PennDOT Resiliency Policy

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ACEC / PA Water Environment Energy Committee - Fall Conference

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PennDOT Resiliency Policy - Assets

- Highways and Bridges:
  - 40,000 miles of PennDOT Highways
  - 121,000 miles of Interstate and Local Roads
  - 25,400 PennDOT owned Bridges
  - Approximately 6,400 Locally owned Bridges
- Bicycle & Pedestrian:
  - Sidewalks
  - Bicycle Routes

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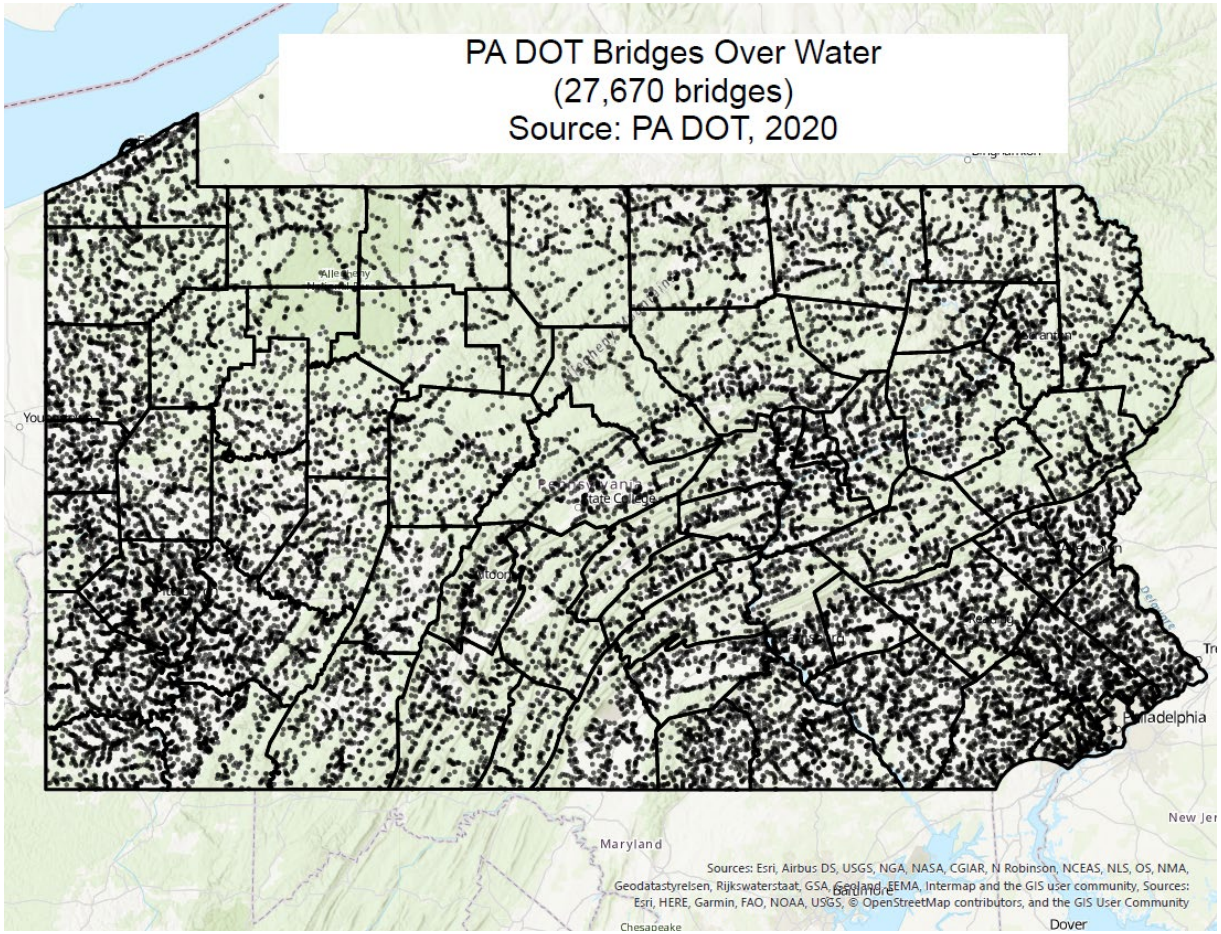
PennDOT Bridge Assets



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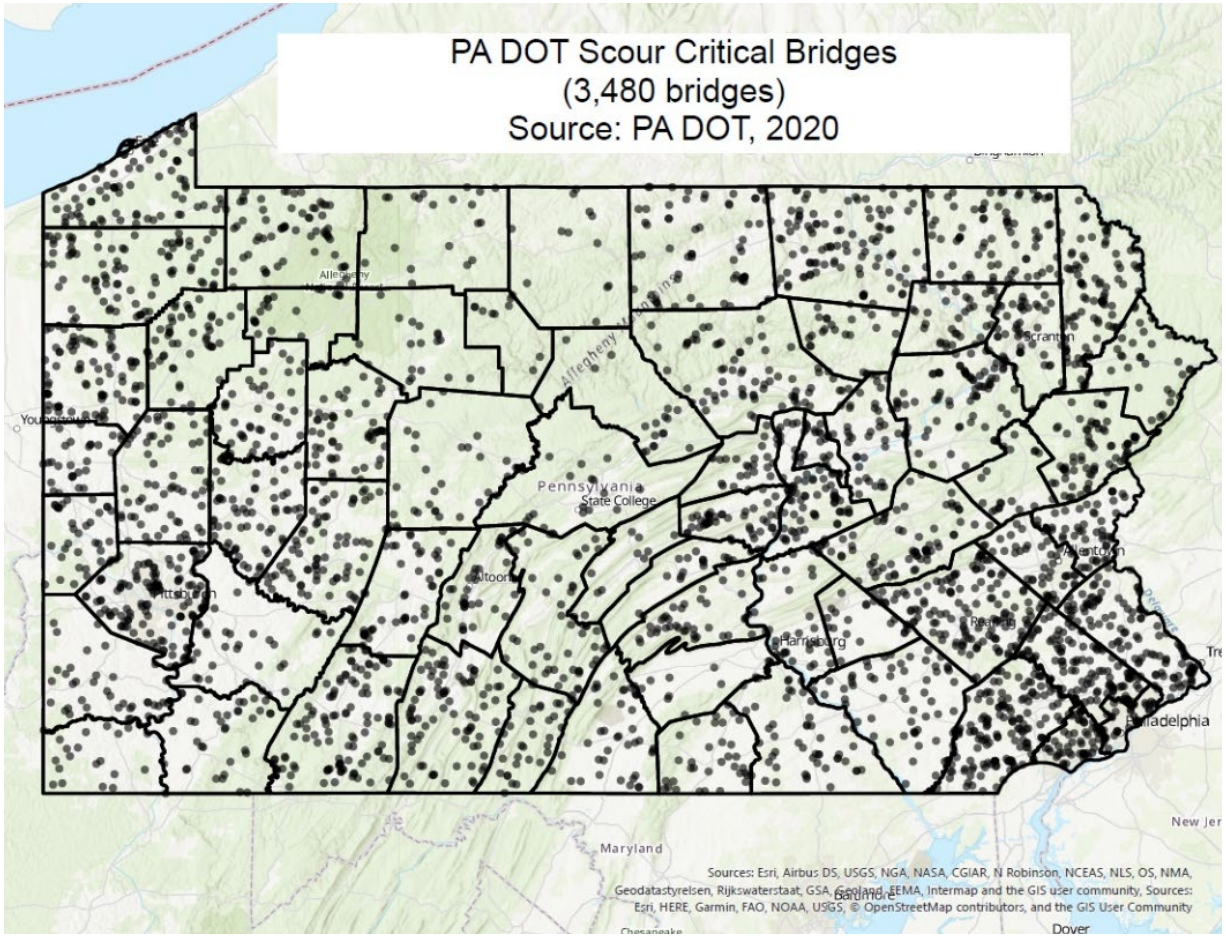
PennDOT Bridge Assets



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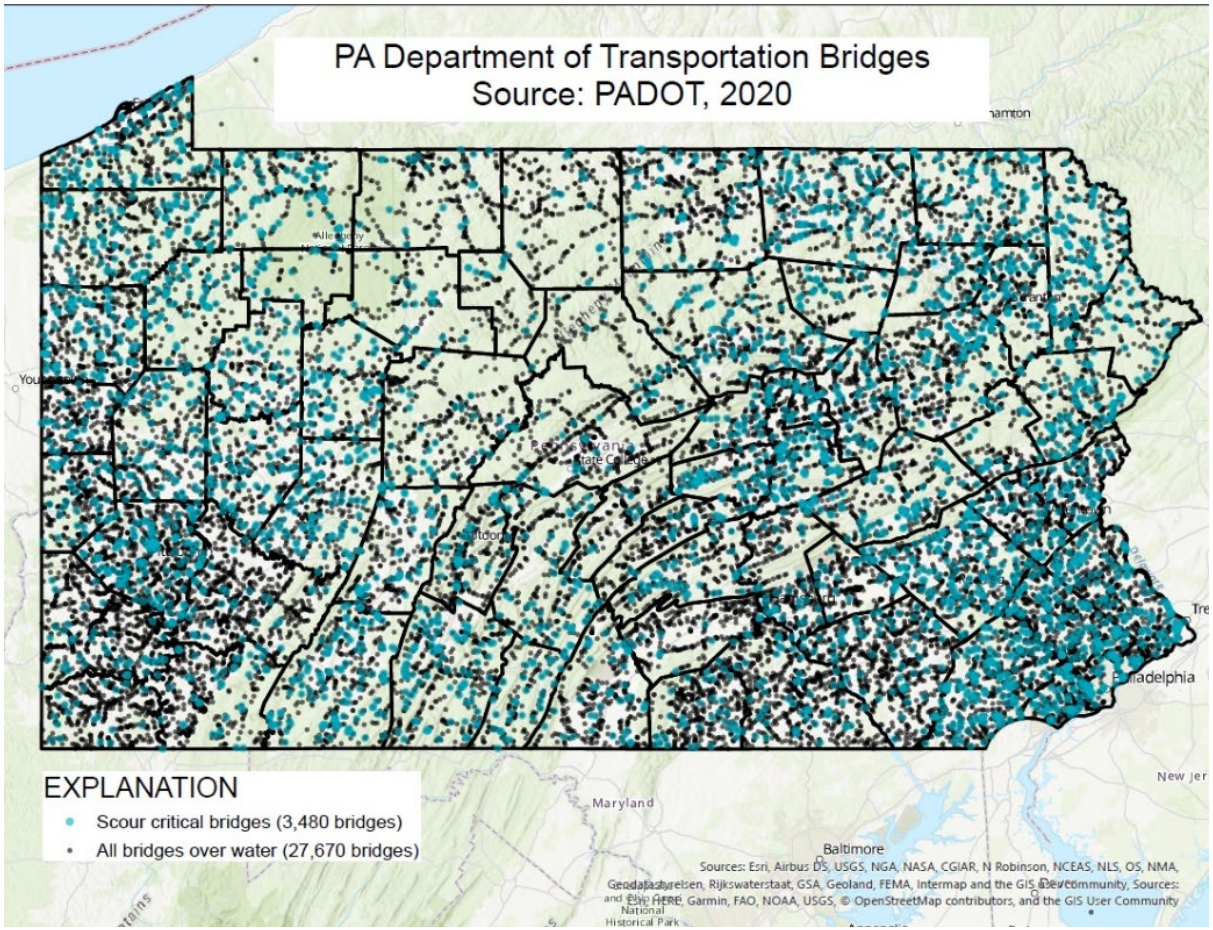
PennDOT Bridge Assets



