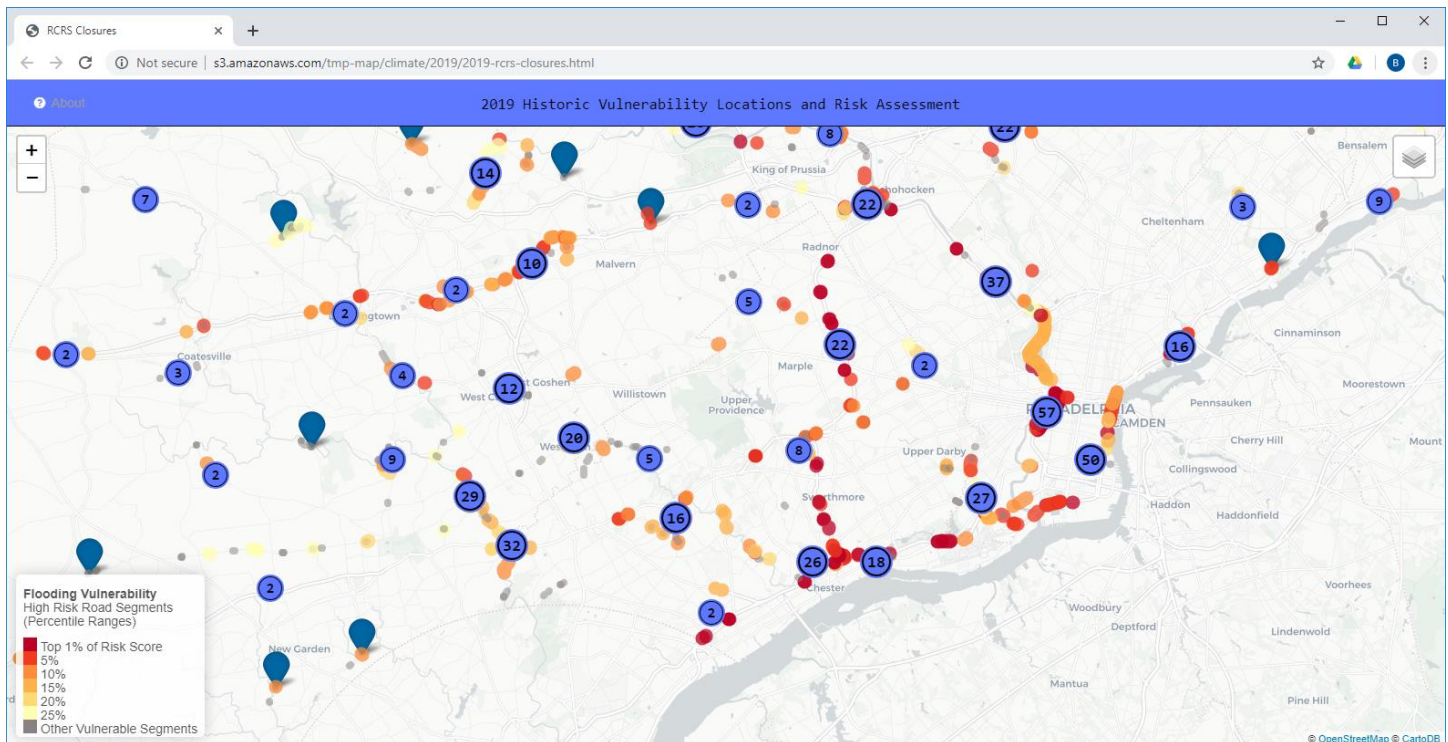


This document discusses the 2019 source data refresh and model re-run of the [Phase1 PennDOT Extreme Weather Vulnerability Study](#), the principal data component from the risk assessment model that has been updated is the source *Road Condition Reporting System* (RCRS) database and the introduction of a statewide *FEMA National Flood Hazard Layer* (NFHL) to constrain the visual appearance of roadway segments as an *option* for viewing the most likely flood locations along an RMS segment. The most current supporting data sources that make up the **Risk Cumulative Score**: RMS Admin, RMS Segment, RMS Traffic and RMS Pipe have been downloaded from the [PennDOT Open Data Portal](#). To calculate the risk assessment 1 day and 3 day Precipitation Scores, historical daily rainfall station data was downloaded from the NOAA Global Historical Climatology Network ([GHCN](#)).

