	12%
Native American	1	0.30%
Other	11	3%

Table 6. Participating Respondents by Educational Background

Educational background	N	%
No high school diploma	1	0.34
High school graduate	17	5.76
Some college	56	18.98
Bachelor degree	102	34.58

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[1] Note that here we only consider those who have completed the survey as the participants.
[2] Percentages sum to more than 100 because respondents could check more than one category.

Master degree	106	35.93
Doctoral degree	0	0
Other Graduate Degree	13	4.41

3.   Substantive Findings

In this section we summarize the key findings from the national survey including: recent experiences with extreme weather events, perception of weather risks to the local transit system, assessment of the agency's capacity and challenges in dealing with weather risks, and organizational responses and adaption to extreme weather events and potential weather risks. The survey provided the following definition of Extreme Weather Events for respondents: "*Extreme weather events include unusually severe storms, floods, heat waves or other weather incidents that lie outside of historic norms or experience.*"

3.1   Recent experience with extreme weather

To understand how transit agencies are affected by extreme weather, we asked respondents to assess the frequency and severity of the weather events that have <u>occurred in their service area over the last two years</u>. Respondents were asked the number of times extreme events had occurred on a four point scale (1=never; 2= once; 3=two to three times; 4=more than three times).

Table 7. Frequency of Extreme Weather Events that Occurred in the Past Two years

Types of Extreme Weather Events	N	Mean	Std. Dev.
1. Severe rainstorms/thunderstorms	291	3.03	1.01
2. Extreme cold temperatures	292	2.59	1.22
3. Extreme high winds	294	2.58	1.07
4. Extreme heat wave	290	2.57	1.15
5. Extreme snow storms	294	2.17	1.19
6. Floods	291	1.79	0.93
7. Tornadoes	290	1.51	0.85
8. Wildfires	291	1.37	0.80
9. Hurricanes/tropical storms	292	1.28	0.63
10. Tides/storm surges	294	1.21	0.65

Results show that severe rainstorms/thunderstorms are the most frequent type of extreme weather event experienced by U.S. transit agencies (Table 7), followed by extreme cold, extreme high winds and extreme heat. For example, on average, transit agencies experienced two to three extreme events over the past two years. Understandably, given their geographic specificity, hurricanes and tides/storm surges were experienced least frequently.

Respondents who indicated that they had experienced at least one extreme event were asked in a subsequent question assess the severity of the event(s) in terms of adverse impact on their local area. (Scale: 1=no impact; 2=minor impact; 3=moderate impact; 4=major impact; 5=catastrophic impact). Table 8 shows that extreme snow storms are the most severe, followed by floods,

hurricanes and tides/storm surges. Events that occur more frequently – extreme cold temperatures, rainstorms/thunderstorms, and extreme high winds – are ranked slightly lower.[3]

Table 8. Severity of Extreme Weather Events that Occurred in the Past Two years

Types of Extreme Weather Events	N	Mean	Std. Dev.
1. Severe rainstorms/thunderstorms	258	2.27	0.77
2. Extreme cold temperatures	203	2.31	0.87
3. Extreme high winds	225	2.24	0.86
4. Extreme heat wave	212	2.14	0.76
5. Extreme snow storms	166	3.11	0.86
6. Floods	147	2.36	0.88
7. Tornadoes	96	2.06	0.83
8. Wildfires	64	1.97	0.84
9. Hurricanes/tropical storms	60	2.32	1.02
10. Tides/storm surges	34	2.32	0.98

The survey asked respondents to identify on extreme weather event that had the <u>most adverse impact on their agency during the past two years.</u> Consistent with our findings above, more than half of the respondents identified a snow storm or a floods/heavy rainfall (Table 9). Importantly, only 23 percent of the respondents indicated that their regions had not experienced and extreme weather event in the past two years.

Table 9. Extreme Weather Event that Affected Your Agency Most Adversely

Type of Extreme Weather Events	Frequency	Percent
Snow storms	118	41.11
Flood / Heavy rainfall	40	13.94
Tornadoes / High Winds	25	8.71
Heatwaves / Extreme Hot	11	3.83
Fire	10	3.48
Hurricane / tropical storms	6	2.09
Extreme cold temperatures	5	1.74
Landslide / Mudslide	2	0.7
Severe rainstorms/thunderstorms	2	0.7
Storm Surge	2	0.7
Drought	1	0.35
No event	65	22.65

Referencing the extreme event identified above, the survey asked respondents to identify the types of impacts the event caused (Table 10). The most common consequence of the identified extreme weather was significant delays in transit service (72%), followed by temporary shutdowns (55%) and damages to vehicle or equipment (30%). Importantly, one in five

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[3] It should be noted that the standard deviations show substantial distribution of perceived severity which is likely explained by location or particular storms.

respondents indicated that the extreme event resulted in complete or partial failure of transit services or systems, or damage to infrastructure or facilities.

Table 10. Impact on the Transit System as a Result of the Most Adverse Weather Event

Weather Impacts	N	% responding yes
1. Significant delays in transit services	233	72%
2. Temporary shutdown in transit services	233	55%
5. Damage to vehicles or equipment	233	30%
3. Complete failure of portions of transit services or systems	233	21%
4. Damage to infrastructure or facilities	233	21%
6. Passenger or operator injuries	233	12%
7. Passenger or operator loss of life	233	0%
8. Other injuries or loss of life (e.g., bystanders)	233	2%
9. Others	233	13%

Additionally, the survey asked respondents about the actions their agencies take in response to extreme weather events (Table 11). More than half of the respondents indicated that their agencies had used re-routing (71%) or partial closures of some routes (59%) when extreme weather events occur in their service areas. Around 40% of the respondents close services at some transit stations or stops, but around one-third undertake system- or route-closures.