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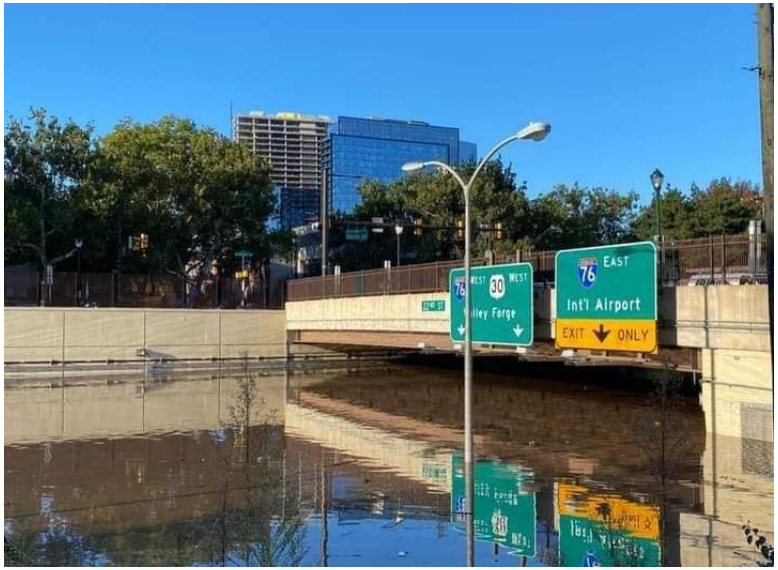
PennDOT Resiliency Policy

- The ability to resist, limit impacts, and rapidly return to service after an extreme event.



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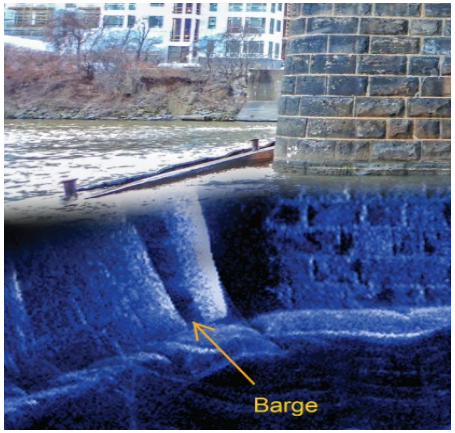
- Hazards
  - Flooding – Primary
  - Others
    - Land Slides and Sink holes
    - Fire
    - Vehicle impacts
    - Barge impact
    - Terrorist Attacks



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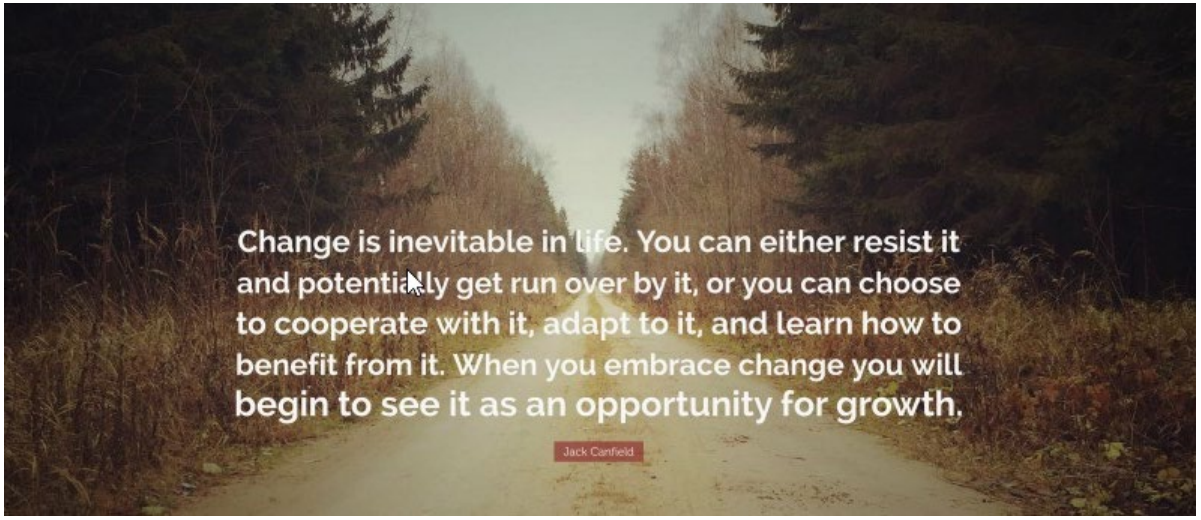
PennDOT Resiliency Policy

- Transportation systems that can effectively resist and readily adapt to conditions above and beyond standard design conditions.



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- Intensity-Duration-Frequency (IDF) Charts
  - Use to determine precipitation amounts or rainfall intensities for use in various design methods
  - Current IDF charts were based on NOAA Atlas 14, Volume2, Version 3 Data
    - 278 Daily and 139 Hourly rainfall gages from April 1863 – December 31, 2000 (137 years)
    - Previous IDF Charts were based on data from 1948 – 1983 (35 years)

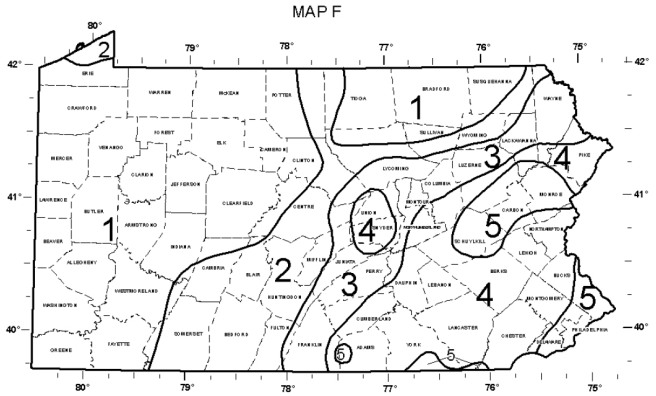

Photo Source: NOAA, Climate.gov

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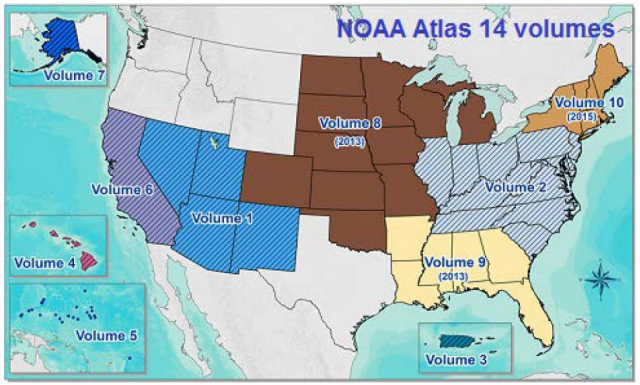
Background Pennsylvania IDF Charts

- NOAA NWS Atlas 14, Vol 2, Version 3
  - Initial published 2004, revised 2006
  - Rainfall durations ranging from 5 minutes to 60 days
  - Rainfall frequency ranging from 1-year to 1000-year
  - Available via PDF Publication or Web Application

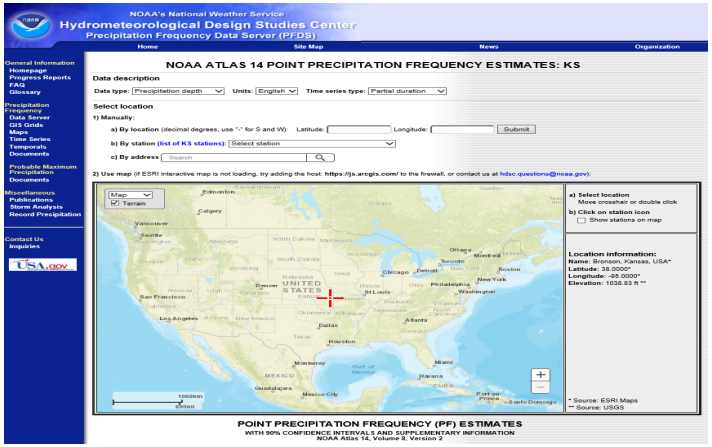


NOAA Atlas 14

Precipitation-Frequency Atlas of the United States

Volume 2 Version 3.0: Delaware, District of Columbia, Illinois, Indiana, Kentucky, Maryland, New Jersey, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, West Virginia

Geoffrey M. Bonnin, Deborah Martin, Bingzhang Lin, Tye Parzybok, Michael Yekta, David Riley