2019 Historic Vulnerability Location and Risk Assessment example web map



<http://s3.amazonaws.com/tmp-map/climate/2019/2019-rcrs-closures.html>

(Phase1 RCRS dates **Nov 2006 – Aug 2017**)

(2019 RCRS dates **Nov 2006 – Apr 2019**)

**Risk Cumulative Score =**

**3 x (Precipitation Score x 0.5 + Floodplain Score x 0.5) +**

**3 x (OPI Score x 0.4 + Scour Score x 0.4 + Pipe Score x 0.2) +**

**4 x (Volume Score x 0.4 + Functional Class Score x 0.3 + Detour Score x 0.1 + Truck Volume Score x 0.2)**

Figure 6.2 from Vulnerability study

- The 2019 RCRS database export contains additional ‘administrative’ fields which were not known to be available during the original study development period, these additional fields assist greatly in the processing and normalization of the closure data into a format that directly corresponds to PennDOT’s standardized Roadway Management System (RMS) linear referencing format; County Code, State Route Number, Segment Begin and Segment End. In many instances valid Offset Begin & End values are present in the source RCRS data, however due to changes over time in the RMS end of segment values, the whole segment value is used as the minimum level of detail needed to join data throughout PennDOT databases (RMSSEG, RMSTRAFFIC, RMSADMIN, RMSPIPE, BMS).
- ‘New’ fields used to improve accuracy:
  - The **is\_master\_record** field identifies the primary RCRS event record, each RCRS **eventid** can have several status update entries, using the **is\_master\_record** field improves the accuracy of the closure datetime stamp and location information used.
  - When populated, the **brkey\_ids** field contains an array of BMS bridge numbers, this field is not uniformly used across all flood closure events and does not appear to directly identify bridges that are affected during a flood event. Based upon review the **brkey\_id** field may be an automatically generated list of bridges based upon an RMS segment, we make note of the field, as it may be useful for future research efforts.
  - The most-significant fields included in the 2019 RCRS update are the sentinel fields **loc\_type\_bgn** and **loc\_type\_end** which contain a sequence number that references the LRS information field to parse. For example, the most common type of LRS strategy present is a **loc\_type\_bgn** = 1 & **loc\_type\_end** = 1 (96,782 RCRS records). These location begin & end codes indicate that the LRS information are contained in database fields called **street\_bgn\_id** & **street\_end\_id**.
  - The table below contains a listing of all existing LRS combinations in the RCRS 2019 database, the primary LRS begin and end field names, and a count of RCRS records for each LRS strategy.

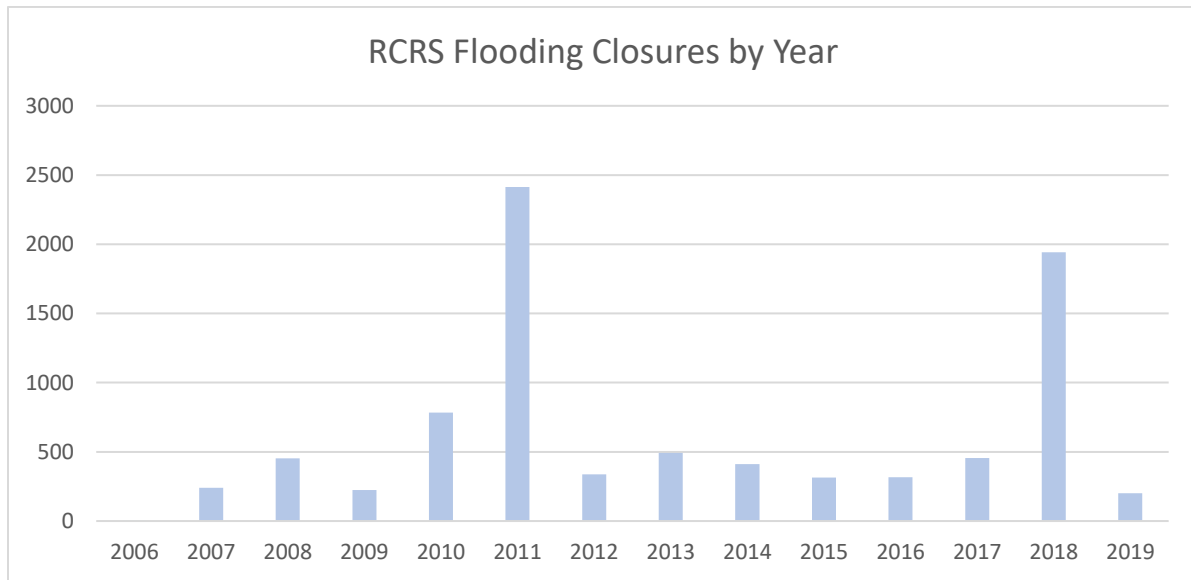
Location Type Code	LRS Begin Field	LRS End Field	loc_type_bgn	loc_type_end	total record count	flood record count (Type 7)
1-1	street_bgn_id	street_end_id	1	1	96,782	4,578
1-2	none		1	2	0	0
1-3	street_bgn_id	st_rt_no_end-seg_no_end	1	3	1,577	34
1-4	street_bgn_id	intersr_end	1	4	9,739	829
1-5	street_bgn_id	exit_end	1	5	5,147	138
1-6	street_bgn_id	onramp_end	1	6	1,354	29
2-1	none		2	1	0	0
2-2	startlocal_bomo	endlocal_bomo	2	2	43,270	28
2-3	none		2	3	0	0
2-4	none		2	4	0	0
2-5	startlocal_bomo	exit_end	2	5	2,336	2
2-6	startlocal_bomo	onramp_end	2	6	217	1

