

# Richmond- Crater Hazard Mitigation Plan Update Public Meeting #2

June 28, 2021

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Salter's Creek Consulting, Inc.



CRATER PLANNING  
DISTRICT COMMISSION



CRATER PLANNING  
DISTRICT COMMISSION

# Introductions

Please Sign  
In via the  
Chat

# 24 Participating Communities

- Charles City County
- Chesterfield County
- Dinwiddie County
  - McKenney
- Goochland County
- Greenville County
  - Jarratt
- Hanover County
  - Ashland
- Henrico County
- New Kent County
- Powhatan County
- Prince George County
- Claremont
- Sussex County
  - Stony Creek
  - Wakefield
  - Waverly
- Colonial Heights
- Emporia
- Hopewell
- Petersburg
- Richmond
- Town of Surry



# 10-Step Process within the 4-Phase FEMA Guidance

## Phase I: Organize Resources

- ✓ Get organized
- ✓ Plan for public involvement
- ✓ Coordinate with other departments & agencies

## Phase II: Assess Risk

- ❑ Identify the hazards
- ❑ Assess the risks



## Phase III: Develop Mitigation Plan

- ❑ Review mitigation alternatives
- ❑ Set planning goals
- ❑ Draft an action plan

## Phase IV: Adopt & Implement

- ❑ Adopt the plan
- ❑ Implement the plan



# Natural Hazards Summary

## 2017 Plan's List of Hazards

Hazard Category	Rank Score	Rank	Rank Category
Hurricanes	2.75	1	Significant
Tornado	2.73	2	Significant
Thunderstorm	2.34	3	Moderate
Flood	2.24	4	Moderate
Winter	2.08	5	Moderate
Drought	1.81	6	Limited
Wind	1.79	7	Limited
Wildfire	1.13	8	Limited
Earthquake	1.13	8	Limited
Landslide	1.13	8	Limited
Karst	1.13	8	Limited
Mass Evacuation	0.63	12	Limited

### New for 2022!!

- Pandemic Flu
- Flooding due to Impoundment Failure
- Landslide, Karst → Mass Movement
- Radon Exposure
- Each hazard:
  - Climate Change
  - Equity Analysis
  - Mass Evacuation

# Hazards Examined Today

## Focusing on new and critical hazards

- FLOODING & IMPOUNDMENT FAILURE
- TROPICAL STORMS
- TORNADOES
- PANDEMIC FLU
- WINTER WEATHER
- WILDFIRE
- MASS MOVEMENT
- RADON EXPOSURE



# Recent Presidential Disaster Declarations

Date	Number	Disaster Type
September 13, 2018	3403	Hurricane Florence
January 20, 2020	3448	Pandemic COVID-19

# Exposure – Built Environment

PlanRVA				
Community	Wood	Manufactured Homes	Masonry, Concrete, Steel	Total
Goochland Co	\$2,351,402,000	\$26,620,000	\$1,194,603,000	\$3,572,625,000
Hanover Co, inc. Ashland	\$10,323,535,000	\$41,239,000	\$6,111,963,000	\$16,476,737,000
Henrico Co	\$27,935,064,000	\$24,559,000	\$17,284,140,000	\$45,243,763,000
New Kent Co	\$1,828,641,000	\$23,172,000	\$831,277,000	\$2,683,090,000
Powhatan Co	\$2,518,231,000	\$23,597,000	\$1,200,380,000	\$3,742,208,000
Richmond	\$15,310,205,000	\$38,719,000	\$13,797,923,000	\$29,146,847,000
<b>Totals</b>	<b>\$60,267,078,000</b>	<b>\$177,906,000</b>	<b>\$40,420,286,000</b>	<b>\$100,865,270,000</b>