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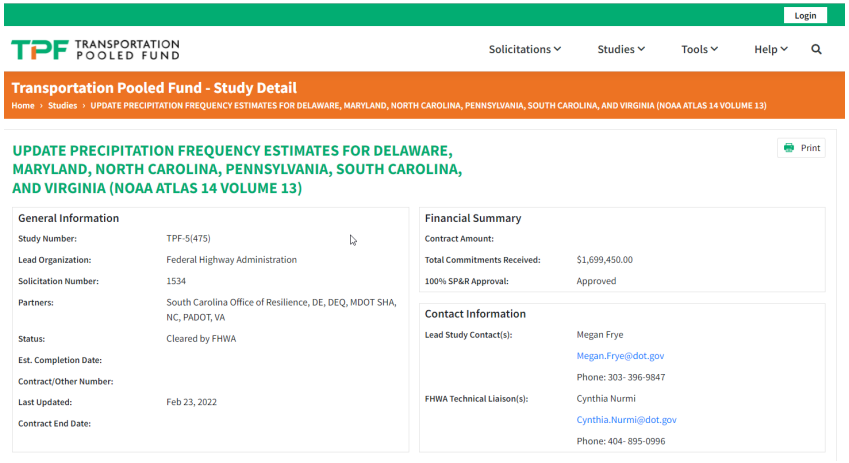
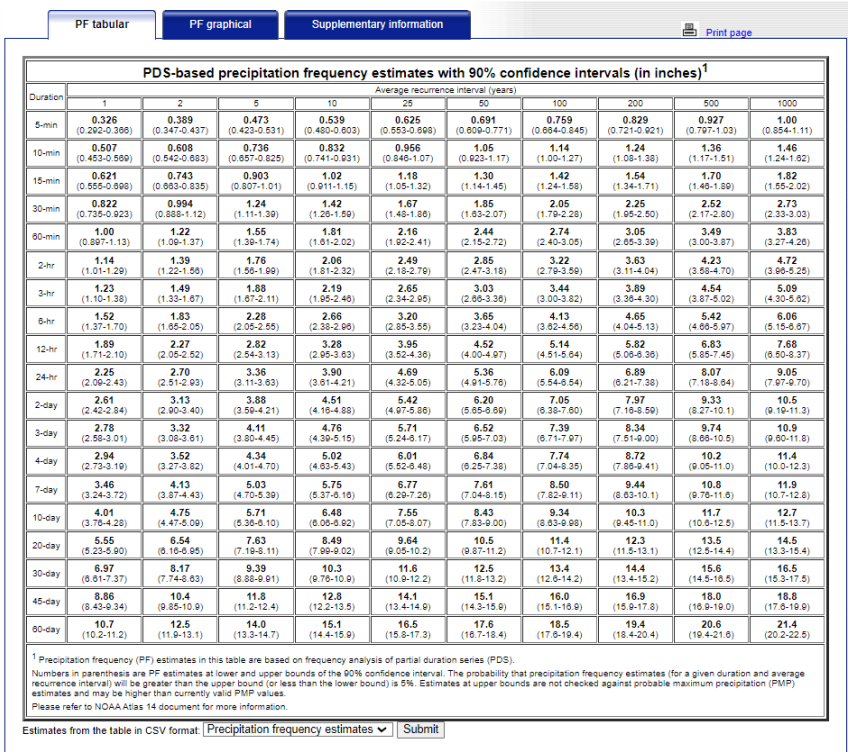
Future Pennsylvania IDF Charts

- Update of IDF Curves planned to capture data from 2000-2020
  - NOAA Atlas 14, Volume 13 plans to update precipitation regions
  - Transportation Pooled fund
    - https://www.pooledfund.org/Details/Study/702




PF tabular | PF graphical | Supplementary information | Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years) 1	2	5	10	25	50	100	200	500	1000
5-min	0.326 (0.292-0.366)	0.389 (0.347-0.437)	0.473 (0.423-0.531)	0.539 (0.480-0.603)	0.625 (0.553-0.698)	0.691 (0.609-0.771)	0.759 (0.664-0.845)	0.829 (0.721-0.921)	0.927 (0.797-1.03)	1.00 (0.854-1.11)
10-min	0.507 (0.453-0.569)	0.608 (0.542-0.683)	0.736 (0.657-0.825)	0.832 (0.741-0.931)	0.956 (0.846-1.07)	1.05 (0.923-1.17)	1.14 (1.00-1.27)	1.24 (1.08-1.38)	1.36 (1.17-1.51)	1.46 (1.24-1.62)
15-min	0.621 (0.555-0.698)	0.743 (0.663-0.835)	0.903 (0.807-1.01)	1.02 (0.911-1.15)	1.18 (1.05-1.32)	1.30 (1.14-1.45)	1.42 (1.24-1.58)	1.54 (1.34-1.71)	1.70 (1.46-1.89)	1.82 (1.55-2.02)
30-min	0.822 (0.735-0.923)	0.994 (0.888-1.12)	1.24 (1.11-1.39)	1.42 (1.26-1.59)	1.67 (1.48-1.86)	1.85 (1.63-2.07)	2.05 (1.79-2.28)	2.25 (1.95-2.50)	2.52 (2.17-2.80)	2.73 (2.33-3.03)
60-min	1.00 (0.897-1.13)	1.22 (1.09-1.37)	1.55 (1.39-1.74)	1.81 (1.61-2.02)	2.16 (1.92-2.41)	2.44 (2.15-2.72)	2.74 (2.40-3.05)	3.05 (2.65-3.39)	3.49 (3.00-3.87)	3.83 (3.27-4.26)
2-hr	1.14 (1.01-1.29)	1.39 (1.22-1.56)	1.76 (1.56-1.99)	2.06 (1.81-2.32)	2.49 (2.18-2.79)	2.85 (2.47-3.18)	3.22 (2.79-3.59)	3.63 (3.11-4.04)	4.23 (3.58-4.70)	4.72 (3.96-5.25)
3-hr	1.23 (1.10-1.38)	1.49 (1.33-1.67)	1.88 (1.67-2.11)	2.19 (1.95-2.46)	2.65 (2.34-2.95)	3.03 (2.66-3.36)	3.44 (3.00-3.82)	3.89 (3.36-4.30)	4.54 (3.87-5.02)	5.09 (4.30-5.62)
6-hr	1.52 (1.37-1.70)	1.83 (1.65-2.05)	2.28 (2.05-2.55)	2.66 (2.38-2.96)	3.20 (2.85-3.55)	3.65 (3.23-4.04)	4.13 (3.62-4.56)	4.65 (4.04-5.13)	5.42 (4.66-5.97)	6.06 (5.15-6.67)
12-hr	1.89 (1.71-2.10)	2.27 (2.05-2.52)	2.82 (2.54-3.13)	3.28 (2.95-3.63)	3.95 (3.52-4.36)	4.52 (4.00-4.97)	5.14 (4.51-5.64)	5.82 (5.06-6.36)	6.83 (5.85-7.45)	7.68 (6.50-8.37)
24-hr	2.25 (2.09-2.43)	2.70 (2.51-2.93)	3.36 (3.11-3.63)	3.90 (3.61-4.21)	4.69 (4.32-5.05)	5.36 (4.91-5.76)	6.09 (5.54-6.54)	6.89 (6.21-7.38)	8.07 (7.18-8.64)	9.05 (7.97-9.70)
2-day	2.61 (2.42-2.84)	3.13 (2.90-3.40)	3.88 (3.59-4.21)	4.51 (4.16-4.88)	5.42 (4.97-5.86)	6.20 (5.65-6.69)	7.05 (6.38-7.60)	7.97 (7.16-8.59)	9.33 (8.27-10.1)	10.5 (9.19-11.3)
3-day	2.78 (2.58-3.01)	3.32 (3.08-3.61)	4.11 (3.80-4.45)	4.76 (4.39-5.15)	5.71 (5.24-6.17)	6.52 (5.95-7.03)	7.39 (6.71-7.97)	8.34 (7.51-9.00)	9.74 (8.66-10.5)	10.9 (9.60-11.8)
4-day	2.94 (2.73-3.19)	3.52 (3.27-3.82)	4.34 (4.01-4.70)	5.02 (4.63-5.43)	6.01 (5.52-6.48)	6.84 (6.25-7.38)	7.74 (7.04-8.35)	8.72 (7.88-9.41)	10.2 (9.05-11.0)	11.4 (10.0-12.3)
7-day	3.46 (3.24-3.72)	4.13 (3.87-4.43)	5.03 (4.70-5.39)	5.75 (5.37-6.16)	6.77 (6.29-7.26)	7.61 (7.04-8.15)	8.50 (7.82-9.11)	9.44 (8.63-10.1)	10.8 (9.76-11.6)	11.9 (10.7-12.8)
10-day	4.01 (3.76-4.28)	4.75 (4.47-5.09)	5.71 (5.36-6.10)	6.48 (6.06-6.92)	7.55 (7.05-8.07)	8.43 (7.83-9.00)	9.34 (8.63-9.98)	10.3 (9.45-11.0)	11.7 (10.6-12.5)	12.7 (11.5-13.7)
20-day	5.55 (5.23-5.90)	6.54 (6.16-6.95)	7.63 (7.19-8.11)	8.49 (7.99-9.02)	9.64 (9.05-10.2)	10.5 (9.87-11.2)	11.4 (10.7-12.1)	12.3 (11.5-13.1)	13.5 (12.5-14.4)	14.5 (13.3-15.4)
30-day	6.97 (6.61-7.37)	8.17 (7.74-8.63)	9.39 (8.88-9.91)	10.3 (9.76-10.9)	11.6 (10.9-12.2)	12.5 (11.8-13.2)	13.4 (12.6-14.2)	14.4 (13.4-15.2)	15.6 (14.5-16.5)	16.5 (15.3-17.5)
45-day	8.86 (8.43-9.34)	10.4 (9.85-10.9)	11.8 (11.2-12.4)	12.8 (12.2-13.5)	14.1 (13.4-14.9)	15.1 (14.3-15.9)	16.0 (15.1-16.9)	16.9 (15.9-17.8)	18.0 (16.9-19.0)	18.8 (17.6-19.9)
60-day	10.7 (10.2-11.2)	12.5 (11.9-13.1)	14.0 (13.3-14.7)	15.1 (14.4-15.9)	16.5 (15.8-17.3)	17.6 (16.7-18.4)	18.5 (17.6-19.4)	19.4 (18.4-20.4)	20.6 (19.4-21.6)	21.4 (20.2-22.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.
Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in CSV format: Precipitation frequency estimates Submit

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- IDF Curves based on HISTORICAL precipitation data and used for design purposes

