



# EXTREME WEATHER AND CLIMATE RESILIENCY

at the PA Turnpike Commission

2022 HIGHLIGHT REPORT



# IN THIS REPORT

- 3 Introduction
- 4 Impacts of Extreme Weather
- 6 Evaluating Future Climate Changes
- 8 Current PTC Strategies and Initiatives
- 15 An Action Plan for Further Resiliency



## RESILIENCE (RE·SIL·IENCE)

The Federal Highway Administration (FHWA) defines resilience as the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.

# INTRODUCTION

According to the United Nations, climate change refers to long-term shifts in temperatures and weather patterns. The Earth is now about 1.1°C (1.98°F) warmer than it was in the late 1800s, with the last decade (2011-2020) being the warmest on record. One of the consequences of a warming world is an increase in the intensity and frequency of extreme weather events.

The Pennsylvania Turnpike Commission (PTC) has undertaken a comprehensive assessment of its internal planning, operations, and best management practices related to extreme weather events such as flooding, blizzards, hurricanes, and heatwaves.

Included are examples on how extreme weather has historically impacted the PTC, proactive actions the Commission has undertaken in recent years, and opportunities to further improve preparedness and responsiveness to create an even more resilient system.

The assessment concluded that the PTC is prepared for extreme weather events based on its diligent efforts to improve agency coordination and planning for extreme weather events, and implementation of effective strategies and technology solutions.

Much of the information gathered was obtained through targeted outreach and dialogue with PTC departments and supporting agencies including:

- Engineering – Construction
- Engineering – Design
- Engineering – Facilities & Energy Management Operations
- Information Technology
- Maintenance
- Toll Collection Operations
- Traffic Engineering & Operations
- Pennsylvania State Police (Troop T)

## FOCUS OF INTERNAL PTC ASSESSMENT

How has extreme weather impacted the Turnpike?

What is the Turnpike doing now to address extreme weather?

How is the Turnpike preparing for the future?



# IMPACTS OF EXTREME WEATHER

The PTC understands the potential impacts that extreme weather events could have on the safety, reliability, and sustainability of their roadway system. While the infrastructure itself is not as susceptible to extreme weather, many of the redundancies in design standards allow it to be more resilient than other aspects of their operations. Hence the PTC continuously evaluates the safety and operations of their roadway and identifies ways to prepare for and adapt to extreme weather events.

## EXAMPLES OF EXTREME WEATHER IMPACTS ON PTC



### FLOODING

- Hurricane Ida (2021) caused flooding and ponding on the Turnpike near Fort Washington, Valley Forge, and Bedford, PA
- Ponding and flooding occurred during other rainfall events at Willow Grove, Fort Washington, and Virginia Drive as well as multiple construction locations



### SLIDES

- Hurricane Ida caused multiple locations of mud and rock slides including at locations where construction was underway



### ICING

- Cold weather conditions created ice buildup at tunnels requiring traffic stoppages to clear



### SNOW

- Snowstorms caused significant issues related to closures, crashes and other safety issues
- Snow events resulted in truck restrictions
- Impacted access to other PTC infrastructure including tower locations
- It is difficult to anticipate yearly impacts and salt usage



### WIND

- Tornadoes caused falling trees, limbs, and debris resulting in, power losses that required backup generators to maintain infrastructure



### TEMPERATURE

- Additional strain on construction equipment
- Additional employee safety protocols required
- Caused increased monitoring of tolling equipment during high temperatures