3-1	st_rt_no_bgn-seg_no_bgn	street_end_id	3	1	1,552	36
3-2	none		3	2	0	0
3-3	st_rt_no_bgn-seg_no_bgn	st_rt_no_end-seg_no_end	3	3	40,870	768
3-4	st_rt_no_bgn-seg_no_bgn	intersr_end	3	4	574	10
3-5	st_rt_no_bgn-seg_no_bgn	exit_end	3	5	1,189	2
3-6	st_rt_no_bgn-seg_no_bgn	onramp_end	3	6	167	0
4-1	intersr_bgn	street_end_id	4	1	9,552	817
4-2	none		4	2	0	0
4-3	intersr_bgn	st_rt_no_end-seg_no_end	4	3	698	24
4-4	intersr_bgn	intersr_end	4	4	4,194	291
4-5	intersr_bgn	exit_end	4	5	1,013	26
4-6	intersr_bgn	onramp_end	4	6	258	7
5-1	exit_bgn	street_end_id	5	1	4,317	102
5-2	exit_bgn	endlocal_bomo	5	2	1,976	1
5-3	exit_bgn	st_rt_no_end-seg_no_end	5	3	1,365	6
5-4	exit_bgn	intersr_end	5	4	1,065	23
5-5	exit_bgn	exit_end	5	5	71,231	269
5-6	exit_bgn	onramp_end	5	6	6,352	28
6-1	onramp_bgn	street_end_id	6	1	2,060	32
6-2	onramp_bgn	endlocal_bomo	6	2	323	0
6-3	onramp_bgn	st_rt_no_end-seg_no_end	6	3	387	1
6-4	onramp_bgn	intersr_end	6	4	333	5
6-5	onramp_bgn	exit_end	6	5	10,246	35
6-6	onramp_bgn	onramp_end	6	6	2,302	15

- In addition to the primary Flooding closures (RCRS Type 7), the 2019 RCRS database export contains all the cause of closure types that are available. Additional closure types that have been incorporated into the analytical model are the Bridge Flood Precaution and Bridge Washout/Damage (Type 11 & 18) records. The table below lists all cause of closure types and the count of occurrence in the 2019 RCRS database export.