- Climate models use various FUTURE PROJECTIONS to estimate potential FUTURE precipitation data
  - Climate model data compared to historical data to create ratios that can be considered for future climate scenarios
  - For example; for future design process, IDF Curves would still be used to determine precipitation amount and intensity. Future Climate Ratios could be used to supplement the historic data for resilient designs at vulnerable sites

PennDOT Resiliency Policy

Extreme Weather and Climate Change

- Concerning number and intensity of storms and damage
- End of July 2019 marked the end of the wettest two-year, three-year, and four-year periods on record. The National Oceanic and Atmospheric Administration keeps monthly records dating back to 1895.
- 24-month period (July 2017-June 2019): 113.13
- 36-month period (July 2016-June 2019): 158.87
- 48-month period (July 2015-June 2019): 198.18

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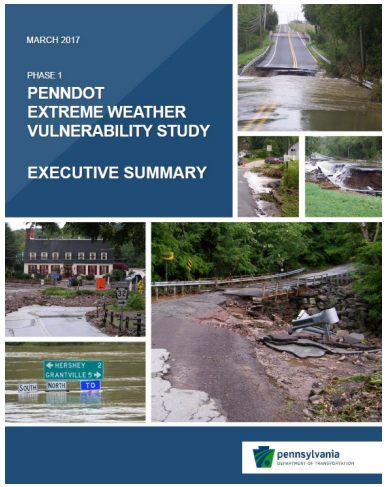
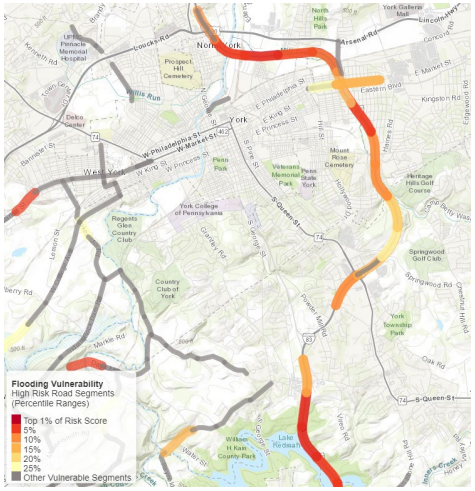
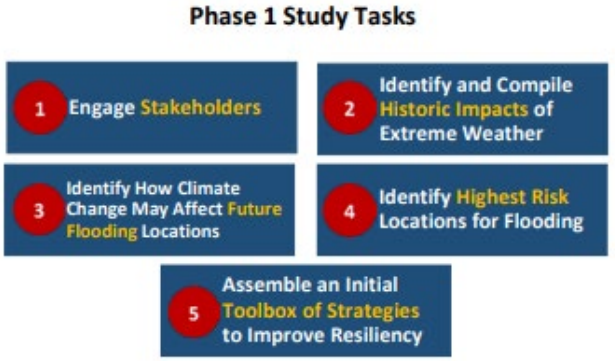
Extreme Weather and Vulnerability Study

- Initial study completed by PennDOT Program Center March 2017
- Distributed to Districts, MPOs, and other state agencies for comments on maps and methods
- Assessments of flooding vulnerability and risks should be considered an evolving process.
- Goal is to update data yearly.







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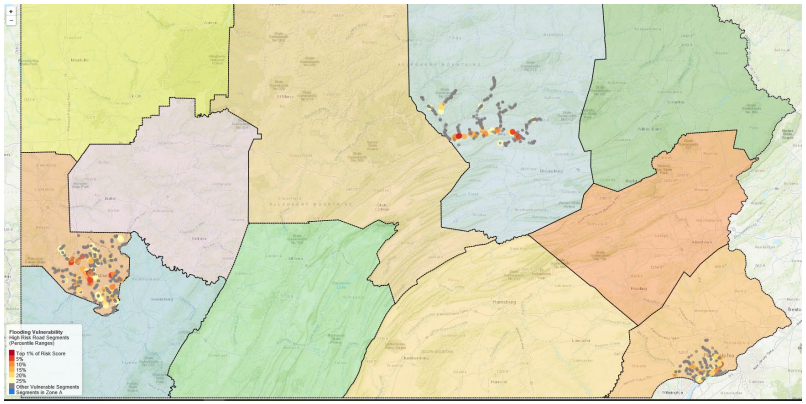
Extreme Weather and Vulnerability Study

- Assessed historic vulnerability as well as future vulnerabilities
- Future vulnerabilities were determined with a risk formula
  - 3 Counties were selected to pilot this process
  - Map Data from 2017-2022



Impacts of Climate Change

- Share forecast scenario vulnerability analyses for further assessment and review
- Explore options for application of forecasting methodology beyond the three pilot counties
- Continue to track Department of Environmental Protection and Penn State University climate assessments and adaptation efforts
- Evaluate new data sources and agency activities related to flood zones

Assessing Adaptation Strategies

- Establish strategy working groups to evaluate strategies in more detail.
- Conduct more detailed focus studies to evaluate vulnerabilities and strategies for specific locations

Integration of Resiliency Concepts

- Support integration of study results to address other Department requirements and initiatives
- Support districts and metropolitan planning organizations in conducting resiliency planning
- Provide local technical assistance to support resiliency planning.
- Determine other improvements in capabilities and funding necessary for successful implementation.

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Impacts of Extreme Weather

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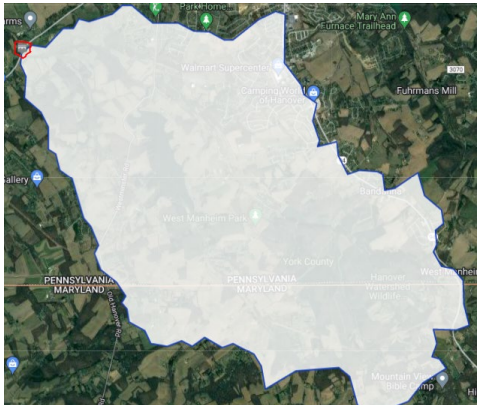
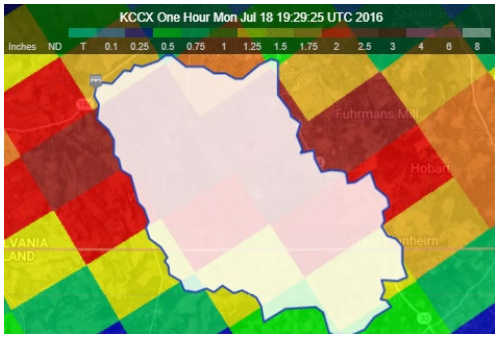
BridgeWatch System

- Minimum Input:
  - Structure identification data (name, stream intersected, roadway, etc)
  - Structure location
  - Drainage Area feeding the stream under the structure
  - Threshold values for inspection (rainfall, stream flow, etc)
- BridgeWatch background process:
  - Monitors the drainage area to determine if the rainfall exceeds threshold
  - Monitors stream gages (where relevant) to determine if stream flow exceeds threshold
- Output:
  - If a threshold is exceeded, alerts are sent out containing the name, the threshold value, rainfall amount, etc.
- Next step:
  - Go inspect the bridge



Critical Year Peak	1-HR	2-HR	3-HR	6-HR	12-HR	24-HR	48-HR	72-HR	96-HR
50	2.69	3.09	3.45	4.33	5.46	6.53	7.19	7.71	8.08
50	2.69	3.09	3.45	4.33	5.46	6.53	7.19	7.71	8.08
50	2.69	3.09	3.45	4.33	5.46	6.53	7.19	7.71	8.08
50	2.69	3.09	3.45	4.33	5.46	6.53	7.19	7.71	8.08



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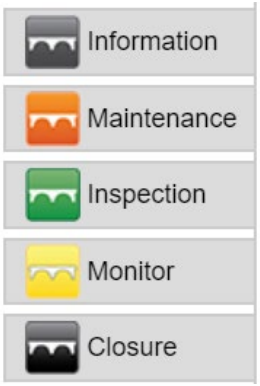
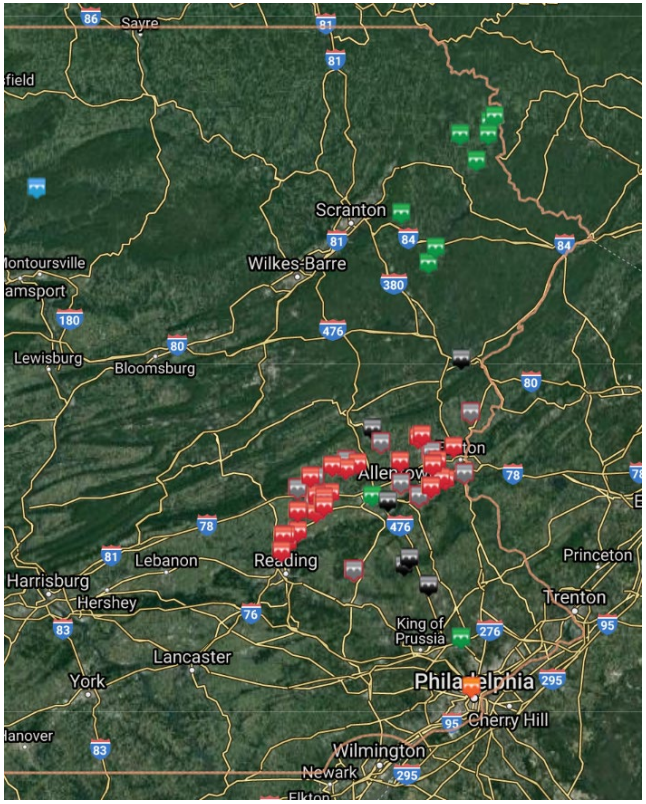
BridgeWatch System

- Notification Hierarch
  - Icon Color changes based on status





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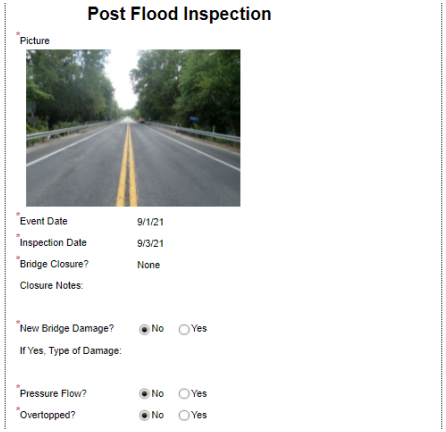
BridgeWatch System

- Bridge Inspections and Inspection Forms
  - Once an inspection form is submitted, the red Alert icon will be replaced with a green Inspection icon and Alert will be closed out
  - Captures important information that can be used:
    - To help design a more resilient bridge in the future
    - help refine the threshold values of the structure to generate more accurate Warnings and Alerts



Post Flood Inspection

*Picture

*Event Date 9/1/21

*Inspection Date 9/3/21

*Bridge Closure? None

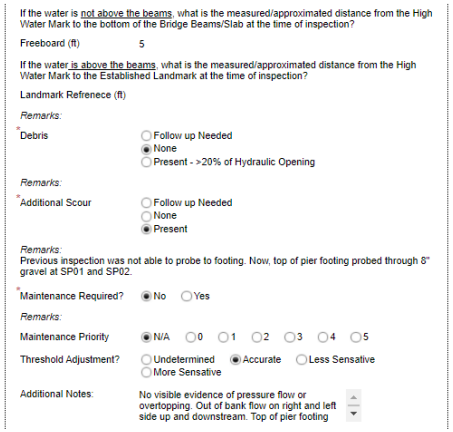
Closure Notes:

*New Bridge Damage? ◉ No ○ Yes

If Yes, Type of Damage:

*Pressure Flow? ◉ No ○ Yes

*Overtopped? ◉ No ○ Yes



If the water is not above the beams, what is the measured/approximated distance from the High Water Mark to the bottom of the Bridge Beams/Slab at the time of inspection?