# Exposure – Built Environment

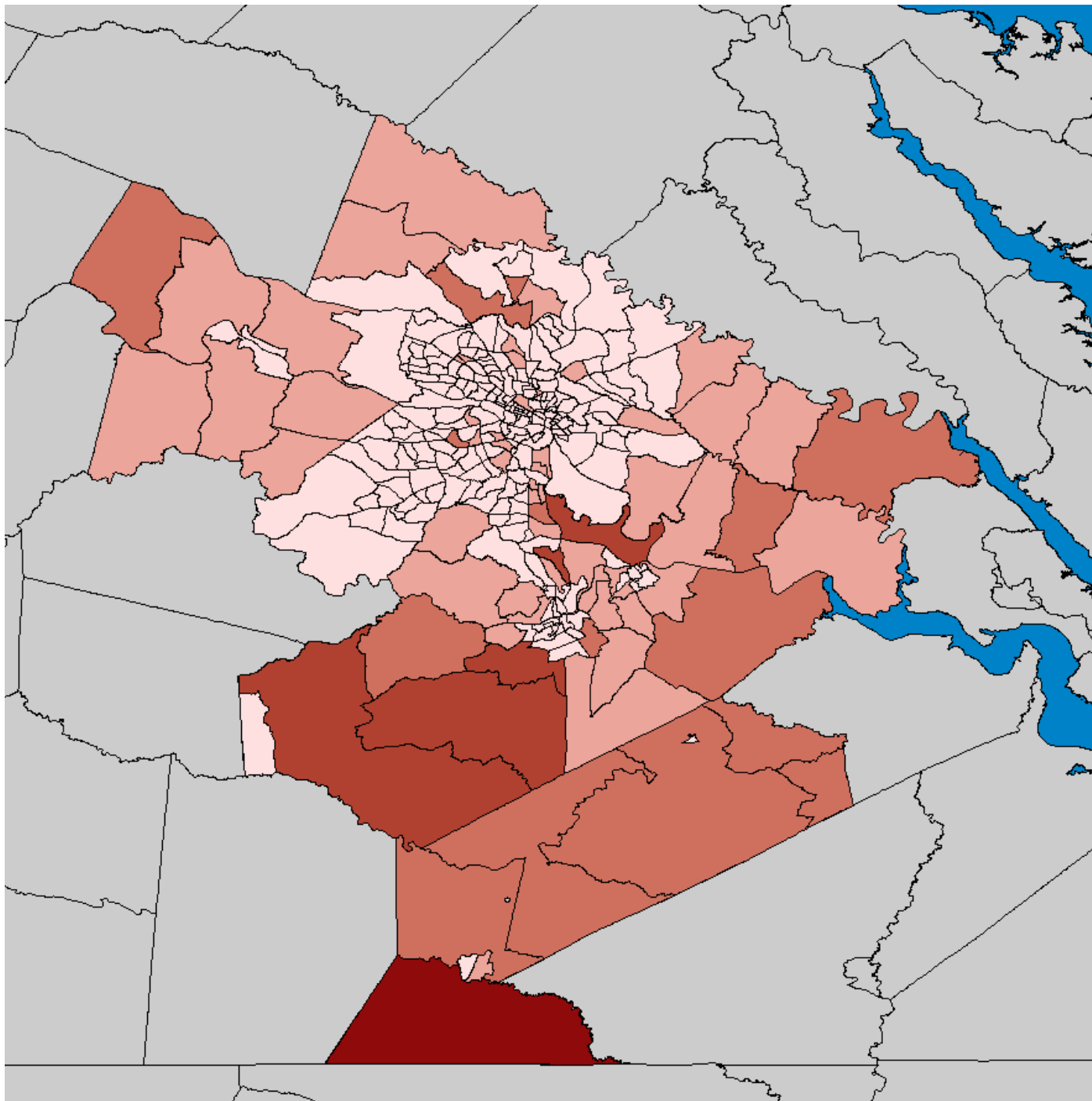
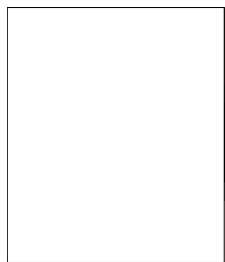
HAZUS  
Level 1

## Crater

Community	Wood	Manufactured Homes	Masonry, Concrete, Steel	Total
Charles City	\$523,409,000	\$27,482,000	\$271,230,000	\$822,121,000
Chesterfield Co	\$29,732,123,000	\$126,389,000	\$15,045,912,000	\$44,904,424,000
Colonial Heights	\$1,484,948,000	\$510,000	\$1,079,487,000	\$2,564,945,000
Dinwiddie Co	\$1,832,966,000	\$89,731,000	\$974,490,000	\$2,897,187,000
Emporia	\$356,446,000	\$5,176,000	\$389,636,000	\$751,258,000
Greensville Co, includes Jarratt	\$491,746,000	\$51,033,000	\$366,232,000	\$909,011,000
Hopewell	\$1,532,553,000	\$6,872,000	\$1,016,928,000	\$2,556,353,000
Petersburg	\$2,242,405,000	\$21,342,000	\$2,209,937,000	\$4,473,684,000
Prince George Co	\$2,359,394,000	\$53,205,000	\$1,283,049,000	\$3,695,648,000
Sussex Co, inc. Stony Creek, Wakefield, Waverly	\$541,312,000	\$58,292,000	\$423,059,000	\$1,022,663,000
<b>Totals</b>	<b>\$41,097,302,000</b>	<b>\$440,032,000</b>	<b>\$23,059,960,000</b>	<b>\$64,597,294,000</b>

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# Manufactured Homes by Census Tract





# Flooding

Broad definition used in this plan encompasses impacts from:

- Stormwater, “urban” flooding
- Riverine flooding
- Nor’easters
- Coastal storms and storm surge

Flooding from impoundment (dam or levee) failure is a separate hazard.