Table 11. Transit Agency Actions during Extreme Weather Events

	N	% Responding Yes
1. Re-routing of part or all of a particular route	297	71%
2. Partial closures of a specific route (or routes)	297	59%
3. Closings of specific stations or stops	297	39%
4. System closures	297	33%
5. System-wide closure of a specific route (or routes)	297	30%
6. Other	297	10%

Taken together, the findings presented in this section demonstrate that extreme weather is a major challenge facing U.S. transit agencies. Events are not rare, but rather commonly experienced across agencies, while impacts and actions taken indicate the costs associated with extreme weather events are substantial.

3.2   Perception of Weather and Climatic Risks

The survey asked a range of questions to understand how transit managers perceive risks related to extreme weather. The survey first asked respondents to rate the severity that different types of extreme weather events would pose for their agencies <u>in the next ten years</u> (Scale: 1=very low risk; 2=low risk; 3=slight risk; 4= high risk; 5=very high risk). Similar to findings on prior experience presented in 3.1, rainstorms/thunderstorms are perceived to pose the highest risk, followed by extreme high winds, extreme heat wave, extreme snow storms and cold temperatures.

Table 12. Severity of Weather Risks in the Future

Types of Extreme Weather Events	N	Mean	Std. Dev.
1. Severe rainstorms/thunderstorms	293	3.14	1.06
2. Extreme high winds	294	2.88	1.14
3. Extreme heat wave	293	2.83	1.13
4. Extreme snow storms	294	2.73	1.45
5. Extreme cold temperatures	294	2.57	1.24
6. Floods	295	2.50	1.09
7. Tornadoes	291	2.05	1.09
8. Wildfires	294	1.86	1.15
9. Hurricanes/tropical storms	294	1.80	1.22
10. Tides/storm surges	294	1.55	1.05

Respondents were also asked to indicate their level of agreement or disagreement with five statements about their agencies' perspectives on extreme weather events (1=strongly disagree; 2=disagree; 3=neither disagree or agree; 4=agree; 5=strongly agree). Responses, summarized in Table 13 indicate that extreme weather is a growing concern for many transit agencies in the United States. Over 40% of all respondents either agree or strongly agree that extreme weather is becoming more frequent, while half agree or strongly agree that concerns about impacts from extreme weather on infrastructure and operations are rising. Less than five percent believe agree or strongly agree that extreme events are becoming less severe.

Table 13. General Opinion within Your Agencies on the Impact of Extreme Weather Events

	N	Mean	Std. Dev.	% Agree/ Strongly Agree
My agency is increasingly concerned about the impact of extreme weather events on our transit infrastructure.	294	3.27	1.10	48.15%
Most people in my agency recognize that extreme weather events are becoming more frequent.	290	3.24	0.88	41.41%
My agency is increasingly concerned about the impact of extreme weather events on our transit operations.	292	3.30	1.02	49.83%
Most people in my agency recognize that extreme weather events are becoming less severe.	294	2.38	0.71	4.38%

3.3   Organization priorities, capacities and challenges related to managing extreme weather

Transit agencies face numerous safety and security risks. Some of these risks arise from their internal operation such as misconduct of operators, others such as terrorism incidents and natural disasters, are external. To assess how transit agencies perceive the risk of extreme weather relative to other risks, the survey asked respondents to rate the level of risk associated with different safety and security issues they face (Scale: 1=very low risk, 2=low risk, 3=moderate risk, 4=high risk, 5=very high risk).

Results show that extreme weather is considered by transit managers to be an important safety issue: it is rated as the second highest, following only accidents and/or collisions (not related to operator misconduct and equipment failure). Weather-related risks are perceived to be higher than non-weather-related natural disasters such as earthquakes. Importantly, most of the listed safety and security issues are ranked "low-to-moderate" risk, although the standard deviations indicate that there is substantial variation with some agencies.

Table 14. Risk Assessment of Safety and Security Issues that Affect Transit

	N	Mean	Std. Dev.
1. Accidents and/or collisions (not operator/equipment)	296	2.94	0.93
2. Extreme weather events (e.g. major storms)	293	2.84	1.03
3. Equipment failure	296	2.78	1.01
4. Operator misconduct	295	2.65	0.99
5. Misdemeanor crime (e.g. theft)	294	2.52	0.94
6. Natural disasters (e.g. earthquakes)	294	2.34	1.14
7. Violent crime	291	2.27	0.97
8. Disease transmission or public health concerns	294	2.12	0.91
9. Terrorism incidents	295	1.98	0.98
10. Social or political protests	294	1.82	0.79

Further, the survey asked respondents about their level of confidence that their agency could effectively respond to each of the different safety and security issues (Scale: 1=no confidence; 2=slight confidence; 3=moderate confidence; 4=high confidence; 5=very high confidence).