Freeboard (ft) 5

If the water is above the beams, what is the measured/approximated distance from the High Water Mark to the Established Landmark at the time of inspection?

Landmark Refrenece (ft)

Remarks:

*Debris ○ Follow up Needed ◉ None ○ Present - >20% of Hydraulic Opening

Remarks:

*Additional Scour ○ Follow up Needed ○ None ◉ Present

Remarks:
Previous inspection was not able to probe to footing. Now, top of pier footing probed through 8" gravel at SP01 and SP02.

*Maintenance Required? ◉ No ○ Yes

Remarks:

Maintenance Priority ◉ N/A ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Threshold Adjustment? ○ Undetermined ◉ Accurate ○ Less Sensative ○ More Sensative

Additional Notes: No visible evidence of pressure flow or overtopping. Out of bank flow on right and left side up and downstream. Top of pier footing

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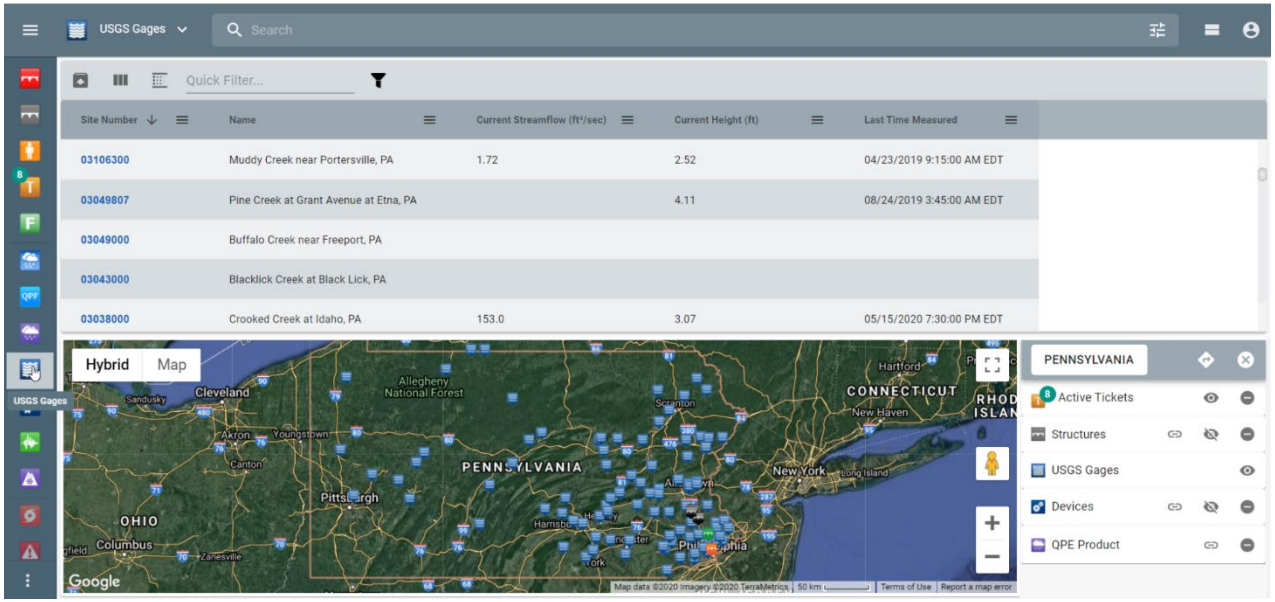
BridgeWatch Example

- USGS Gages



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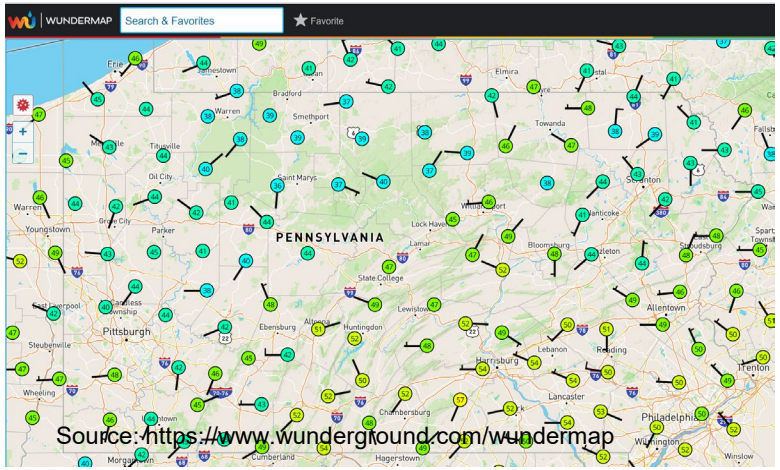
BridgeWatch Example

- Wunderground Rain Data
  - Extra data that has not yet been added to BridgeWatch System
  - Numerous rain gages that provide real rain fall data
  - Issue with consistency of data due to power outages



Source: https://www.wunderground.com/wundermap

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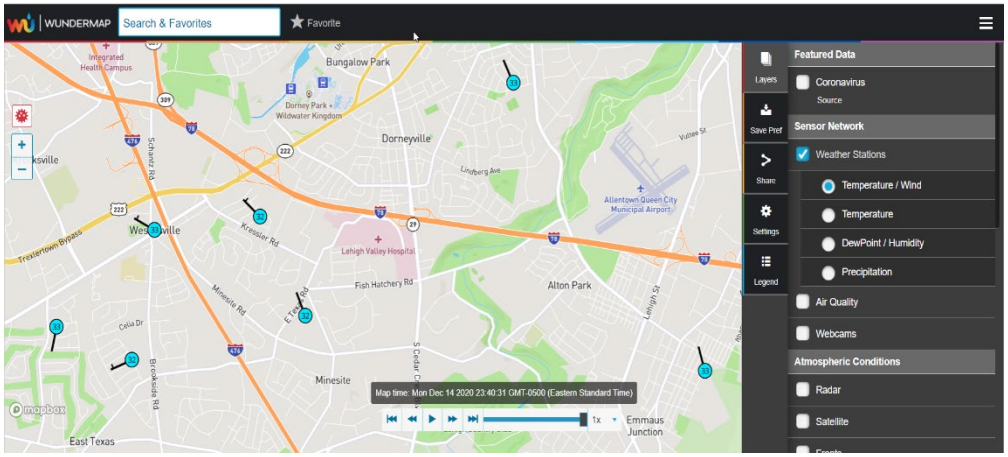
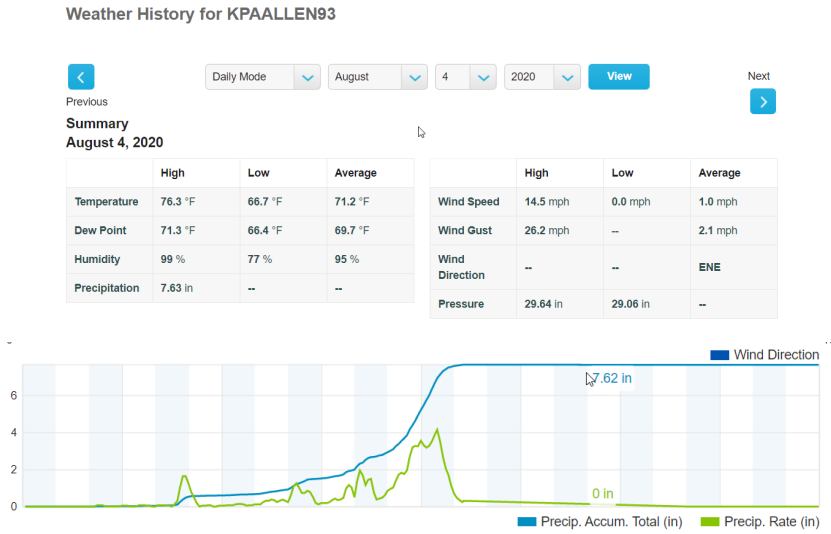
BridgeWatch Example

- Wunderground Rain Data





Source: https://www.wunderground.com/wundermap

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BridgeWatch Example

- Wunderground Rain Data

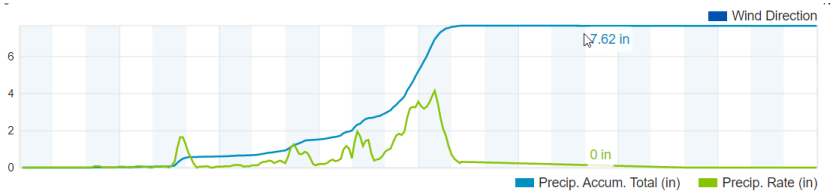
Weather History for KPAALLEN93

Previous | Daily Mode | August | 4 | 2020 | View | Next

Summary
August 4, 2020

	High	Low	Average
Temperature	76.3 °F	66.7 °F	71.2 °F
Dew Point	71.3 °F	66.4 °F	69.7 °F
Humidity	99 %	77 %	95 %
Precipitation	7.63 in	--	--