# Flooding

- Severe flooding in the region can cause:
  - Inundation of low-lying neighborhoods, including damage to houses (structural and long-term mold), garages, landscaping;
  - Roads closures limiting access/egress, water rescues, damage to businesses and lost business revenue, and school closures;
  - Damage to infrastructure;
  - Inundation of critical facilities and hazardous materials facilities; and
  - In some areas, coastal erosion and shoreline damage, including to ports.



# Recent Flood Events

May 18-19, 2018

Flooding occurred along the Chickahominy River, North Anna River, South Anna River, and Pamunkey River over a couple of days, with roads and low-lying areas near the river impacted the most.

Numerous road closures in:

- Charles City County
- Chesterfield County (Otterdale Rd, Enon Church Rd off Rte 10)
- Dinwiddie County
- Goochland County (Riddles Bridge Rd washed out)
- Hanover County (Horseshoe Bridge Rd, Greenwood Rd)
- Ashland
- Henrico County ([water rescue](#) on Gayton Rd at Cedarbluff Dr, Patterson Ave, Old Springfield Rd, Laurel area, lanes of I-195 North near Broad St, Raintree area)
- New Kent County
- Petersburg
- Powhatan County
- Prince George County
- Richmond
- Charles City County
- Hanover County

# Recent Flood Events

June 2-3,  
2018

Flash flooding and many inundated roads reported in:

- Henrico County with vehicle stuck in water on Cox Road
- New Kent County with water on road at I-64, exit 220
- Hanover County with a sinkhole reported near Huguenot Trail and Rte 288
- Charles City County
- Hanover County with sinkhole at Crown Hill Road (\$2000 damage) and Cross Corner Road washed out (\$1000 damage)

June 7, 2019

Slow moving thunderstorms produced intense rainfall of 4 to 6 inches resulting in flash flooding on June 7th, causing flash flooding in Charles City County (portion of Rte 5 closed), Chesterfield County (portion of Turner Rd closed), Ashland (home flooded with \$2000 damage), Hanover County (portions of East Patrick Henry Rd), Henrico County (flooding of roads in Glen Allen) and Wakefield (Hwy 460 closed at Main and Hwy 31, impacts to Virginia Diner and James River Equipment with \$100,000 damage).



# Recent Flood Events

August 15,  
2020

Scattered showers and thunderstorms associated with low pressure and a frontal boundary produced heavy rain which caused flash flooding across portions of central and southeast Virginia. Flooding reported in Colonial Heights ([2 water rescues](#)), Hopewell, Petersburg, and northwest Prince George County. Chesterfield County and Colonial Heights declared state of emergency.

Chesterfield County – Following 8-12” of rain, flash flooding began at 7:15am. Nearly 60 roads impassible, including major highways. Initial damage assessment submitted to VDEM was \$2.8 million; event was 700-year flood for some areas. Six dams were at Emergency Stage; evacuation called for Falling Creek Reservoir resulted in evacuation of 140 residents and opening a shelter for evacuees. Spring Run Road was damaged and there was damage to water treatment facilities and sanitary sewers, but no disruption of water or wastewater service. Flooding of Addison-Evans Water Plant and Jahnke Road Pump Station; highlighted need for floodwall around the water treatment plant.





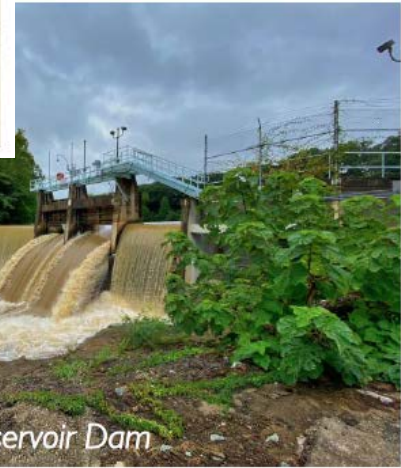
Chesterfield County  
August 15, 2020



Water Rescue – Otterdale Road



Spring Run Road



Falling Creek Reservoir Dam



Addison-Evans Water Treatment Plant

# Flood Risk Assessment

## Multiple Approaches Taken

1. Risk to structures and populations by 100-year flood event – HAZUS analysis results




and



2. Critical Facilities analysis
3. Structure analysis
  - National Flood Insurance Program Claims & Coverage
  - Repetitive Flood Loss Analysis