Table 15. Confidence in Agency's Capacity for Responding to the Following Occurrences

	N	Mean	Std. Dev.
1. Operator misconduct	292	4.20	0.71
2. Accidents and/or collisions (not operator/equipment)	292	4.15	0.67
3. Equipment failure	291	4.13	0.69
4. Extreme weather events (e.g. major storms)	290	3.84	0.80
5. Misdemeanor crime (e.g. theft)	290	3.76	0.74
6. Violent crime	290	3.45	0.87
7. Terrorism incidents	292	3.01	0.93
8. Disease transmission or public health concerns	292	2.93	0.92
9. Social or political protests	292	3.26	0.96
10. Natural disasters (e.g. earthquakes)	291	3.26	0.96

Results show higher confidence that agencies can effectively respond to internal challenges than external safety threats (Table 15). Confidence levels were higher for operator misconduct, accidents and equipment failure, whereas ability to respond to extreme weather events is ranked fourth. In comparison, the lowest levels of confidence were associated with highly uncertain events such as terrorism, disease transmission and natural disasters.

Moving beyond perceptions about relative risk levels and confidence to address them, the survey asked respondents about their agreement or disagreement with statements regarding specific agency efforts to plan and prepare for extreme weather events (Scale: 1=strongly disagree; 2=agree; 3=neither disagree nor agree; 4=agree; 5=strongly agree). Results continue to demonstrate that agencies have relatively high confidence that they are able to address extreme weather event challenges.

Respondents believe their agencies possess adequate weather information, internal expertise and available staff, and adequate emergency plans which allow them to effectively manage different extreme weather events. They also believe that prior responses to extreme weather have been effective and that they will be able to do so in the future. Nevertheless, respondents generally agree on the need to commit resources and effort to plan for extreme weather.

Table 16. Planning and Preparation for Extreme Weather Events

	N	Mean	Std. Dev.
So far my agency has been able to effectively respond to extreme weather events.	294	4.03	0.65
My agency has adequate weather information to undertake effective emergency responses.	296	3.99	0.75
My agency's emergency plans are adequate to manage a broad range of extreme weather events.	294	3.83	0.66
Because significant weather events occur so rarely, committing substantial effort to strategic planning for them does not make sense for my agency.	294	2.34	0.93
Because every extreme weather event is unique, my agency cannot effectively plan for emergency responses.	296	2.08	0.74
My agency does not have adequate internal expertise and available staff to effectively respond to extreme weather events.	296	2.09	0.85
My agency may not be able to effectively respond to the next extreme weather event.	294	2.10	0.85

One important goal of this national study is to understand the key challenges faced by transit agencies in managing extreme weather risks and accordingly to provide policy remedies. The survey asked respondents to assess factors that may limit their agency's ability to prepare for extreme weather. They were provided with a list of possible factors and then asked to rate each

of them in terms of its constraining influence (Scale: 1=not significant at all; 2=slightly significant; 3=moderately significant; 4=very significant; 5=extremely significant).

Table 17. Factors that Limit Agency's Ability to prepare for extreme weather

	N	Mean	Std. Dev.
Access to financial resources	288	2.62	1.14
Internal coordination	288	2.07	1.09
Awareness of extreme weather risks	285	2.02	1.04
Public concerns about extreme weather	281	2.01	1.06
Uncertainty about best options available	283	1.97	0.97
Political support and guidance outside my organization	287	1.93	1.08
Support from the leadership within my organization	290	1.82	1.19

According to Table 17, among all possible factors respondents considered [lack of] access to financial resources to be the most important barrier to effective preparation for extreme weather. This sentiment is also consistent with findings from interviews with the selected transit agencies. Most transit agencies tight budgets and multiple competing organizational priorities, often making it difficult to focus resources on extreme weather.

Other important limiting factors include internal coordination, awareness of extreme weather risks, and public concerns about extreme weather. By contrast, respondents perceive relatively lower influence of other factors, such as agency's leadership and external political support, on their agencies' weather-related preparatory efforts. These findings suggest that most agencies believe that as professional organizations and with sufficient resources they should be able to manage the challenges associated with extreme weather.

3.4   Organizational responses and adaptation to extreme weather events

A key interest of this study is to understand how U.S. public transit agencies manage and plan for weather-related risks. Several general questions guided this part of the inquiry:

- Are agency responses to weather events reactive or are they planned?
- Do agencies develop any long-term plans or develop simple coping strategies to mitigate the risks of extreme weather events?
- What type of technologies or facilities, if any, do agencies invest in to improve their preparedness for extreme weather?
- How do transit agencies interact and collaborate with other public agencies in responding to extreme weather events?

Drawing the emergency management and climate adaptation literature, the survey included several questions concerning risk-management. Given that multiple responses were received from many agencies, this part of the report collapses the individual responses to the agency level to obtain 197 agency-level values for each question.

Table 18 presents the responses to a set of questions related to emergency management strategies for response to extreme weather events. Specifically, we asked respondents whether their agencies had conducted any of the listed activities to address extreme weather over the past two years. Results show that the majority of the responding agencies have adopted most emergency management strategies for extreme weather, including hiring professionals in charge of emergency responses, developing emergency plans, conducting safety training, and engaging in external coordination/collaborative activities. By contrast about one half of all agencies have developed mutual aid agreements with other transit agencies and only one third of all agencies have conducted simulation exercises to prepare for extreme weather events.