	High	Low	Average
Wind Speed	14.5 mph	0.0 mph	1.0 mph
Wind Gust	26.2 mph	--	2.1 mph
Wind Direction	--	--	ENE
Pressure	29.64 in	29.06 in	--



6:19 AM	71.1 °F	70.8 °F	99 %	SE	0.0 mph	0.0 mph	29.54 in	0.07 in	0.62 in	0	1.2 w/m²
6:24 AM	71.4 °F	71.1 °F	99 %	SE	0.0 mph	0.0 mph	29.53 in	0.12 in	0.63 in	0	0.9 w/m²
6:29 AM	71.5 °F	71.2 °F	99 %	ESE	0.7 mph	0.8 mph	29.53 in	0.14 in	0.64 in	0	2.1 w/m²
6:34 AM	71.4 °F	71.1 °F	99 %	ESE	0.5 mph	1.1 mph	29.52 in	0.14 in	0.65 in	0	2.9 w/m²
6:39 AM	71.4 °F	71.1 °F	99 %	SE	0.0 mph	0.2 mph	29.53 in	0.12 in	0.65 in	0	3.8 w/m²
6:44 AM	71.4 °F	71.1 °F	99 %	SSE	0.0 mph	0.0 mph	29.53 in	0.05 in	0.65 in	0	3.4 w/m²
12:44 PM	67.5 °F	67.2 °F	99 %	NNW	6.7 mph	13.9 mph	29.08 in	2.06 in	7.38 in	2	230.2 w/m²
12:49 PM	67.4 °F	67.0 °F	99 %	NW	4.8 mph	11.2 mph	29.07 in	1.70 in	7.48 in	1	143.1 w/m²
12:54 PM	67.2 °F	66.8 °F	99 %	NNW	4.6 mph	8.6 mph	29.07 in	1.13 in	7.51 in	1	144.4 w/m²
12:59 PM	66.9 °F	66.6 °F	99 %	NW	5.3 mph	11.0 mph	29.10 in	0.71 in	7.56 in	1	181.3 w/m²
1:04 PM	66.8 °F	66.5 °F	99 %	West	6.2 mph	10.6 mph	29.09 in	0.47 in	7.58 in	1	136.2 w/m²
1:09 PM	66.8 °F	66.5 °F	99 %	NNE	4.9 mph	10.0 mph	29.10 in	0.35 in	7.60 in	1	106.2 w/m²
1:14 PM	66.9 °F	66.6 °F	99 %	West	5.4 mph	13.3 mph	29.11 in	0.24 in	7.62 in	0	95.8 w/m²
1:17 PM	66.9 °F	66.6 °F	99 %		6.0 mph	11.7 mph	29.11 in	0.31 in	7.63 in	1	142.3 w/m²
8:04 PM	76.1 °F	70.0 °F	82 %	SSE	0.1 mph	2.2 mph	29.45 in	0.00 in	7.62 in	0	2.9 w/m²
8:09 PM	76.0 °F	70.1 °F	82 %	SSE	0.0 mph	0.6 mph	29.45 in	0.00 in	7.62 in	0	1.7 w/m²
8:14 PM	75.9 °F	70.0 °F	82 %	South	0.0 mph	0.6 mph	29.45 in	0.00 in	7.62 in	0	1.2 w/m²

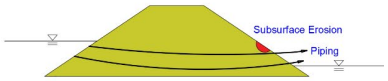
Source: https://www.wunderground.com/wundermap

PennDOT Resiliency Policy

Research

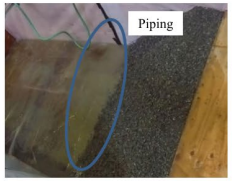
- Partner with Academia to develop design solutions for a more resilient transportation infrastructure.
- Research program cultural change to focus on extreme events and resiliency.

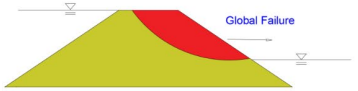
- Rapidly increase water head difference
- Maximum head difference ~ 18 in.
- Piping and slope failure before overtopping
- Global failure was observed with overtopping



Piping

Slope failure before overtopping





Global failure

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PennDOT Resiliency Policy

Resilience Improvement Plan – DRAFT POLICY

- New IIJA PROTECT Funding expands importance of resiliency policy to funding.
- Process to develop the policy – To be added to (PUB 13) DM-2, Chapter 10.
  - Draft policy coordination with Resiliency Team
  - Poll with Districts on draft policy
  - Discuss poll results and update policy; additional coordination with resiliency team and OCC for a few legal coordination questions
- Review Current Draft Policy
- Planned Examples
  - Bridge Example – Complete
  - Culvert Example – Under development
  - Slide Example – Under development

PennDOT Resiliency Policy

Resilience Improvement Plan– DRAFT POLICY

- New section of DM 2, Chapter 10 Section 10.6.7

10.6.7 – Resilient Design Assessment …

1. If PennDOT has not previously assigned a resilient design level at project scoping, determine the vulnerability score for the project using Exhibit 10.21. The following resources may be helpful in determining which conditions are applicable for a project:
    a. The completed existing and proposed hydraulic analysis
    b. Scour calculations performed for the proposed project
    c. BMS2 (bridge inspection) data
    d. Field observations
    e. Project scoping information
    f. Environmental documents
    g. Floodplain maps
2. Based on the vulnerability score, determine if the project meets the requirements for an exception. If you meet the requirements for an exception outlined in 2.a., a full, quantitative assessment is not required. However, it is recommended to consider resilient design options as part of the project, and it is required to document the vulnerability score and any resiliency measures that were included in the design as a separate memo to be included with the TS&L/Design Field View submission. If the project does not meet the requirements for an exception, then complete steps 3-8.
    a. Projects must meet ALL of the following criteria for an exception:
        i. Any proposed structures are culverts (closed-bottom structures); and
        ii. Roadway has an ADT less than 400; and
        iii. Vulnerability score is 2 or less.
    b. If you **do not meet** the requirements for an exception, apply the applicable ratio from Exhibit 10.22 to project design discharges computed using applicable methods in Section 10.6.C**. Alternatively**, a designer can choose to increase discharges using best available climate science for future conditions out to the year 2080 under representative concentration pathway (RCP) 8.5.

PennDOT Resiliency Policy

Resilience Improvement Plan– DRAFT POLICY

- New section of DM 2, Chapter 10 Section 10.6.7

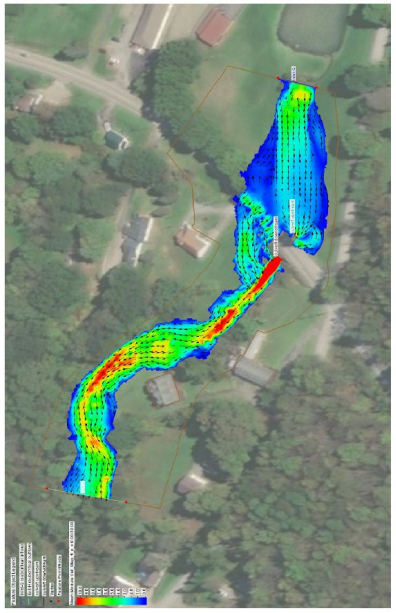
3. Re-run the proposed hydraulic model for your project using the future condition discharges determined in Step 2 for the project design event, 0.01 AEP (100-year) event, and additional worst-case scour design events, if needed. The minimum level of detail needed to evaluate the resilient design flows in the hydraulic model should be incorporated.
4. Complete the Resilient Design Checklist that is applicable for your project (Exhibit 10.23 for bridges and culverts and Exhibit 10.24 for roadways). It is important to note in the checklist if a project site is eligible for PROTECT funds.
5. Use the results of the Resilient Design Checklist, engineering judgment, interdisciplinary coordination, and knowledge of existing and proposed site conditions to determine the project's potential for resilient design. The checklists consist of interdisciplinary parameters, including hydraulics, traffic, safety, and others, that are compared between proposed and future conditions to determine if the site will be more vulnerable to issues such as scour, stability, and roadway overtopping.
6. Where possible, design adjustments should be considered to provide at least 1 foot of freeboard for the design storm under future conditions. However, adjustments to freeboard that would require roadway profile increases and result in upstream water surface elevation increases must be avoided. Where the freeboard requirement cannot be met, additional consideration should be given to other countermeasures.
7. Recommend reasonable design adaptations and countermeasures to improve the resiliency of the project design under future climate scenarios, such as:
    a. Adjustments to scour protection, foundations, or structure hydraulic opening to reduce future scour potential.
    b. Additional embankment protection or changes to structure anchoring to reduce impacts of increased frequency, depth, or velocity of overtopping flow.
    c. Possible changes to bridge or beam type if structure low chord may be inundated under future conditions, but not under current proposed conditions.
    d. Possible superstructure design adjustments if future condition may increase overtopping depth at bridge or result in bridge barrier overtopping.
8. Document the Design Assessment process and any resiliency measures recommended for consideration in the Resilient Design Assessment Report. Appendix J includes examples of Resilient Design Assessments for bridge and roadway projects. Resiliency measures that are recommended based on the Resilient Design Assessment should be coordinated with other disciplines in the design team, such as structures, roadway, and foundations, and incorporated into the design, as appropriate.