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# Flood Exposure

## 100-year Floodplain

Community	Occupancy type			Total Exposure
	Residential	Commercial	Other	
Charles City Co	\$140,376,000	\$17,730,000	\$16,310,000	\$174,416,000
Colonial Heights	\$655,970,000	\$98,404,000	\$34,866,000	\$789,240,000
Greensville Co	\$172,262,000	\$22,840,000	\$21,044,000	\$216,146,000
New Kent Co	\$354,157,000	\$20,232,000	\$16,216,000	\$390,605,000
Prince George Co	\$672,556,000	\$74,505,000	\$54,918,000	\$801,979,000
Sussex Co	\$159,223,000	\$23,069,000	\$11,259,000	\$193,551,000

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Level 2

# Flood Exposure

## 100-year Floodplain

Community	Occupancy type – Building Count				Total Exposure
	Residential	Commercial	Other	Total	
Chesterfield	3,439	82	67	3,588	\$2,102,470,500
<i>Dinwiddie</i>	22	0	0	22	\$2,312,429
Emporia	318	26	0	344	\$41,645,000
Goochland	144	13	5	162	\$187,844,900
Hanover	553	15	553	1,121	\$684,577,201
Henrico	2,532	89	85	2,706	\$1,311,017,100
Hopewell	229	11	14	254	\$447,071,000
Petersburg	201	50	71	322	\$130,984,400
<i>Powhatan</i>	93	1	0	94	\$34,180,309
Richmond	538	96	140	774	\$717,880,000



# Flood Risk Assessment

100-year Flood Analysis - Damages Expected

COMMUNITY	NUMBER OF BUILDINGS DAMAGED				DOLLAR LOSSES		
	0-20%	21-40%	41-50%	SUBSTANTIAL DAMAGE	BUILDING	CONTENTS	INVENTORY
Charles City Co	0	0	0	0	\$940,000	\$840,000	\$20,000
Colonial Heights	45	38, inc. 1 school	10	9	\$25,730,000	\$23,560,000	\$23,0000
Greensville Co	0	0	0	0	\$1,630,000	\$1,360,000	\$20,000
New Kent Co	12	1	1	2	\$5,240,000	\$3,290,000	\$30,000
Prince George Co	2	6	2	2	\$7,980,000	\$5,910,000	\$90,000
Sussex Co	1	0	0	0	\$2,470,000	\$3,440,000	\$110,000



HAZUS  
Level 2

# Flood Risk Assessment

100-year Flood Analysis - Damages Expected

COMMUNITY	NUMBER OF BUILDINGS DAMAGED				DOLLAR LOSSES		
	0-20%	21-40%	41-50%	SUBSTANTIAL DAMAGE	BUILDING	CONTENTS	INVENTORY
<b>Chesterfield Co</b>	1,210	1,150	334	893	\$570,061,000	\$729,134,000	\$13,822,000
<b>Dinwiddie Co</b>	10	5	1	6	\$835,000	\$285,000	<\$500
<b>Emporia</b>	230	63	15	26	\$9,339,000	\$5,326,000	\$333,000
<b>Goochland Co</b>	52	37	11	62	\$61,751,000	\$32,256,000	\$231,000
<b>Hanover Co</b>	319	261	162	379	\$278,407,431	\$316,143,853	\$178,700,249
<b>Henrico Co</b>	1,068	1,042	204	392	\$320,109,000	\$388,081,000	\$949,000
<b>Hopewell</b>	156	66	16	16	\$117,906,000	\$151,770,000	<\$500
<b>Petersburg</b>	217	70	10	25	\$29,080,810	\$36,961,004	<\$500
<b>Powhatan Co</b>	21	8	3	62	\$21,462,000	\$7,014,000	<\$500
<b>Richmond</b>	424	179	58	113	\$210,114,000	\$289,767,000	<\$500



# Flood Risk Assessment

100-year Flood Analysis - Damages Expected

COMMUNITY	NUMBER OF BUILDINGS DAMAGED				DOLLAR LOSSES		
	0-20%	21-40%	41-50%	SUBSTANTIAL DAMAGE	BUILDING	CONTENTS	INVENTORY
Dinwiddie County	0	0	0	0	\$5,010,000	\$4,290,000	\$0
Powhatan County	12	7	0	0	\$9,310,000	\$6,260,000	\$30,000