### FOG

- Impact on traffic safety especially at locations at higher elevations

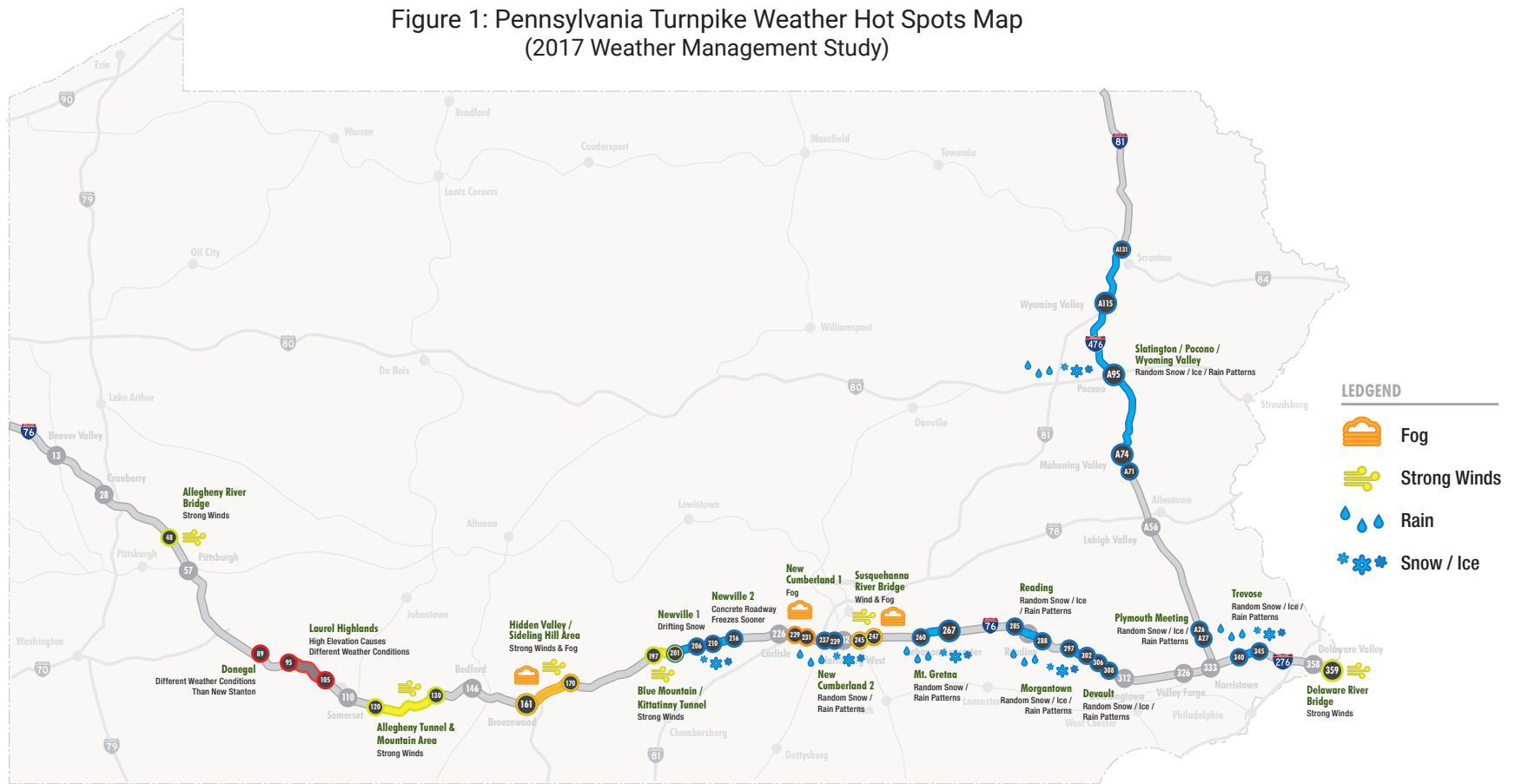


Figure 1 provides a summary of key weather hot spot issues at different locations along the system. The map was compiled based on comments received during the agency's 2017 Weather Management Study and confirmed through outreach for this assessment.

The PTC continues to track extreme weather impacts through various reports and historical data sets including, but not limited to:

- Maintenance Situational Reports
- Dashboards
- Advanced Transportation Management System (ATMS)
- After-Action Review (AAR) Reports

Figure 1: Pennsylvania Turnpike Weather Hot Spots Map (2017 Weather Management Study)



Pennsylvania Turnpike Weather Hot Spots Map

# EVALUATING FUTURE CLIMATE CHANGES

The Pennsylvania Climate Change Act (Act 70 of 2008) requires the Pennsylvania Department of Environmental Protection (DEP) to prepare and periodically update an assessment of potential climate change in the state.

The latest report, Pennsylvania Climate Impacts Assessment 2021, evaluates the most recent forecasts from Global Climate Models and provides how those forecasts may vary within different regions of the state. Figure 2 highlights some of the key anticipated changes that are expected over the next 50 to 75 years. Many of the forecasted trends are now beginning to be realized including increased temperatures and precipitation. In eastern Pennsylvania, historical gaging data for streams crossing the Turnpike have indicated higher annual peak stream flows over the last decade consistent with climate forecasts.