Table 18. Emergency Management Approach to Extreme Weather Events

	N	% responding yes
Developed or updated an emergency plan including extreme weather	185	84%
Attended weather/disaster-related meetings outside your organization	177	84%
Conducted safety training of the operating staff and drills	186	83%
Coordinated with other organizations (other than transit agencies) in developing a joint response	182	82%
Designated a person to be in charge of extreme weather response	191	79%
Developed or maintained a mutual aid agreement (or other collaborative relationships) with other transit agencies	171	50%
Conducted extreme weather simulation exercises	179	34%

Several survey questions sought to ascertain what activities transit have undertaking to plan for and mitigate the effects of extreme weather. Presented in Table 19 the most common strategies taken by transit agencies include investing in back-up power supplies/equipment and information and communication technologies. These measures they are generic risk-mitigating strategies relevant to a broad range emergency situations.

While two thirds of all agencies have assessed their vulnerability to extreme weather, most transit agencies appear to manage extreme weather risks using the traditional emergency management approaches. However only a third have assessed costs related to extreme weather response and few agencies apply *ex ante* risk-mitigating strategies such as asset protection and infrastructure retrofitting to address extreme weather risks. Certainly, many of the actions listed in Table 19 are costly. Yet in general it is evident that the confidence respondents have in their agencies' abilities to address extreme weather are generally not based a proactive planning approach, but rather on the application of traditional emergency response methods.

Table 19. Agency's Adaptation Approaches to Addressing Extreme Weather

	N	% responding yes
Risk assessment and strategy identification		
Assessed your agency's vulnerability to extreme weather	176	65%
Estimated the costs of responding to an extreme weather event	162	35%
Conducted or contracted research on the risks of extreme weather events	149	13%
Investment in weather-proof/risk-mitigating facilities and technologies		
Invested in weather-smart equipment and technologies (e.g. sensors that detect changes in pressure and temperature in materials)	171	11%
Invested in information and communication technologies	186	67%
Invested in back-up power supplies and equipment	185	76%
Invested in weather-proof infrastructure improvement or retrofitting projects (e.g., strengthening parts of a building, improving stations or tracks)	167	34%
Safety improvement of current assets		
Adopted stricter safety standards in infrastructure building	149	27%
Abandoned or relocated transit infrastructure that was located in high-risk areas	178	4%
Financing adaption activities		
Set aside funds dedicated to managing extreme weather events	155	19%
Applied for external grants aimed at mitigating adverse weather impacts	145	13%

The survey also asked respondents to identify the types of communication channel their agencies employ to inform riders of changes or delays in services during an extreme weather event. Responses show that the vast majority of transit agencies now use their own websites and social media to disseminate information (Table 20). Other channels that are also commonly include radio stations, local TV, and cellphone text messages. Overall, this suggests that agencies apply a wide range of information channels to inform and communicate with their riders.

Table 20. Communication Channels Used during Extreme Weather Events

	N	% responding yes
Radio stations	190	80%
Local TV	191	78%
Websites	194	97%
Press conferences	178	44%
Social media (e.g., Facebook, Twitter)	190	93%
Cellphone text messages	181	56%

During extreme weather events, transit agencies are rarely the sole responder. Transit agencies typically collaborate and coordinate with other external stakeholders and organizations as a joint response to extreme events. Managing extreme weather also requires considerable internal coordination among different functions within the same transit systems. One survey questions asked respondents which organizations transit agencies engage with in the event of the extreme weather. Specifically it asked: *When an extreme weather event occurs, does your agency use specially designed protocols to communicate or coordinate with* [the following organizations]?

Results demonstrate that transit agencies commonly coordinate responses to extreme weather events with a wide variety of organizations. About 86% of the transit agencies responding use specific protocols to coordinate responses across multiple internal departments. Externally, almost all transit agencies have special protocols to communicate with riders during an extreme weather event. In addition, coordination activities are prevalent with emergency government agencies, local government departments, and other local transit agencies based on specially-designed protocol. Only about 16% of the agencies in the survey indicate that they do not have specifically designed protocols, although that does not necessarily indicate a lack of coordination with other stakeholders or organizations.

Table 21. Internal & External Coordination in Response to Extreme Weather

	N	% responding yes
Transit riders	194	91%
Other departments within your agency	194	86%
Outside emergency government agencies (e.g., police, fire, FEMA)	194	86%
Outside non-emergency local government departments (e.g., Public Works).	194	73%
Other local transit agencies	192	56%
Local utility companies	193	54%
State Department of Transportation	192	53%
Other state agencies	192	46%
Federal Transit Administration	188	45%
Other federal agencies	191	37%
My agency does not have specifically designed protocols.	177	16%

Appendix 1. Agency Responses by States

State	# Non-responding agencies	# Responding agencies	Total Sampled Agencies
Alaska	1	0	1
Alabama	1	2	3
Arkansas	0	1	1
Arizona	0	3	3
California	20	35	55
Colorado	0	3	3
Connecticut	2	2	4
Delaware	0	1	1
Florida	5	13	18
Georgia	2	6	8
Iowa	2	0	2
Illinois	1	9	10
Indiana	2	5	7
Kansas	1	3	4
Kentucky	1	2	3
Louisiana	1	2	3
Massachusetts	3	5	8
Maryland	0	4	4
Maine	2	0	2
Michigan	0	8	8
Minnesota	3	1	4
Missouri	1	3	4
Mississippi	0	1	1
North Carolina	3	5	8
Nebraska	0	2	2
New Jersey	0	1	1
New Mexico	0	2	2
Nevada	1	2	3
New York	7	7	14
Ohio	2	7	9
Oklahoma	0	1	1
Oregon	2	2	4
Pennsylvania	2	12	14
Rhode Island	0	1	1
South Carolina	1	4	5
Tennessee	1	4	5
Texas	2	10	12
Utah	0	1	1
Virginia	4	8	12
Vermont	1	0	1
Washington	2	10	12
Wisconsin	0	7	7
West Virginia	0	1	1

Appendix 2. Transit and Extreme Weather Study - Interview Script

[Intro about project] We would like to ask you a set of questions about your work and how your agency has responded to past extreme weather events.