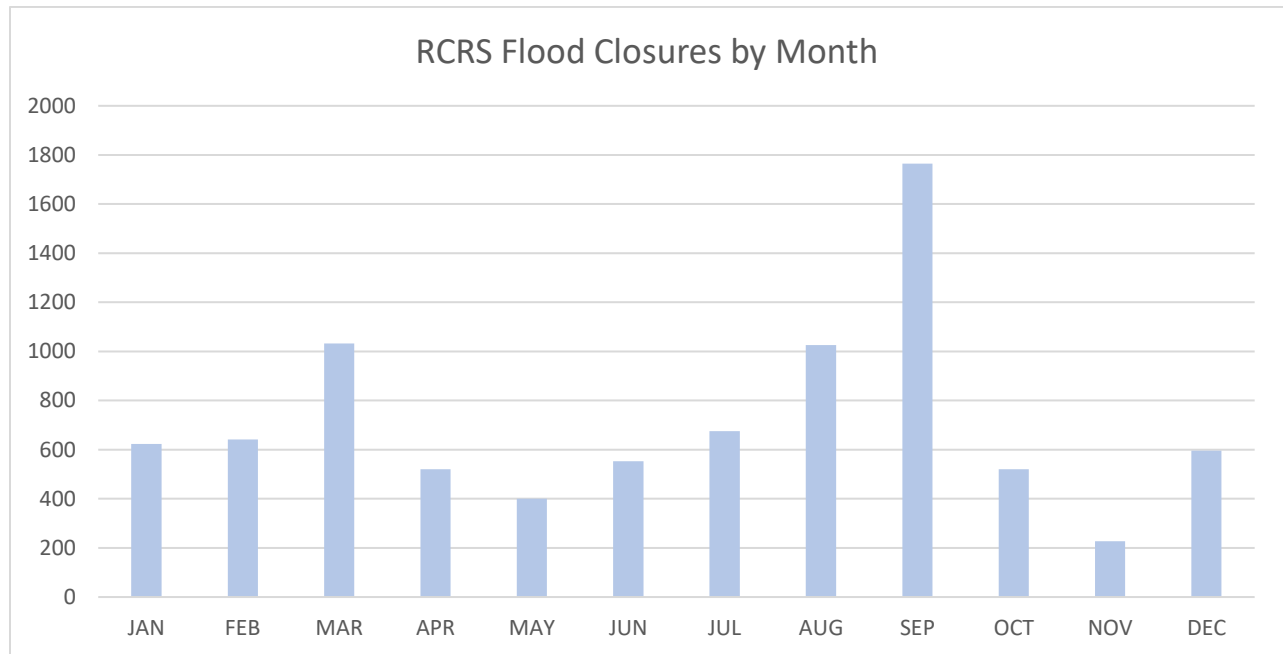
Cause of Closure	Record Count
ROADWORK	275,410
CRASH	48,783
CRASH (Multi-vehicle)	34,048
DISABLED VEHICLE	19,609
FLOODING	8,584
OTHER	8,564
INCIDENT CLEARED	7,385
WINTER WEATHER	6,810
DOWNED UTILITY	5,884
SPECIAL EVENT	4,799
POLICE ACTIVITY	3,532
VEHICLE FIRE	3,107
DEBRIS ON ROADWAY	2,833
DOWNED TREE	2,489
DOWNED TREE IN WIRES	1,270
BRIDGE OUTAGE	1,228
FIRE DEPARTMENT ACTIVITY	813
SLOW VEHICLE	704
BRIDGE PRECAUTION	196
BRIDGE FLOOD PRECAUTION	65
BRIDGE FLOOD WASHOUT/DAMAGE	51

- The chart and table below contain counts of the RCRS Flooding closures (Type 7) by year.



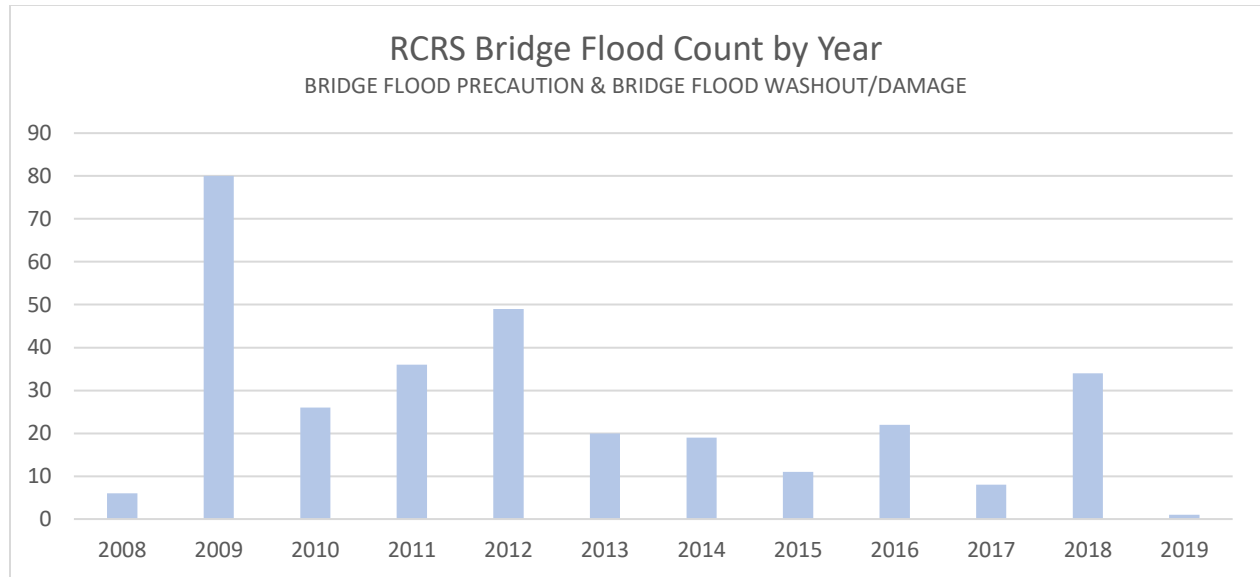
RCRS Flooding Closures by Year	
Year	Closure Count
2006	2
2007	240
2008	453
2009	224
2010	783
2011	2,414
2012	337
2013	492
2014	412
2015	315
2016	316
2017	455
2018	1,941
2019	200