Specific extreme weather events are very difficult to predict; however, the consensus from researchers is that extreme storms are expected to be stronger, leading to heavier rainfalls. As a result, cumulative precipitation from storms is expected to increase, which may bring amplified risks of flooding and landslides. In addition, these impacts can affect bridge structures, resulting in increased scour and damage.

While severe non-tropical rain events are anticipated to become more frequent, snowstorms are projected to decrease in frequency. Increasing temperatures may also decrease the severity of winter weather and reduce the amount of precipitation that falls as snow. Projections indicated a decrease in the days in which snow events may occur.

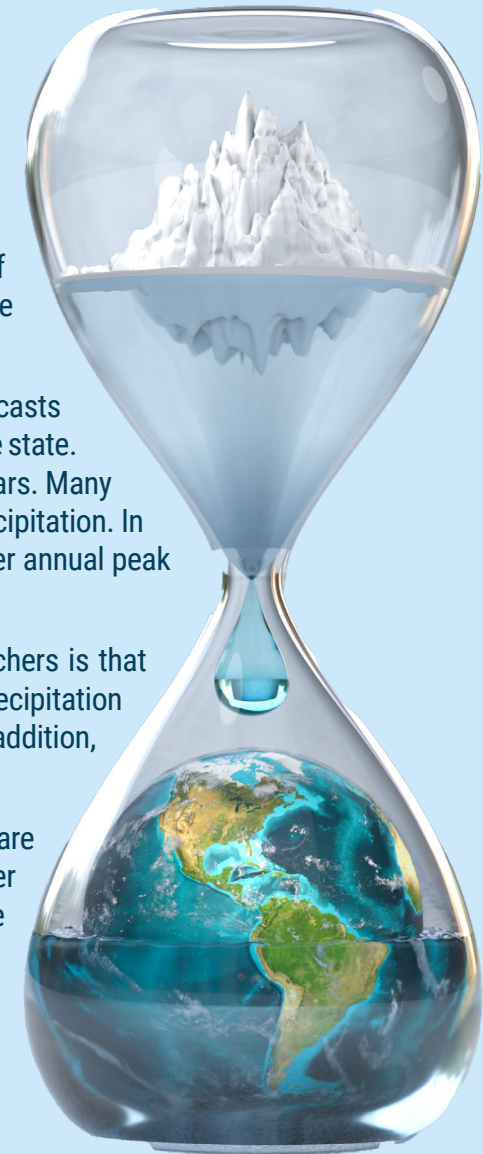
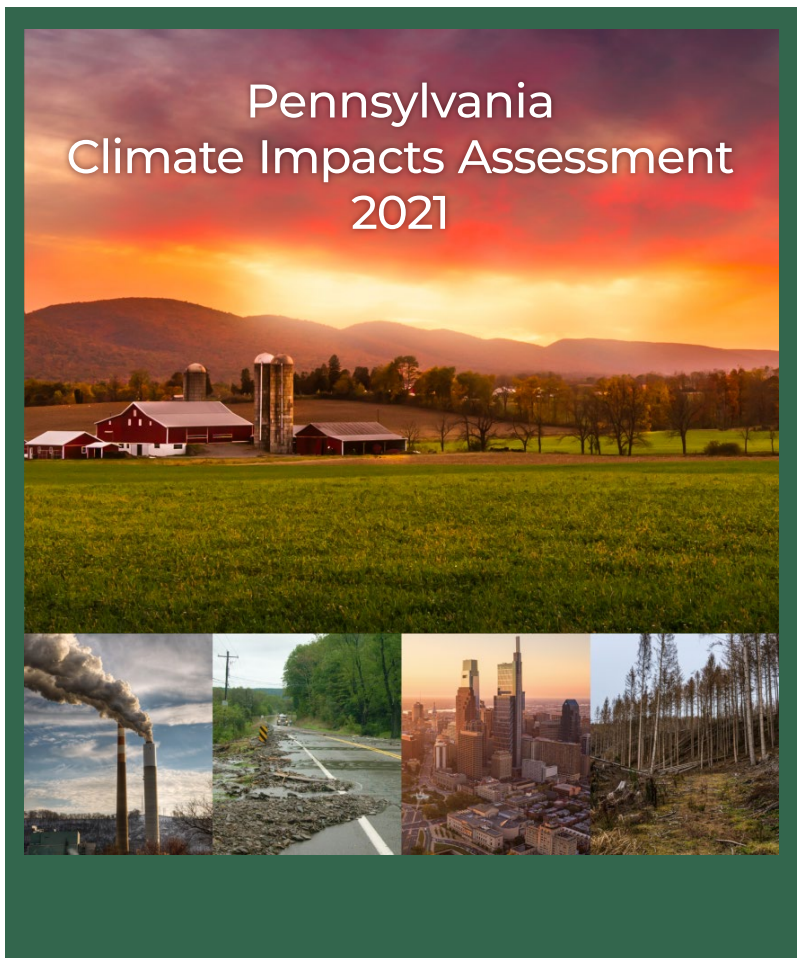
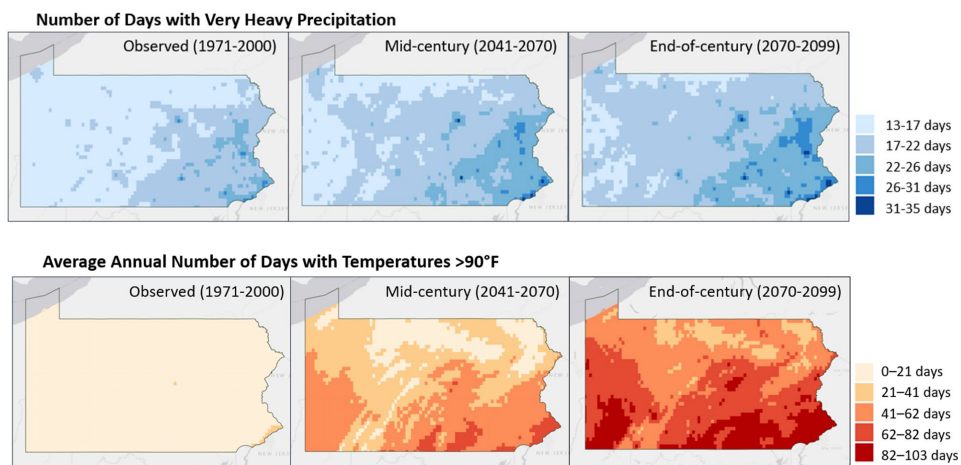