# Critical Facilities Analysis

PlanRVA – Number of Structures per Zone, using HAZUS essential facility data

Community	100-Year Floodplain	500-year Floodplain	Storm Surge Zone
Goochland Co	1	0	0
Hanover Co	2	1	0
Henrico Co	0	0	0
New Kent Co	0	0	1
Powhatan Co	1	0	0
Richmond	8, inc. 2 in floodway	4	4

# Critical Facilities Analysis

Crater – Number of Structures per Zone, using HAZUS essential facility data

<b>Community</b>	<b>100-Year Floodplain</b>	<b>500-year Floodplain</b>	<b>Storm Surge Zone</b>
Charles City	0	0	3
Chesterfield Co	2, inc. 1 in floodway	1	9
Colonial Heights	2	0	1
Dinwiddie Co	2	0	0
Emporia	1, inc. 1 in floodway	2	0
Greensville Co	1	0	0
Hopewell	0	0	2
Petersburg	3	1	2
Prince George Co	0	0	0
Sussex Co	2, inc. 1 in floodway	0	0

# Flood Insurance Analysis

PlanRVA

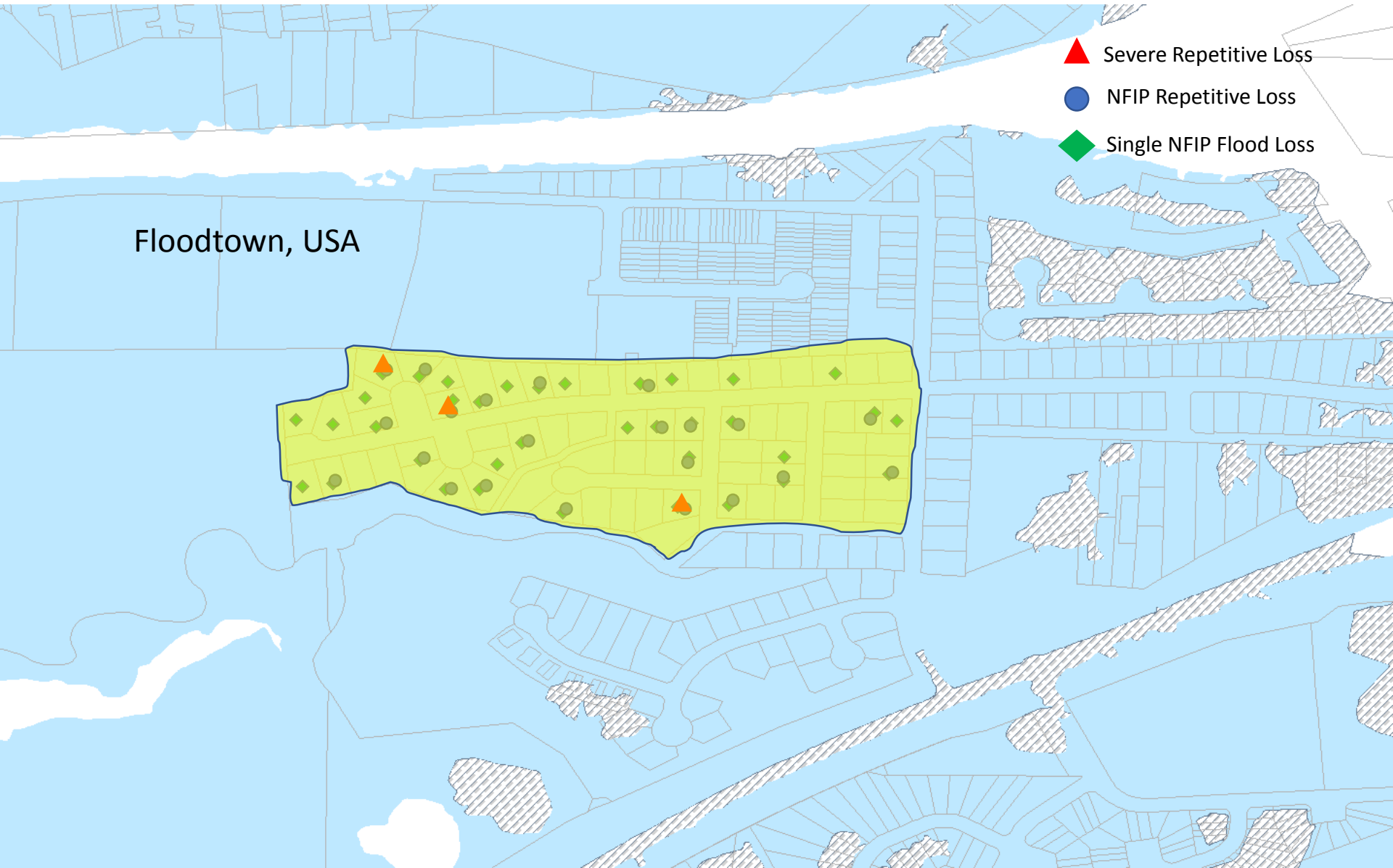
Community	Number of NFIP Policies 2021	% change (2016-2021)	Insurance in Force 2021
Goochland Co	56	19.1%	\$17,890,100
Hanover Co	207	16.9%	\$63,928,100
<i>Ashland</i>	50	13.6%	\$16,290,200
Henrico Co	1032	4.7%	\$274,960,700
New Kent Co	113	-5.0%	\$33,582,000
Powhatan Co	38	26.7%	\$12,595,000
Richmond	582	-0.7%	\$176,882,300