Q1. Warm-up: Can you please briefly talk about your current job at XXX agency?
Prompt: How long have you been working in your current position?
Prompt: Does your current job function involve interaction with other departments? If so, would you please describe how you normally interact with each other?

Q2. Extreme Weather: Has your region recently experienced any extreme weather events? By extreme events we mean, for example, extreme precipitation or heat, floods, hurricanes, strong winds or severe storms.
Prompt: When was the last time an extreme event occurred in your city? What happened?
Prompt: Do you think extreme weather is or will be a serious issue for your region and agency? And how would you rank its importance for your agency/department compared to other issues (such as…)
Prompt: Did it affect your organization? How?
Prompt: What did your agency or your department do during and after the event? Do you think overall your agency is well prepared for extreme weather events?

Q3: Impact and Response: Can you please talk about how your agency was affected when the extreme weather event happened last time? What did you agency / department do during and after the event?
Prompt: For example, did it affect the transit ridership? Did it cause any severe damages to the infrastructure? Did it cause any financial losses?
Prompt: How did your department / agency respond right after the event occurs?
Prompt: Do you think any long-term changes caused by the event to your agency? For example, did you agency start adopting certain equipment/system design/technologies (more examples) that may potentially can reduce the impacts of extreme weather events?

Q4. Collaboration, Coordination and Organizational Learning
1) Intra-agency: From the perspective of your current job function, do you think it is important to work together with other departments in responding to extreme weather events?
Prompt: Does your agency have any existing mechanism for within-agency coordination?
Prompt: How do you view the effectiveness of the current collaborative activities?

2) Inter-agency: When an extreme weather event occur, does your agency work with other public agencies (for example, public works, FEMA, public health) to cope with it?
Prompt: What are the agencies your organization normally works with?
Prompt: Are you aware of any regular meetings or networks in which your agency or your department participates and interact with other public agencies?
Prompt: In your agency's service area, is public transit system integrated in any local emergency management plans? For example, is bus fleet usually mobilized when evacuation occurs?

3) Interaction with other transit agencies: Does you agency/ department normally interact with other transit agencies? Has your agency/department ever engaged with other transit agencies to identify risks and appropriate strategies to address extreme weather?

Prompt: What are the agencies your organization primarily interact with? Can you please talk more about the way you interact with each other?

Prompt: Has your agency/department learned anything from other agency's current management practices with extreme weather?

Q6: <u>Barriers</u>: What do you think are the major challenges in responding to extreme weather events?

Prompt: In your agency's planning activities, operations, risk management, or other related decision-making processes?

Prompt: Do you see any formal/informal arrangement within your organization that may specifically encourage or inhibit the consideration of extreme weather events in the planning and operating activities?

Appendix 3: Transit and Extreme Weather Survey Instrument

Transit Agency and Extreme Weather Survey

The purpose of this study is to investigate how public transit agencies prepare for and respond to extreme weather events. This project is funded by the Department of Transportation Federal Transit Administration and is being conducted by researchers at Arizona State University and University of Illinois at Chicago.

The survey will ask you about your work and organization, how your agency perceives and manages risks of extreme weather events, and how your agency interacts with other organizations in responding to weather events. The survey takes about 30 minutes to complete.

Your responses are confidential. Before the data are examined and analyzed, your name and all personal identifiers will be removed and replaced with unique numbers to protect your confidentiality. Data will be examined for trends and only aggregated findings will be reported. You will not be identified in the results.

Your participation is voluntary. If you decide not to participate, you are free to withdraw at any time. If you have any questions about your rights as a research subject, you may email research.integrity@asu.edu.

Your participation is very valuable. Results of the research will be helpful to policy makers and public transit managers interested in developing better decision tools that can more effectively address future weather events. At the end of the survey you will be asked if you would like to enter your name to win one of twenty $50 Amazon gift cards. We will also ask if you would like to receive a copy of the survey results.

If you have any questions about this survey or the underlying research project, please contact Dr. Eric Welch at EricWelch@asu.edu, or by phone at 602-859-7431.

Section 1. Transit and Transportation in Your Region

In your opinion, what level of priority should be placed on addressing the following public transportation problems in your region today? [very low priority, low priority, moderate priority, high priority, very high priority]

1. Improve conditions of highways and roads
2. Improve public transit service
3. Improve conditions of rail infrastructure
4. Improve condition of bus infrastructure and equipment – stations, stops, facilities, vehicles
5. Improve transit safety and security
6. Increase affordability of public transit
7. Increase access to public transit
8. Increase funding for public transit
9. Other (please specify) _____

Section 2. Transit Services Your Agency Provides

Which of the following services does your agency provide (including outsourced services) for the local residents? Please check all that apply.
1. Bus mass transit
2. Heavy rail (subway, elevated, or at grade) transit
3. Light rail and commuter rail transit
4. Water mass transit (e.g. ferry)

Does your agency contract with another organization to provide either part or all of these transit services [yes/no]? skip logic: including only modes checked in the previous question
1. Bus mass transit
2. Heavy rail (subway, elevated, or at grade)
3. Light rail and commuter rail
4. Water mass transit (e.g. ferry)

Considering only the public transit infrastructure used by your agency and based only on your general knowledge, how would you rate the state-of-good-repair of the following components from "poor" to "excellent"? Please use the following scale to make your assessment.