Figure 2: Highlights from Pennsylvania Climate Impacts Assessment (DEP, 2021) - [Link To Document](#)



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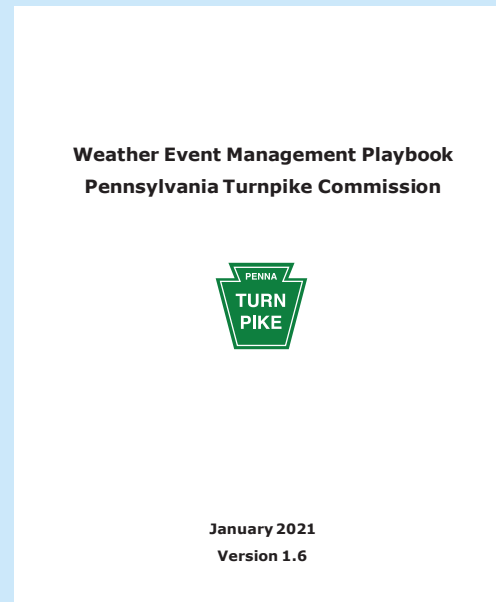
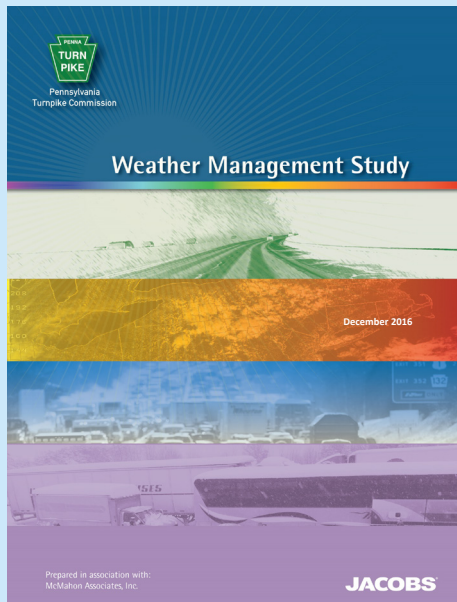
Climate Hazard	Current Risk Rating	Mid-century Risk Rating
1 Increasing average temperatures	Medium	High
2 Heavy precipitation and inland flooding	High	High
3 Heat waves	Medium	High
4 Landslides	Medium	Medium
4 Sea level rise	Low	Medium
6 Severe tropical and extra-tropical cyclones	Medium	Medium