■ Flood closures by month for all years.



RCRS Flood Closures by Month	
Month	Closure Count
JAN	623
FEB	642
MAR	1,033
APR	521
MAY	401
JUN	553
JUL	676
AUG	1,026
SEP	1,765
OCT	521
NOV	227
DEC	596

■ ‘New’ Bridge Flood Precaution and Bridge Washout/Damage (Type 11 & 18) records.



RCRS Bridge Flood Count by Year	
Year	Closure Count
2008	6
2009	80
2010	26
2011	36
2012	49
2013	20
2014	19
2015	11
2016	22
2017	8
2018	34
2019	1

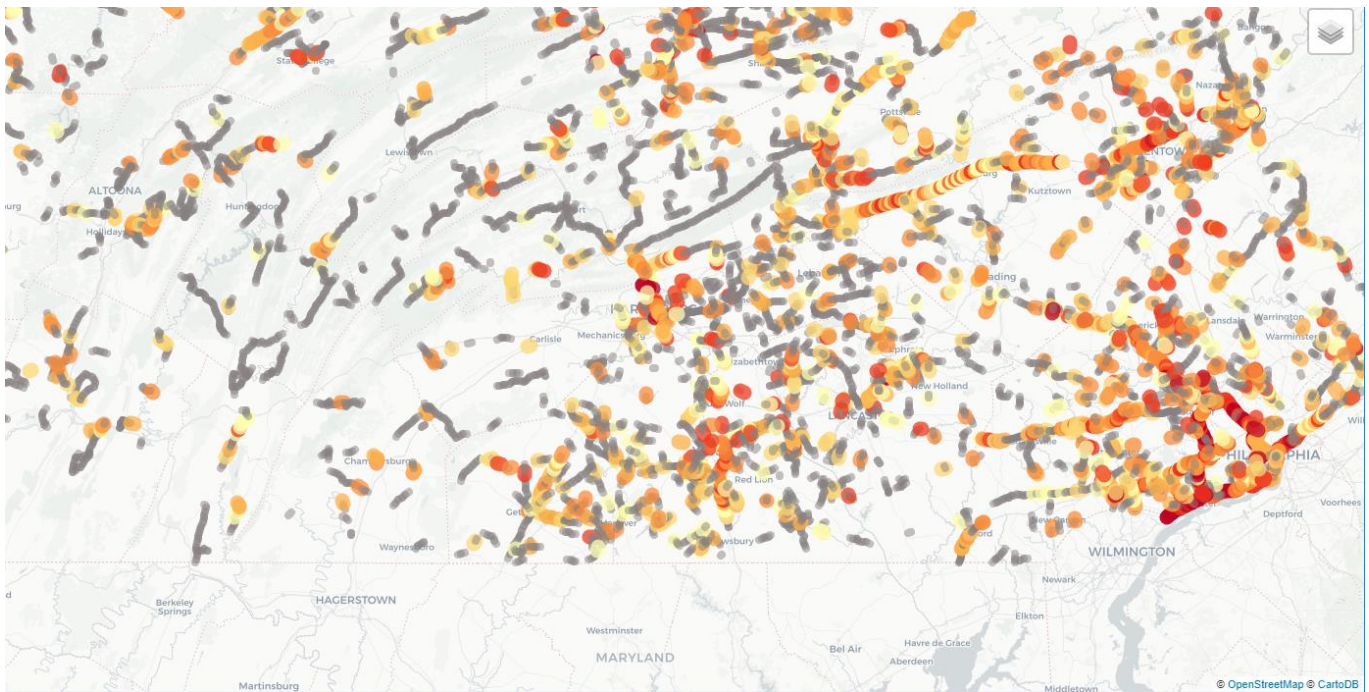
■ Constraining the visual map view of flood locations using the FEMA National Flood Hazzard Layer (NFHL).