Poor - Asset is past its useful life and is in need of immediate repair or replacement; may have critically damaged component(s)

Marginal - Asset reaching or just past the end of its useful life; increasing number of defective or deteriorated component(s) and increasing maintenance needs
Adequate - Asset has reached its mid-life (condition 3.5); some moderately defective or deteriorated component(s)
Good - Asset showing minimal signs of wear; some (slightly) defective or deteriorated component(s)
Excellent - New asset; no visible defects

1. Bus transit vehicles
2. Bus station structures and shelters
3. Commuter rail transit vehicles [Rail only]
4. Rail control systems [Rail only]
5. Rail bridges, elevated structures and tunnels [Rail only]
6. Rail track, switches, and track work [Rail only]
7. Rail station structures and platforms [Rail only]
8. Streets, roads and highways
9. Roadway bridges, structures and tunnels
10. Transit facility ventilation systems
11. Transit maintenance equipment
12. Electrification/power systems
13. Communication systems
14. Drainage systems
15. Revenue/fare collection systems

Section 3.   Your Work
Now we would like to ask a few questions about your work.

What is your position title? _____

Approximately what percent of your time is spent on the following activities? Please note that percentages need to sum to 100. Use the "other (please specify)" options for work activities not identified below.

1. Developing transit funding strategies, including Federal and state grant opportunities and other financing projects
2. Preparing, administering, directing, operating or supervising capital projects and budgets
3. Selecting, training, supervising, and evaluating personnel
4. Ensuring efficient maintenance and operation of transit equipment
5. Developing and implementing safety/emergency related policies and procedures
6. Planning long-range system modernization, enhancement and expansion projects
7. Developing and implementing service plans
8. Community outreach and public involvement
9. Other (please specify)_____
10. Other (please specify)_____
11. Other (please specify)_____

Section 4. Organizational Risk Management

In your opinion, what <u>level of risk</u> do the following safety and security issues pose for your agency's ability to provide consistent and reliable transit services? [very low risk, low risk, moderate risk, high risk, very high risk]

1. Operator misconduct
2. Equipment failure
3. Accidents and/or collisions (not operator or equipment related)
4. Terrorism incidents
5. Disease transmission or public health concerns
6. Social or political protests
7. Extreme weather events (e.g. major storms)
8. Natural disasters (e.g. earthquakes)
9. Misdemeanor crime (e.g. theft)
10. Violent crime

How confident are you that your agency is able to effectively respond to the following possible occurrences? [No confidence, Slight confidence, Moderate confidence, High confidence, Very high confidence]

1. Operator misconduct
2. Equipment failure
3. Accidents and/or collisions (not operator or equipment related)
4. Terrorism incidents
5. Disease transmission or public health concerns
6. Social or political protests
7. Extreme weather events (e.g. major storms)
8. Natural disasters (e.g. earthquakes)
9. Misdemeanor crime (e.g. theft)
10. Violent crime

To the best of your knowledge, <u>over the last two years</u> for your agency, has there been an increase, decrease, or no change in the following areas? [Substantial decrease, slight decrease, no change, slight increase, substantial increase]

1. Transit fare levels
2. Fare box revenues
3. System ridership
4. Total agency budget
5. Your department's budget
6. State funding for transit
7. Local funding for transit

Please indicate the level of influence the following institutions or individuals exert over your agency. [very strong influence, strong influence, moderate influence, mild influence, no influence]
1. Mayor
2. Mayor's council or other elected officials

3. City departments and agencies
4. State governor
5. State legislature
6. State agencies
7. Federal government
8. Advocacy groups
9. Business groups
10. General public
11. Media

How effective is your agency in managing its relationship with each the following groups? [Very effective, Effective, Neither effective nor ineffective, Ineffective, Very ineffective]
1. Mayor
2. Mayor's council or other elected officials
3. City departments and agencies
4. State governor
5. State legislature
6. State agencies
7. Federal government
8. Advocacy groups
9. Business groups
10. General public
11. Media

Is the director of your agency politically appointed?
- Yes
- No
- I do not know

Section 5: About Your Organization

Please indicate your level of agreement or disagreement with each of the following statements about your organization: (Strongly Disagree, Disagree, Neither agree nor disagree, Agree, Strongly Agree)

[Work routineness]
- People here do the same job in the same way every day.
- One thing people like around here is the variety of work.
- Most jobs here have something new happening every day.