# CURRENT PTC STRATEGIES AND INITIATIVES

The PTC has implemented a wide range of weather mitigation strategies and continues to evaluate and identify new ones. In late 2016, the PTC conducted a *Weather Management Study* to comprehensively assess current weather information systems and data needs. The efforts included a review of information and resources used by other peer agencies and recommendations for streamlining current systems to improve and aid decision-making.

In addition, the PTC developed and regularly updates its *Weather Event Management Playbook* to provide a consistent approach to weather events and to identify Department roles and responsibilities. These procedures focus on pre-event planning and during-event communication protocols to ensure flexibility to adapt to changing conditions. The key products in the Playbook include Department-specific checklists based on the weather event severity type that guide strategy implementation and communication steps.



Each Department provided insights on the most effective strategies being used to address and prepare for extreme weather events. Although opportunities exist for further improvements or integration of new technologies, the PTC is prepared for extreme weather events and potential changes related to climate change. A highlight of these current strategies is provided below.

### Pre-Event Planning and Training for PTC Staff

- Implementation and training on procedures from the *Weather Event Management Playbook* include Department checklists based on the weather event level.

TE&O Procedures Summary Table

Weather Event	Planning	Operations			
	Weather Watch Pre-Event Preparation (24-26 hour prior)	Level 1 Basic Event	Level 2 Medium Event	Level 3 Major Event	Level 4 Extreme Event
Snow	<ul style="list-style-type: none"> <li>• Activate ATMS devices to warn motorists</li> <li>• Attend pre-event meeting (if held)</li> </ul>	<ul style="list-style-type: none"> <li>• Activate ATMS devices to warn motorists</li> <li>• Implement weather schedules</li> </ul>	<ul style="list-style-type: none"> <li>• Activate ATMS devices to warn motorists</li> <li>• Advise activation of the Abandoned Vehicle Procedures</li> <li>• Notify ASPs</li> <li>• Consider restrictions</li> <li>• Deploy standby towing</li> </ul>	<ul style="list-style-type: none"> <li>• Monitor Abandoned Vehicle Procedures</li> <li>• Implement restrictions</li> <li>• Activate ATMS devices to warn motorists in conjunction with media release</li> <li>• Deploy standby towing</li> </ul>	<ul style="list-style-type: none"> <li>• Advise activation of the Abandoned Vehicle Procedures</li> <li>• Implement restrictions</li> <li>• Advise activation of the Abandoned Vehicle Procedures</li> <li>• Implement restrictions</li> </ul>
Ice Accumulation					
Rain					
Wind					
Fog					

- Dedicated PTC staff meteorologist to track storm events and provide accurate forecasts to all Districts.
- PTC pre-event planning meetings are scheduled 48 hours in advance of major storm events. Meetings include the PTC meteorologist and representatives from each Department, and also the Pennsylvania State Police (Troop T). Coordination is also conducted with the Pennsylvania Emergency Management Association Agency (PEMA).

## During Event Coordination and Communication at PTC

- Mobilize key internal PTC staff throughout the lifecycle of extreme weather events to establish a command structure with a predetermined on-call rotation for longer duration events. These meetings can be in-person or virtual with backup power sources and locations as needed.
- PTC's road closure procedures, referred to as "Plan X", are implemented if roadway closures are needed due to weather or related incidents. The PTC has established pre-approved alternative routes for both commercial and passenger vehicles when a closure is required.
- PTC dashboards are used by all Departments to prepare for and monitor conditions at all times, especially during weather events. The dashboards include access to live camera and video feeds, incident locations, vehicle speed monitoring, weather radar and more.
- Specialized computer and phone apps (including the STAR App) support alerts, notifications, and mobile photo uploads from field personnel to the Traffic Operations Center (TOC).
- Safety advisors and select maintenance vehicles have mobile windshield cameras for targeted feedback to the Operations Center if CCTV coverage is not available in a particular incident area.