# Flood Insurance Analysis

Crater

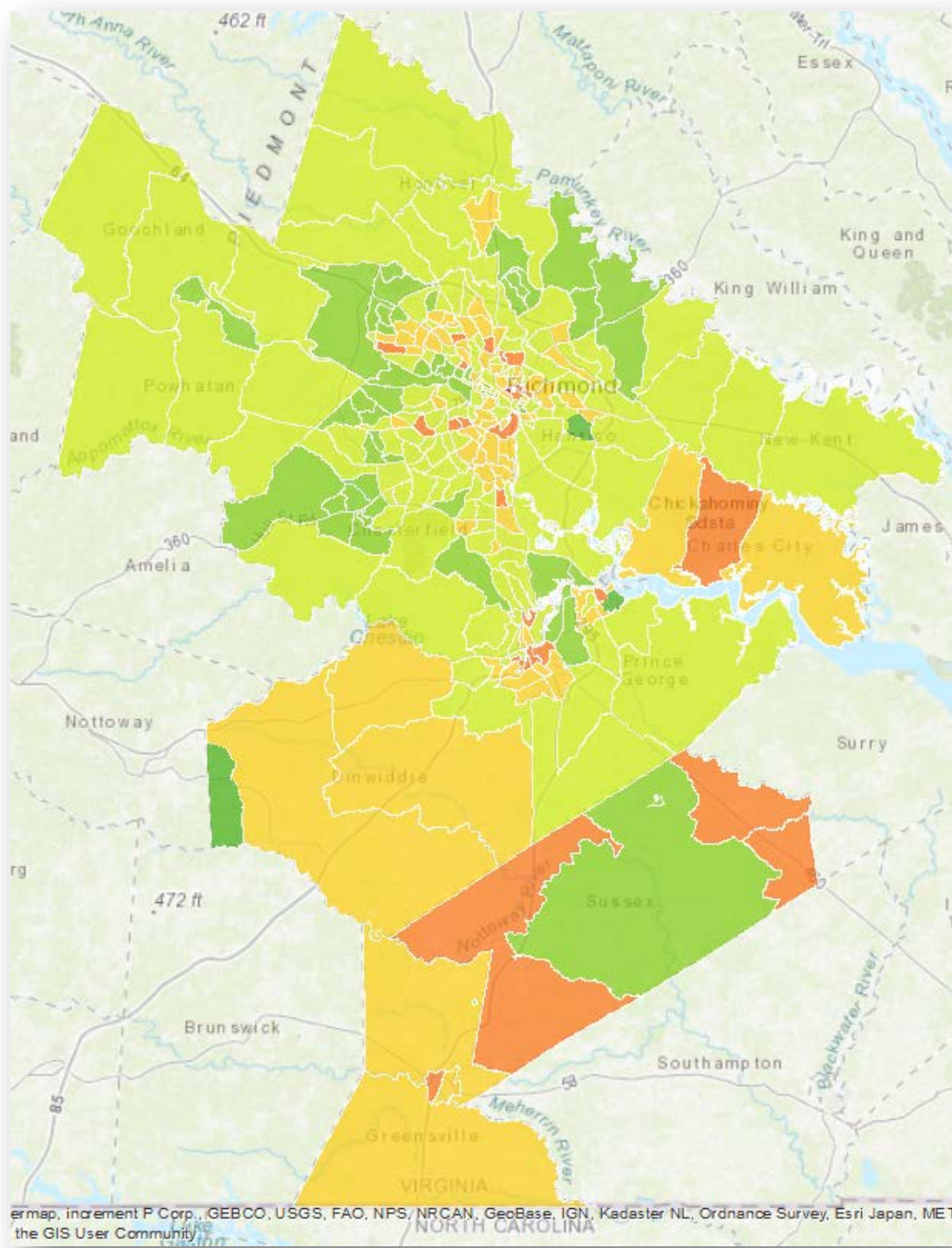
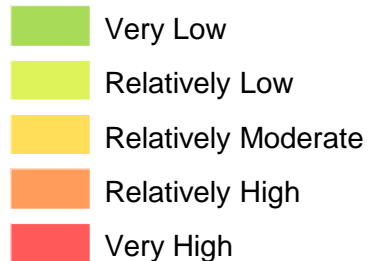
Community	Number of NFIP Policies 2021	% change (2016- 2021)	Insurance in Force 2021
Charles City	21	5.0%	\$6,731,500
Chesterfield Co	903	4.5%	\$258,952,800
Colonial Heights	93	-17.0%	\$25,331,500
Dinwiddie Co	36	-7.7%	\$10,374,600
<i>McKenney</i>	0	0%	\$0
Emporia	30	-21.1%	\$5,403,500
Greensville Co	14	-17.6%	\$3,489,100
<i>Jarrett</i>	0	0%	\$0
Hopewell	29	11.5%	\$9,569,900
Petersburg	98	-28.5%	\$30,180,900
Prince George Co	92	-2.1%	\$26,886,600
Sussex Co	26	8.3%	\$6,565,700
<i>Stony Creek</i>	15	-31.8%	\$2,637,300
<i>Wakefield</i>	3	0%	\$1,020,000