PennDOT Resiliency Policy

Resilience Improvement Plan– DRAFT POLICY

- Vulnerability Score

Existing 100-year Discharge Event Velocity SMS Scalar & Vector Datasets



Proposed 100-year Discharge Event Velocity SMS Scalar & Vector Datasets

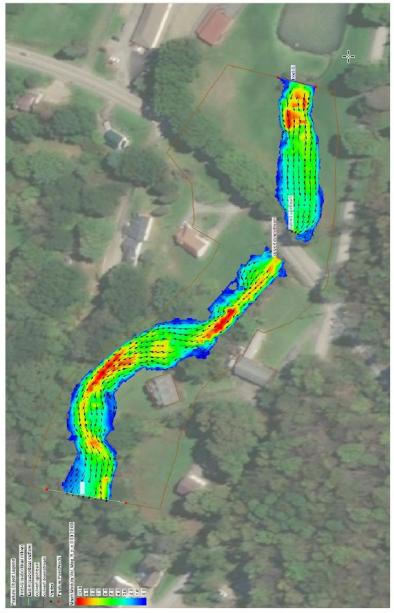


Exhibit 10.21 Vulnerability Scores by Condition

Condition	Number to Add to Score	
	Yes	No
The site provides access to essential services, such as hospitals, other emergency services, major utilities, etc., or is an evacuation route for residential or public facilities, such as nursing homes or prisons.	4	0
The detour length for alternate access exceeds 10 miles.	3	0
The route is an only point of access for homes, schools, businesses, etc., with no available detour.	4	0
Serves members of the community that only have access to non-motorized transportation options.	2	0
The site is located in a FEMA Zone AE floodplain (detailed study area).	1	0
The site has an overtopping frequency of 0.01 AEP (100-year) or more.	2	0
There are buildings in the 0.01 AEP (100-year) floodplain.	1	0
There are existing scour or stream stability concerns, such as migration or deposition, or the site has potential for future concerns.	3	0
The bridge is under pressure flow for any return period.	2	0

PennDOT Resiliency Policy

Resilience Improvement Plan– DRAFT POLICY

- Discharge Multiplier
  - Numbers and percentages based on PennDOT Climate Change Study

Exhibit 10.22 Resilient Design Discharge Multiplier

Vulnerability Score (Based on Exhibit 10.21)	Discharge Multiplier
0-3	1.1 (10% increase)
4-7	1.2 (20% increase)
8+	1.3 (30% increase)

PennDOT Resiliency Policy

Resilience Improvement Plan– DRAFT POLICY

- Resilient Design Checklist for Bridges and Culverts

Exhibit 10.23: Resilient Design Checklist for Bridges

	Parameter	Proposed Condition (Existing Flows)	Future Condition (Flows with Discharge Multiplier)	Indicates Potential for Resilient Design
Site Data	Hydrology Method			
	Embankment Instability			
	Overtopping Frequency			
	Design Event Frequency			
	Provides Access to Critical Services			
	Project is Eligible for PROTECT Funds			
Design Event	Discharge (cfs)			
	% Q Bridge			
	Pressure Flow			
	Bridge Velocity (fps)			
	Overtopping Velocity (fps)			
	Overtopping Depth (Roadway) (ft)			
	Overtopping Depth (Structure) (ft)			
	Adjacent Roadway(s) Impacted			
0.01 AEP Event	Discharge (cfs)			
	% Q Bridge			
	Pressure Flow			
	Bridge Velocity (fps)			
	Scour Depth (ft)			
	Riprap Size			
	Overtopping Velocity (fps)			
	Overtopping Depth (Roadway) (ft)			
	Overtopping Depth (Structure) (ft)			
	Adjacent Roadway(s) Affected			

PennDOT Resiliency Policy

Resilience Improvement Plan– DRAFT POLICY

- Resilient Design Checklist for Roadways

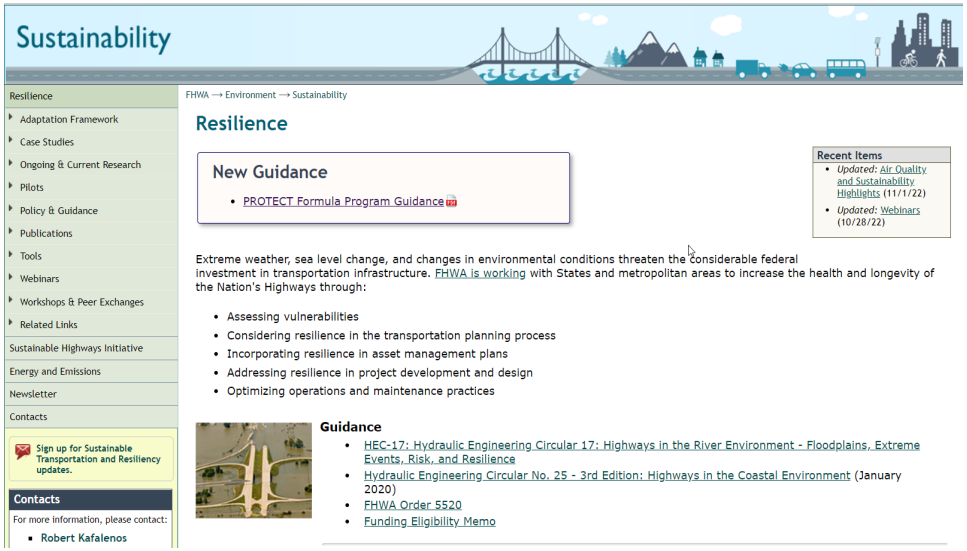
Exhibit 10.24: Resilient Design Checklist for Roadways

	Parameter	Proposed Condition (Existing Flows)	Future Condition (Flows with Discharge Multiplier)	Indicates Potential for Resilient Design
Site Data	Hydrology Method			
	Embankment Instability			
	Overtopping Frequency			
	Design Event Frequency			
	Provides Access to Critical Services			
	Project is Eligible for PROTECT Funds			
Bank full Flow	Discharge (cfs)			
	Channel Velocity (fps)			
	Scour Depth (ft)			
	Event Frequency			
Design Event	Discharge (cfs)			
	Channel Velocity (fps)			
	Overtopping Velocity (fps)			
	Overtopping Depth (Roadway) (ft)			
0.01 AEP Event	Discharge (cfs)			
	Channel Velocity (fps)			
	Overtopping Velocity (fps)			
	Overtopping Depth (Roadway) (ft)			

PennDOT Resiliency Policy

Bipartisan Infrastructure Law (BIL)
Infrastructure Investment and Jobs Act (IIJA)

- **On November 15, 2021, the President signed the Infrastructure Investment and Jobs Act (IIJA) (Public Law 117-58, also known as the "Bipartisan Infrastructure Law") (BIL) into law.**
- **The BIL added the Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Formula Program in section 176(c) of title 23, United States Code (23 U.S.C.).**
- **PennDOT receives an average of 60 million per year for the next 5 years provided by FHWA for projects under this Guidance**
- **Significant money dedicated to wildlife crossings on a competitive grant basis**



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PennDOT Resiliency Policy

PROTECT Funding

- Financial Guidance meetings to discuss distribution.
  - 01-09-2023
  - 02-07-2023
  - 02-21-2023
  - 03-02-2023
  - 04-26-2023
  - 05-02-2023
- Options - Statewide Program vs formula distribution to planning partners.
  - Current plan is – first three years statewide, remaining years to be formula.
  - Committee members to review projects.
- Request Districts to provide problem locations so we can consider projects for allocating the PROTECT funds.
  - Information from the District Maintenance staff:
    i. Roads and bridges that are continually flooded
    ii. Roads and bridges that are continually at risk of land/rockslides
    iii. Roads and bridges that experience repetitive wash outs
  - Information from the District Design staff:
    i. Roads and bridges (Emergency repair projects)
  - Information from RPOs/MPOs:
    i. Known problem areas
    ii. Known areas that receive repetitive repairs
  - Flooding issue in these areas are:
    i. Stormwater infrastructure based
    ii. Stream flooding/floodplain based

PROTECT Formula Program Summary **12-01-2022**

Pennsylvania Totals:	5-year Total	2022	2023	2024	2025	2026
	$301 million	$58 million	$59 million	$60 million	61 million	63 million

Program Guidance:

PROTECT Formula Program Guidance

Program Purpose:

- The Bipartisan Infrastructure Law (BIL) established the *Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation* (PROTECT) Formula Program
- Focuses on funding to make surface transportation more resilient to natural hazards, including climate change, sea level rise, flooding, extreme weather events, and other natural disasters
- The PROTECT Program includes both formula funding distributed to States and competitive grants. This summary describes the program's formula funding

Eligible Activities:

- ***Resilience Planning*** – Development of state Resilience Improvement Plans, other resilience planning activities, capacity building, and evacuation planning and preparation
- ***Resilience Improvements*** – Projects to make existing surface transportation assets more resilient, such as improving drainage, upgrades to meet or exceed design standards, relocating roadways, or elevating bridges
- ***Community Resilience and Evacuation Routes*** – Improvements to make evacuation routes more resilient or add capacity and redundant evacuation routes
- ***At-Risk Coastal Infrastructure*** – Protecting, strengthening, or relocating coastal highway and non-rail infrastructure

Eligible Facilities (Projects are treated as Federal-aid projects):

- Highway projects eligible under Title 23
- Transit projects eligible under Chapter 53 of Title 49
- Port facilities
- Natural infrastructure, storm surge and flood protection, and aquatic ecosystem restoration

Federal / Non-Federal Share:

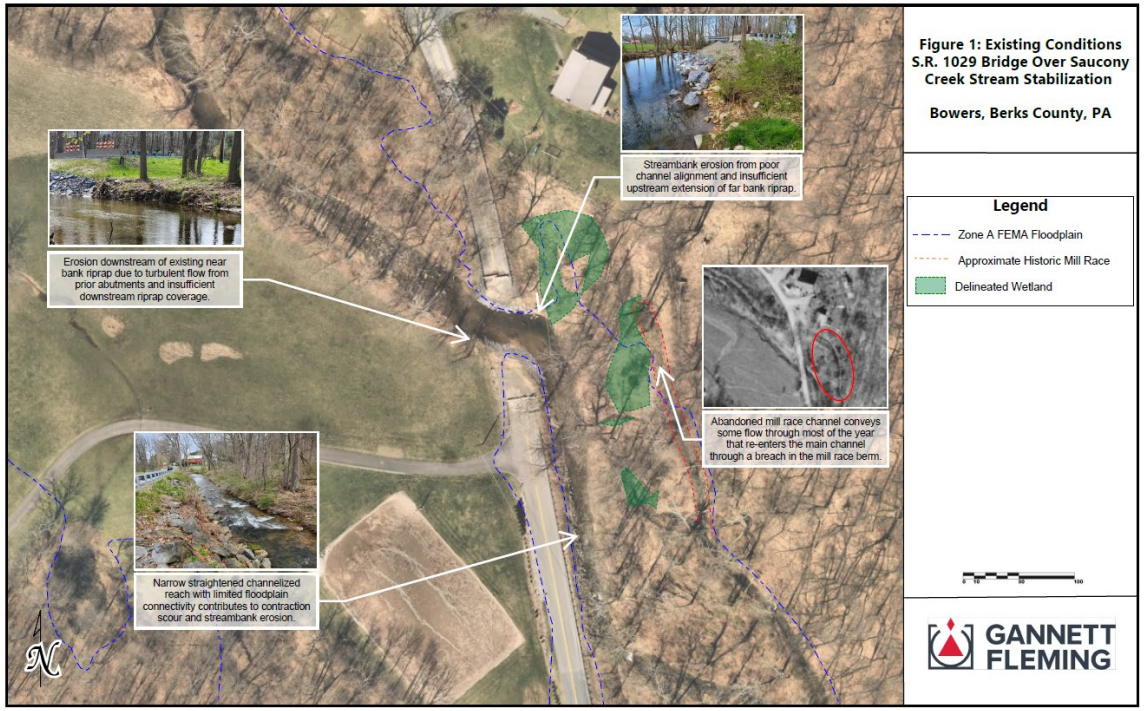
- Maximum 80% Federal share; 20% non-Federal
- Other Federal Funds can be used for the non-Federal share
- Non-Federal share may be reduced by—
  - 7% if the State develops a Resilience Improvement Plan that prioritizes the project; and
  - 3% if a State Resilience Improvement Plan is incorporated into the metropolitan transportation plan or the statewide long-range transportation plan