## Warnings to Motorists

- Utilize available Variable Message Signs to warn motorists of extreme events. The PTC currently operates these signs at strategic locations along the Turnpike as well as off system at many interchanges. These programmable signs are operational 24 hours a day and are controlled from the Operations Control Center in Middletown, Pennsylvania. Plans call for the installation of additional permanent variable message signs to be located at other key points throughout the Turnpike System.
- Portable vehicle-mounted message signs are also used by the PTC and are mobilized quickly to locations where needed.
- PTC partners with the 511PA system to provide test message alerts for motorists who subscribe to the service. These alerts provide important weather notifications, roadway closure, and incident information.
- PTC notifies the media of weather impacts on traffic and road closures. These notifications include traffic advisory services, radio stations and large trucking firms, with updates as appropriate. This also includes the release of information to other customer direct routing apps including Waze, Google Maps and Apple Maps.
- Travel Board info centers are in each of the service plazas along the Turnpike. An electronic message center allows the Operations Control Center to provide instant and updated information on roadway conditions. "Road alert" indicator lights show locations of travel advisories.

## Signage and Barriers

- The PTC conducts regular cycles of sign repair and replacement to ensure that they meet reflectivity standards and can be seen by motorists during extreme weather events.
- In preparation for winter events, snow fences are set up in select locations where snow is prone to blowing or drifting.
- Along mountainous sections of the Turnpike, fog is a key safety issue and concern. Additional signage has been added in these heavy fog areas.
- The PTC continues to phase out the use of waterborne pavement markings by utilizing durable pavement markings with better visibility, reflectivity, and less frequent need for the application.



## Maintenance Activities

- Conducts training for maintenance staff to prepare for extreme weather. This includes a “Snow Academy” held each fall for all plow drivers. Additional winter coordination meetings are conducted between maintenance and operations staff to share ideas and strategies for addressing winter events across the eastern and western Districts.
- Regular maintenance activities are conducted to prevent and minimize flooding, landslides, and wind damage along the Turnpike. These activities include inspecting and cleaning all stormwater pipes and curbing annually, mowing and debris removal up to three times a year in basins, and annual tree trimming. Before heavy rain events, additional litter collection is conducted to prevent inlet clogs.
- Winter maintenance activities continue to be reviewed and enhanced to ensure safe driving conditions. PTC maintenance staff conduct pre-season plow “dry runs” to evaluate hazards, check for issues in work zones, and evaluate inlet and manholes within the plow path. To more efficiently clear snow from the Turnpike, a series of plows (i.e. “plow trains”) are used to clear all lanes concurrently. In addition, multiple plow types including right, left, and bi-directional are used to address special road considerations. PTC staff use telematics to continually monitor plow cycle times based on each storm and can adjust based on the latest conditions. Dual auger spreaders are used to distribute salt more accurately to travel lanes and reduce waste.
- Shoulders and steep slopes are maintained to reduce erosion and improve drainage.





## Construction Activities

- PTC conducts coordinated meetings with contractors before project initiation and during construction to identify potential extreme weather impacts and issues. In addition, pre-winter season coordination is conducted with all contractors that have active work sites during the winter season. The PTC operations centers maintain contact with contractors during weather events.
- PTC utilizes their Documentation Inspection Reporting Technology (DIRT) application for inspecting erosion and sediment control best management practices (BMPs) and provide real-time assessments of their conditions. Extreme weather events can cause sedimentation to accumulate or cause damage to the BMPs. The DIRT app allows the PTC to better monitor and track the repairs and maintenance of the BMPs.
- Contracts for construction work include generic erosion and sediment control line items to provide payment and funding flexibility for repairs due to unforeseen conditions including those caused by extreme weather.
- Digital rain gauges are used on project sites for monitoring precipitation and post-event assessments.