[Innovativeness]
- This organization is a very dynamic and entrepreneurial place. People are willing to stick their necks out and take risks.
- Employees in this organization are rewarded for developing innovative solutions to problems.
- Employees are penalized for new ideas that do not work (Hurley and Hult 1998)
- Innovation in my agency is perceived as too risky and is resisted (Hurley and Hult 1998)

[Centrality]

- Even small matters have to be referred to someone higher up for a final answer. (Hall 1963)
- Top management exerts strong control over this organization.
- There can be little action taken here until a supervisor approves a decision. (Hall 1963)

[Participation] (Robert F. Hurley and Hult 1998; Mohr 1977)
- Decision making is delegated to the lowest possible level of authority. (Hurley and Hult 1998)
- Individuals involved in implementing decisions have a say in making the decisions. (Hurley and Hult 1998)
- All in all, I have very little influence over the agency decisions that affect my department in important ways. (Mohr 1977) (reversed coding)
- If my department had a suggestion for improvement, it would be difficult for us to get a real hearing on it from the leadership. (Mohr 1977)

Section 6: Extreme Weather Events

We would now like to ask a few questions about extreme weather events that have occurred in your area over the last two years and how those may have affected your agency. Extreme weather events include unusually severe storms, floods, heat waves or other weather incidents that lie outside of historic norms or experience.

During the last two years, about how many times have the following extreme weather events occurred in your transit service area? [never, once, two to three times, more than three times]

1. Extreme cold temperatures
2. Extreme heat wave
3. Wildfires
4. Floods
5. Hurricanes/tropical storms
6. Severe rainstorms/thunderstorms
7. Tides/storm surges
8. Extreme high winds
9. Tornadoes
10. Extreme snow storms

Extreme weather may result in one or more adverse impacts on your agency such as loss of power, delays, collisions or injuries.

Considering the extreme weather events that have happened in your area in the previous two years, has the level of adverse impact been catastrophic, major, moderate, minor, or none? [1=none; 2=minor; 3=moderate; 4=major; 5=catastrophic] [Skip logic: Include only options on which you selected anything other than "never"'; if respondents had no experience with the weather events in the past two years, they won't be asked about this question]

1. Extreme cold temperatures
2. Extreme heat wave
3. Wildfires
4. Floods
5. Hurricanes/tropical storms
6. Severe rainstorms/thunderstorms
7. Tides/storm surges

8. Extreme high winds
9. Tornadoes
10. Extreme snow storms

During the past two years, what is the extreme weather event that has had the most adverse impact on your agency? Briefly, describe the event. If your region has not experienced any such events, please put in "N/A". [open ended, one line]

- Entering Text here:

Considering that extreme weather event you just described, which of the following occurred as a result of that event? (Please check all that apply) skip logic: if you leave the previous question blank or choose "N/A" or "None", you should not see this question.

1. Significant delays in transit services
2. Temporary shutdown in transit services
3. Complete failure of portions of transit services or systems
4. Damage to infrastructure or facilities
5. Damage to vehicles or equipment
6. Passenger or operator injuries
7. Passenger or operator loss of life
8. Other injuries or loss of life (e.g., bystanders)
9. Others (please specify) _____

In your opinion, in the next ten years, what level of risk will each of the following occurrences likely impose on your agency? [Very high risk, high risk, slight risk, low risk, and very low risk]

1. Extreme cold temperatures
2. Extreme heat wave
3. Wildfires
4. Floods
5. Hurricanes/tropical storms
6. Severe rainstorms/thunderstorms
7. Tides/storm surges
8. Extreme high winds
9. Tornadoes
10. Extreme snow storms

Please indicate your level of agreement or disagreement with each of the following statements.
[Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree].

1. My agency is increasingly concerned about the impact of extreme weather events on our transit infrastructure.
2. People in my agency generally only worry about extreme weather events when they happen.
3. Most people in my agency recognize that extreme weather events are becoming more frequent.
4. My agency is increasingly concerned about the impact of extreme weather events on our transit operations.
5. Most people in my agency recognize that extreme weather events are becoming less severe.

Section 7: Response to Extreme Weather Events

Please indicate your level of agreement or disagreement with each of the following statements.[Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree]

1. My agency has formed a team of staff tasked with responding to emergencies including extreme weather events.
2. My agency has adequate weather information to undertake effective emergency responses.
3. Because every extreme weather event is unique, my agency cannot effectively plan for emergency responses.
4. My agency does not have adequate internal expertise and available staff to effectively respond to extreme weather events.
5. Most of the action required for extreme weather is the job of emergency management units/agencies.
6. Regardless of the extreme event, there are common procedures that can be followed in all cases.
7. My agency's response differs significantly depending on the characteristics of the particular event.
8. My agency's emergency plans are adequate to manage a broad range of extreme weather events.
9. Because significant weather events occur so rarely, committing substantial effort to strategic planning for them does not make sense for my agency.
10. So far my agency has been able to effectively respond to extreme weather events.

11. My agency may not be able to effectively respond to the next extreme weather event.

In the past two years, which of the following actions has your agency undertaken as a result of extreme weather events? [check all that apply]

1. System closures
2. System-wide closure of a specific route (or routes)
3. Partial closures of a specific route (or routes)
4. Closings of specific stations or stops
5. Re-routing of part or all of a particular route
6. Other (please specify) _____

During an extreme weather event, does your agency use any of the following communication channels to inform riders of any changes or delays in services? (Yes/No)

1. Radio stations
2. Local TV
3. Website
4. Press conferences
5. Social media (e.g., Facebook, Twitter)
6. Cellphone text messages
7. Other (please specify) _____

When an extreme weather event occurs, does your agency use specially designed protocols to communicate or coordinate with: (Yes/No)

1. Other departments within your agency
2. Transit riders
3. Other local transit agencies
4. Outside emergency government agencies (e.g., police, fire, FEMA)
5. Outside non-emergency local government departments (e.g., Public Works).
6. Local utility companies
7. State Department of Transportation
8. Other state agencies
9. Federal Transit Administration
10. Other federal agencies
11. My agency does not have specifically designed protocols.