# Repetitive Flood Loss Analysis



# Measuring Social Vulnerability:

the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood.

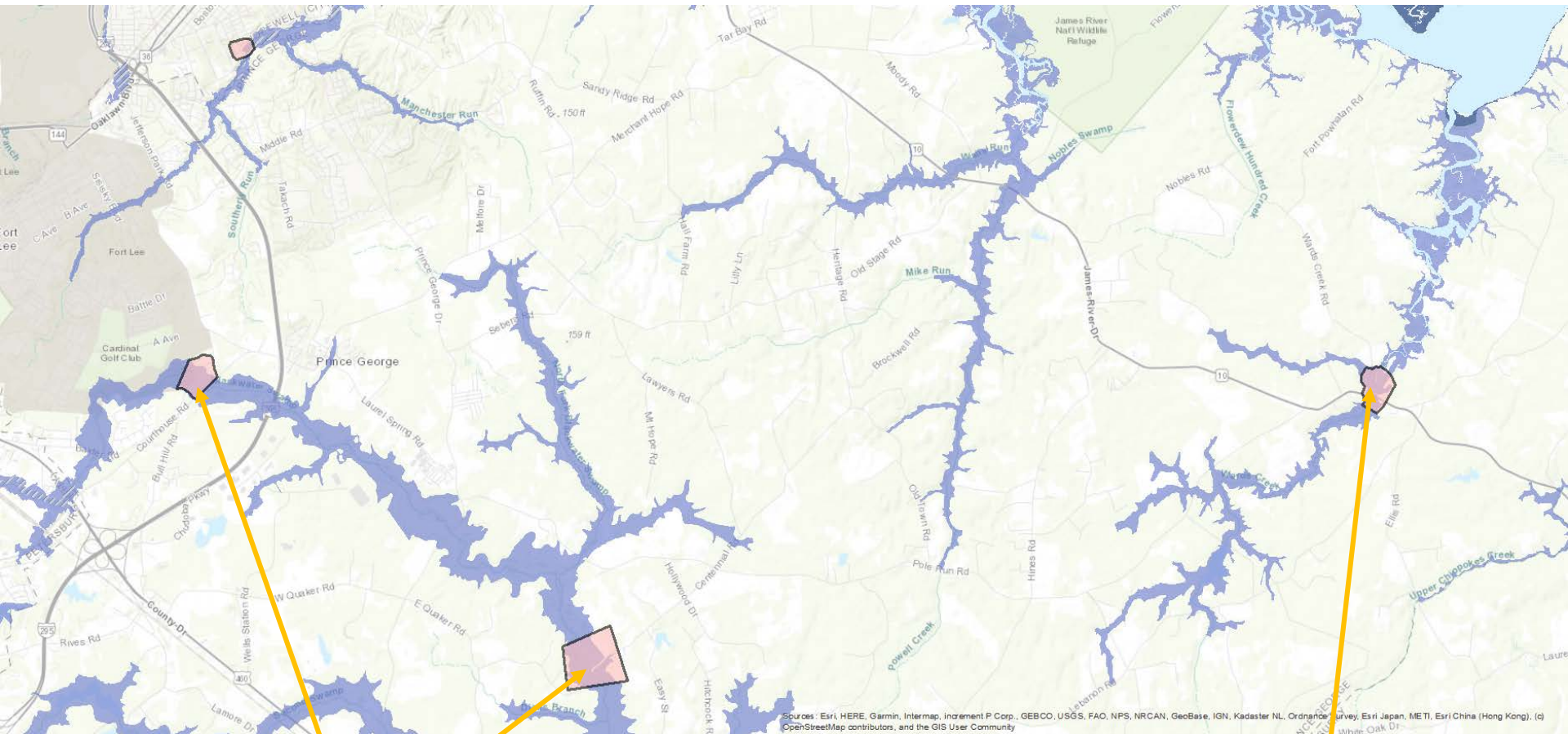