- Detailed FEMA NFHL data is currently available for each county in Pennsylvania except Butler & Lackawanna counties.
- For Butler & Lackawanna counties a substitute flood boundary file from PADEP/PASDA was merged with the Pennsylvania FEMA NFHL statewide flood boundary, creating a unified statewide flood boundary layer.
- Using the unified statewide flood polygon layer, the RCRS ‘whole segment’ locations are clipped (cookie-cutter operation) to the flood polygons.

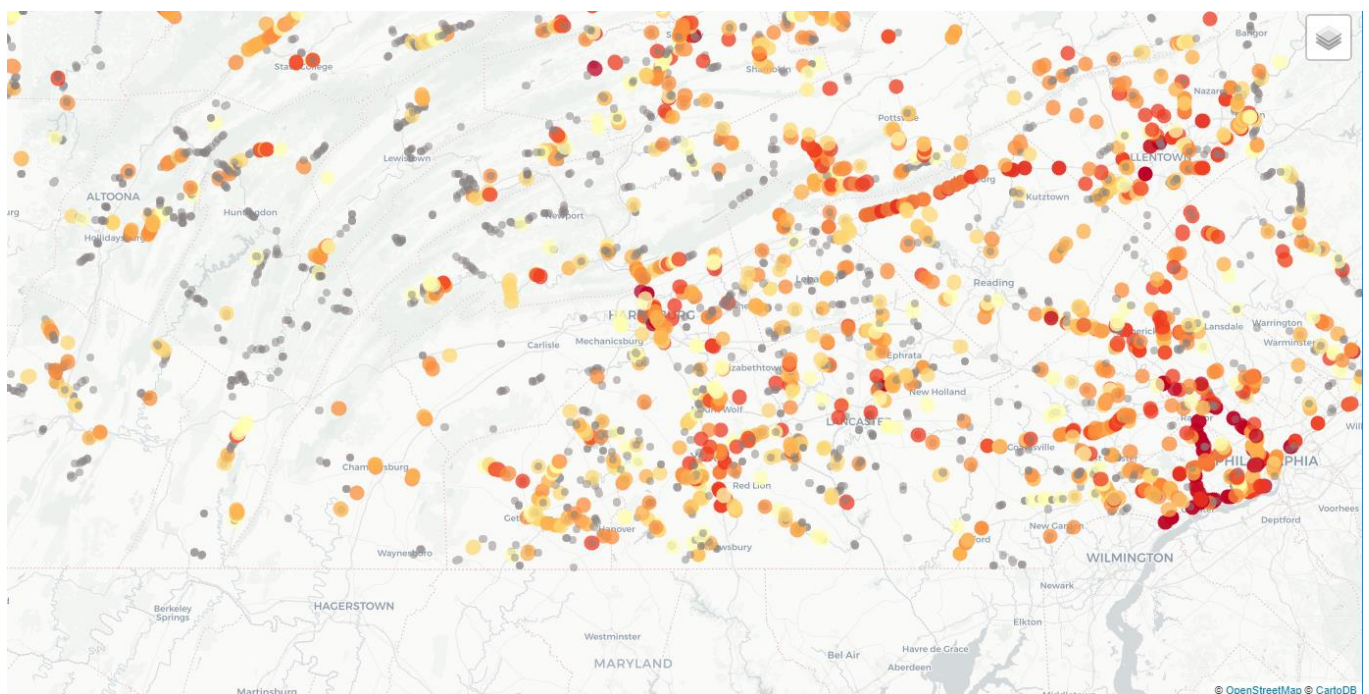


- Clipping the RCRS segments to the NFHL flood polygon significantly reduces the visible portions of an RMS segment that are not inside a flood zone polygon.