PennDOT Resiliency Policy

PROTECT Funding

- Example Projects – District 5

The S.R. 1029 (Smoketown Road) bridge was a single-span steel spread beam bridge that crossed Saucony Creek in Rockland Township, Berks County upstream of Bowers, PA. In May 2021, the bridge was closed after a motorist reported that the far (north) bridge abutment had settled. The Bridge Problem Area Inspection Report completed on May 6, 2021 noted that there was approximately 8 feet of scour in front of the far abutment, and 4 feet of lateral undermining. Streambank erosion had also cut behind the stone masonry abutment and was beginning to undermine a portion of the approach roadway. This erosion extended along the far bank upstream of the far upstream wingwall. A previous inspection report completed in July 2016 also noted significant scour along the far abutment and wingwall with both the footing and previously completed underpinning exposed. Inspections completed after the road closure determined that repairs to the abutment and wingwall were not feasible, so the bridge and associated abutments were removed, and riprap was added to both the near and far streambank.



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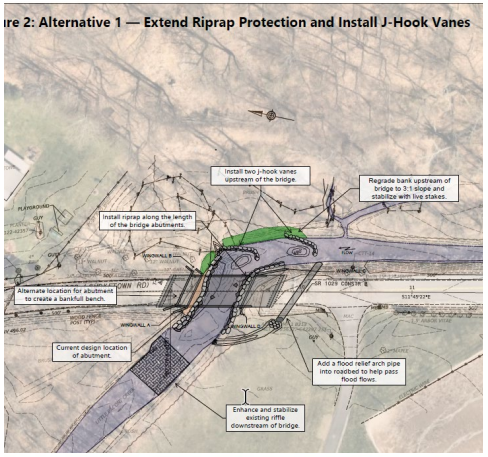
PROTECT Funding

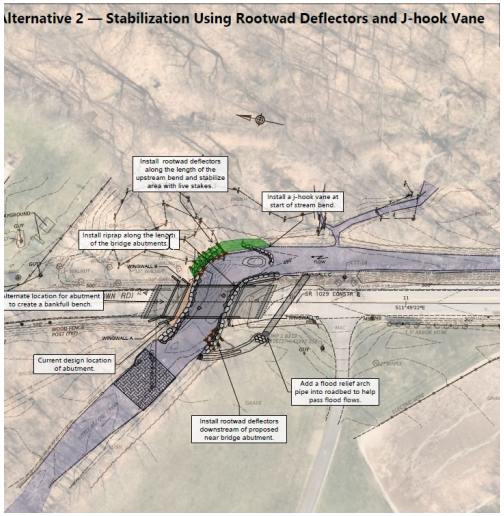
- Example Projects – District 5

Table 1: Concept Alternative Construction Cost Estimates

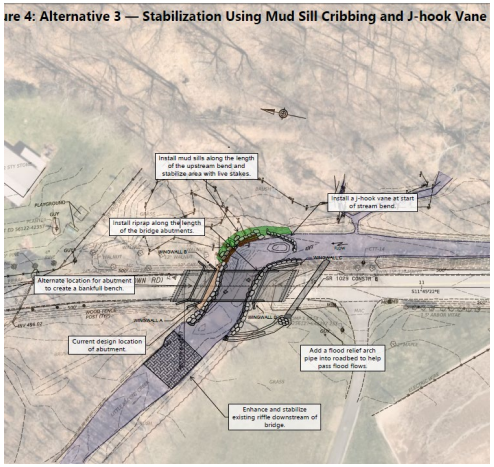
Item Description	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Survey	$4,000	$4,000	$4,000	$6,000
Temporary Measures	$17,000	$17,000	$17,000	$42,000
Construction Activities	$44,000	$46,000	$40,000	$303,000
Arch Pipe Installation	$20,000	$20,000	$20,000	$20,000
Plantings	$6,000	$6,000	$6,000	$15,000
Subtotal	$91,000	$93,000	$87,000	$386,000
10% Contingency	$9,100	$9,300	$8,700	$38,600
Total Cost Estimate	$100,100	$102,300	$95,700	$424,600



re 2: Alternative 1 — Extend Riprap Protection and Install J-Hook Vanes



lternative 2 — Stabilization Using Rootwad Deflectors and J-hook Vane



re 4: Alternative 3 — Stabilization Using Mud Sill Cribbing and J-hook Vane

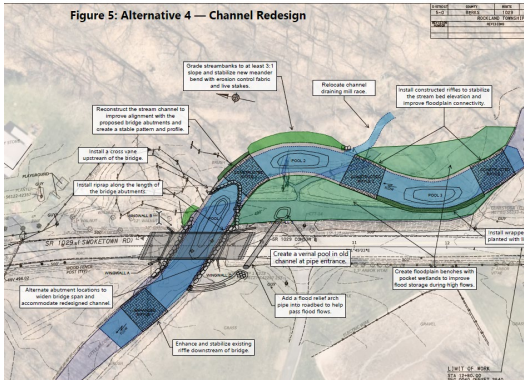


Figure 5: Alternative 4 — Channel Redesign

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PennDOT Resiliency Policy

PROTECT Funding

- Example Projects – District 11

Electronic Communications to monitor water levels and improve evacuation / road closure for safety until larger improvement project is funded.

Nick,

See below and attached. We have an area called the "bathtub" that you may or may not be aware of on the parkway east (I-376) in the City of Pgh, approaching the Ft Pitt bridge. When the Mon Warf floods to a certain elevation it overtops the roadway barrier and floods this section of roadway. We have a future project, unfunded for construction, to most likely raise the barrier to keep the water out, but until that time we are looking to improve the flood monitoring system, which is managed by our maintenance folks when the rivers rise in flooding/potential flooding events.

We were wondering if we would be able to leverage the PROTECT funds to purchase this system and yearly monitoring fee. In addition, we may also pursue for funding the bigger project, but this would ensure we have a more reliable system in the interim.

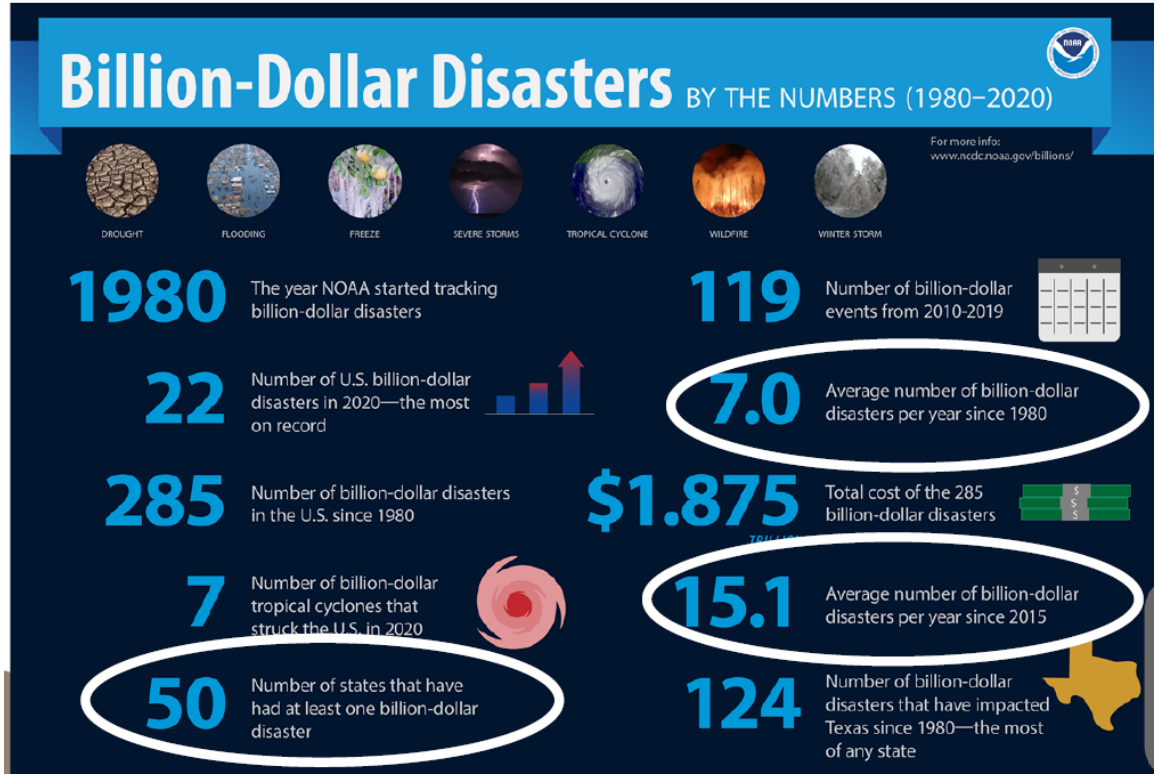
Let me know if this is even a slight possibility and I can arrange a meeting with Lori Musto our ADE Maintenance and some of the others involved in the current process of monitoring/closure of the interstate due to a flooding event.

Thanks!

Doug

PennDOT Resiliency Policy

What if we resist, do nothing?



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PennDOT Resiliency Policy

- Questions?