## Engineering and Design

- Designs bridges to ensure high levels of scour protection, especially at scour critical structures. These designs can withstand future increases in stream flow.
- Implemented a robust Stormwater Asset Management Program (SWAMP), to track management of the stormwater drainage systems and basins across the system, to meet MS4 requirements.





## Technology

- Use Geo-Analytics to map rainfall ponding in the Computer Aided Dispatch System (CADS).
  - Upload to Waze for real-time customer notifications
  - Share maintenance needs with the TOC
- Operate STAR app for PTC staff phones
- Use of customer-driven notifications such as Waze, Google Maps, Apple Maps, social media, etc.
- Use telematics, which collect GPS data as well as send and receive data and diagnostics, on all fleet vehicles to manage cycle times, performance, fleet location, etc.
- Standard procedure to not make any IT system changes prior or during extreme weather events



# AN ACTION PLAN FOR FURTHER RESILIENCY

To remain resilient to extreme weather events, the PTC is expanding on its robust collection of current extreme weather mitigation strategies. For an organization to continue to successfully mitigate future changes, it must always look ahead and strive for continuous improvement.

What future extreme weather conditions will bring is unknown, but constantly seeking new ways to enhance preparedness and communication, utilizing the latest available technology, and enhancing operational and response methods will keep the PTC at the forefront of this ever-changing landscape.

The following action items were identified by their respective PTC departments as goals that require further evaluation or are ready for implementation to address further extreme weather resiliency.





## Engineering – Construction

- Evaluate including additional time in construction schedules for projects within known PTC extreme weather hotspots.
- Consider enhanced protocols and preparedness for “pop-up” storms.

## Engineering – Design

- Evaluate providing additional temporary stormwater management capacity and enhanced erosion control devices within available right-of-way.
- Evaluate future changes to PennDOT’s design standards and procedures to address extreme weather conditions.
- Enhance coordination with regional or local agencies to address off-system flooding that impacts ingress and egress to Turnpike interchanges or facilities.
- Continue to monitor developing technologies for deicing of bridges and roadways.

## Engineering – Facilities & Energy Management Operations

- Complete the on-going solar study and review recommendations on resiliency, backup power supply, etc.
- Attempt to reduce the PTC’s overall energy production at or above the PA GreenGov Council’s goal of 3% annually.
- Evaluate development of specialized PTC staffing and training.
- Evaluate feasibility of increasing design standards beyond minimum requirements.
- Consider transfer switches for back up generator connections at all remaining facilities.







## Maintenance

- Continually evaluate alternative plow styles and advanced technologies for enhanced clearing and safety efficiencies.
- Evaluate salt spreading application technology to minimize salt usage and reduce negative environmental impacts while maintaining safety.
- Investigate proximity openers at all access gates to improve cycle times for the fleet.
- Investigate possible mechanical median barrier gate location(s) between each interchange.

## Information Technology

- Evaluate installing mobile Road Weather Information System (RWIS) on fleet vehicles to provide real-time weather conditions and data.
- Further utilize Geo-Analytics of mapped rainfall ponding areas in the Computer Aided Dispatch System (CADS)
- Attempt to become more predictive with weather forecasting through the use of technology and micro-climate studies.
- Evaluate best practices to utilize real-time customer-driven data received from cellular apps and GPS.
- Continue coordinating available data with departments and field staff including the use of improved apps and web technology.
- Explore installing remote monitoring for all on-site backup fuel storage not currently equipped.





## Toll Collection Operations

- Complete transition to Open Road Tolling (ORT).
- Continually increase the percentage of E-Z Pass transponder use among customers.
- Investigate new tolling technologies, specifically non-imaging options.

## Traffic Engineering & Operations

- Explore certification of the Traffic Operations Center as a Public Safety Answering Point (PSAP) 911 call center.
- Explore solutions to enhance radio communications with the Pennsylvania State Police (PSP) – Troop T.
- Investigate the impacts of micro-climates and their vulnerabilities systemwide.
- Investigate the use of new technology such as the mobile Road Weather Information System (RWIS).



More intense and frequent extreme weather events are projected in a changing climate and can pose serious challenges for transportation agencies. The PTC continues to look to the future to incorporate extreme weather events more proactively into its transportation planning strategies through increased **preparedness, communication,** and **response**, to create a more resilient system.





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INTERNATIONAL