RCRS 2019 (Whole Segment)



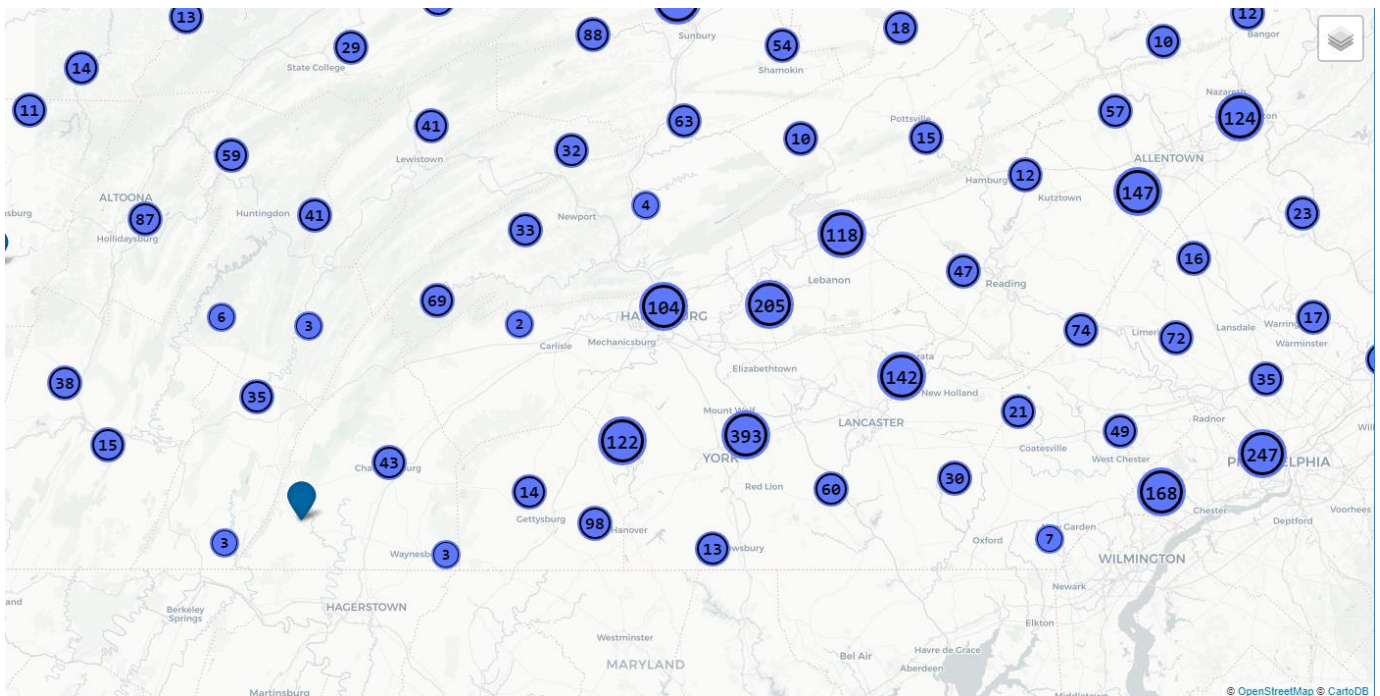
RCRS 2019 clipped to FEMA NFHL (Inside Floodplain)





■ Visualizing the frequency of closures using point clustering.

- With the RCRS segments clipped to the FEMA NFHL it is difficult to visually distinguish locations where flooding occurs most-often, the clipped lines are stacked on top of each other, by taking the midpoint of each clipped RCRS line, we can visualize closure frequency by 'point-clustering' the closures.



**2019 Historic Vulnerability Locations and Risk Assessment**

RCRS 2019 model results at the whole RMS segment level.

[\(5 MB\) rcrs-2019-model-whole-segment.zip \(.shp file\)](#)  
[\(6.3 MB\) rcrs-2019-model-whole-segment.geojson.zip \(.geojson file\)](#)

RCRS 2019 (Inside Floodplain) model results clipped to the FEMA floodplain boundaries.

[\(5 MB\) rcrs-2019-model-inside-floodplain.zip \(.shp file\)](#)  
[\(1.4 MB\) rcrs-2019-model-inside-floodplain.geojson.zip \(.geojson file\)](#)

Close

The RCRS 2019 model results, whole segment and inside floodplain are available for download and review in .shp and .json formats by clicking the About window pop-up on the web map.

<http://s3.amazonaws.com/tmp-map/climate/2019/2019-rcrs-closures.html>