Section 8: Preparation and Planning for Extreme Weather Events

Please indicate your level of agreement or disagreement with each of the following statements.
(Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree)

1. My agency plays a role in the local/regional emergency evacuation system.
2. My agency has full authority to develop risk management strategies for extreme weather as it sees fit.
3. For planning purposes, my agency considers extreme weather events to be one type of general emergency situation.
4. My agency is required by local or regional governments to plan for extreme weather events.
5. My agency has not encountered any event that is large enough to necessitate systematic planning.
6. Units within my agency are allowed to develop independent risk management strategies for extreme weather.

Over the past two years, has your agency done any of the following for extreme weather events? Please answer to the best of your knowledge, thinking about your agency in general, not just your specific division or section. [yes, no, I don't know]

1. Designated a person to be in charge of extreme weather response
2. Fired someone because of mistakes that occurred during extreme weather events
3. Developed or updated an emergency plan including extreme weather
4. Attended weather/disaster-related meetings outside your organization
5. Contracted with other organizations or experts to better prepare for extreme weather
6. Developed or maintained a mutual aid agreement (or other informal collaborative relationships) with other transit agencies
7. Coordinated with other organizations (other than transit agencies) in developing a joint response
8. Conducted safety training of the operating staff and drills
9. Conducted extreme weather simulation exercises
10. Assessed your agency's vulnerability to extreme weather
11. Estimated the costs of responding to an extreme weather event

Over the past two years, has your agency done any of the following for extreme weather events? Please answer to the best of your knowledge, thinking about your agency in general, not just your specific division or section. [yes, no, I don't know]

1. Installed warning systems
2. Invested in weather-smart equipment and technologies, such as sensors that detect changes in pressure and temperature in materials
3. Invested in information and communication technologies
4. Invested in back-up power supplies and equipment
5. Invested in weather-proof infrastructure improvement or retrofitting projects (e.g., strengthening parts of a building, improving stations or tracks)
6. Purchased insurance for extreme weather events
7. Conducted or contracted research on the risks of extreme weather events
8. Adopted stricter safety standards in infrastructure building
9. Abandoned or relocated transit infrastructure that was located in high-risk areas
10. Set aside funds dedicated to managing extreme weather events
11. Applied for external grants aimed at mitigating adverse weather impacts

To what extent do the following factors limit your agency's ability to prepare for extreme weather? [not significant at all, slightly significant, moderately significant, very significant, extremely significant]
1. Access to financial resources
2. Awareness of extreme weather risks
3. Public concerns about extreme weather
4. Internal coordination
5. Support from the leadership within my organization
6. Political support and guidance outside my organization
7. Uncertainty about best options available
8. Other (please specify) _____

Section 9. More about you

We would like to ask you a few questions about your background and work.

How many years have you worked at your current agency? _____ years
How many years have you served in your current position?   _____years

Which of the following best describes your highest educational level?
1   No high school diploma
2   High school graduate
3   Some college
4   Bachelor degree
5   Master degree
6   Doctoral degree
7   Other Graduate Degree (please specify) [Respondent Specify]

Are you male or female? (male, female)

In what year were you born? *(YYYY)*

Which of the following categories represents your race and ethnicity? *(please check all that apply).*
1   White
2   Asian
3   African American
4   Native American
6   Other: (please specify)

Are you Hispanic? (yes or no)

Please indicate the number of years of experience you have in each of the following settings: (Your best estimate will do) try different numbers
1   Public
2   Non-profit
3   Private

About how many full-time employees work in your department? _____ Please try different numbers

How many employees do you directly supervise? Please try different numbers

What is your approximate salary level?
-    Less than $25,000
-    $25,000 to $50,000
-    $50,001-$75,000
-    $75,001-$100,000
-    $100,001-$125,000
-    $125,001 or more

Section 10. Comments

If there is anything else you would like to tell us about any of the topics covered in this questionnaire, please do so in the space provided below.(open-ended, multiple lines)

Section 11. Final Questions

Would you like to be entered into a lottery for a $50 Amazon gift card? (Yes/No)

For your chance to win the gift card, please enter your information below. Skip logic: if you answered no or left the previous question blank, you should not see this question

Name: _____

Email address: _____

Would you like a copy of the survey results (Yes/No) (Output)

For us to distribute the survey results, please enter your information below. Skip logic: if you answered no or left the previous question "Output" blank, you should not see this question. Meanwhile, if you answered yes to the lottery drawing question and filled out your information, you should not see this question either. The rationale is that you won't be asked to put in your information twice if you want to enter the drawing and the output. If you don't want either of the two, you won't be asked to provide your name and email address.

Name: _____

Email address: _____

Thank you for your interest in our study! We will use the information you provided earlier to distribute the survey result. Please click "Next" to proceed. Logic: This only shows up when you have selected "yes" to both lottery drawing and output.

Thank you for participating in this survey!

Thank you for taking your time to complete this questionnaire. Your assistance in providing this information is very much appreciated.

Please click "next" to complete and exit the survey. You will see the CSTEPS webpage after click "next"