# Measuring Social Vulnerability



# Prince George County, Hopewell

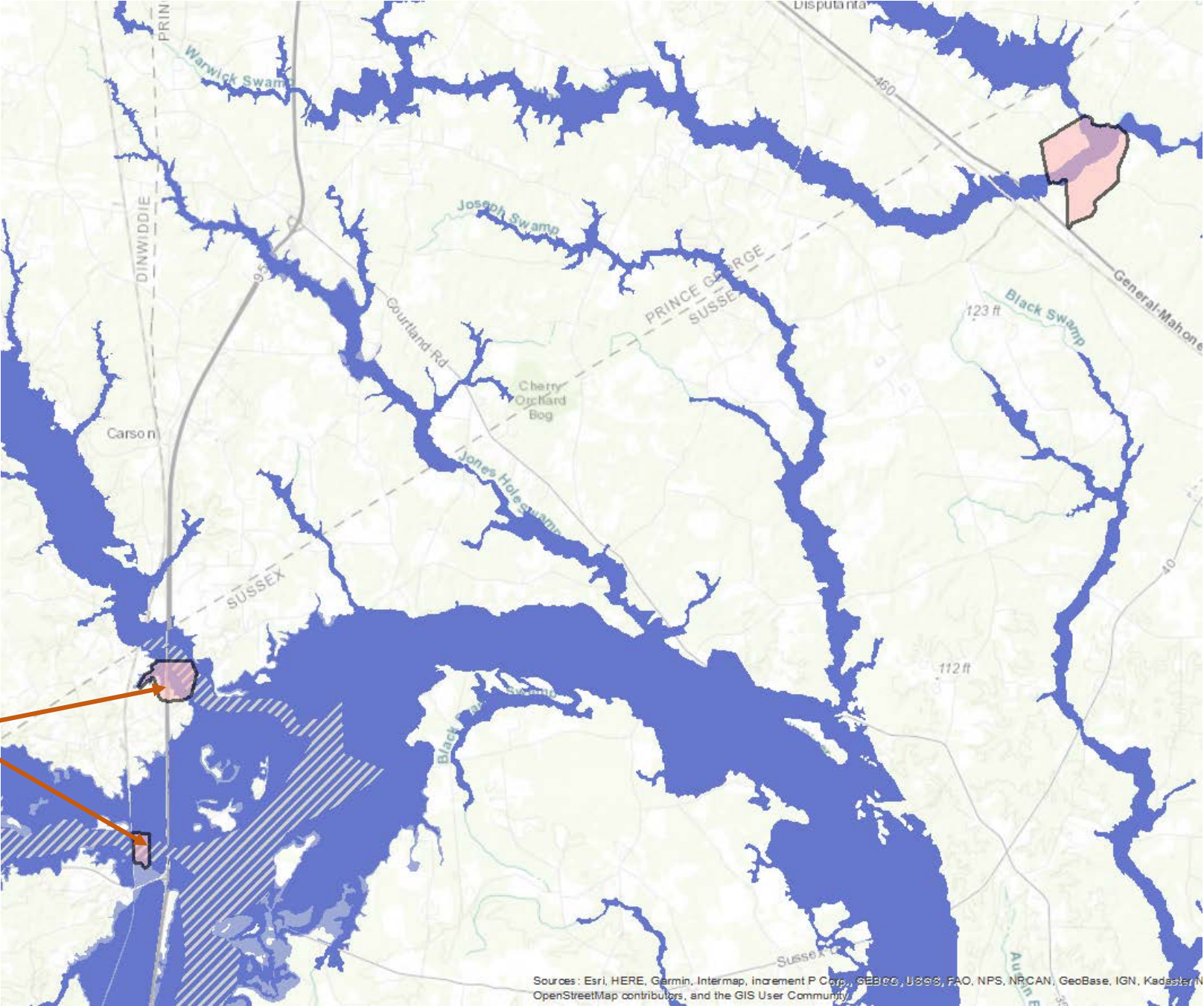


**NRI Moderate  
Risk for Flood**



**NRI Moderate  
Risk for Flood**

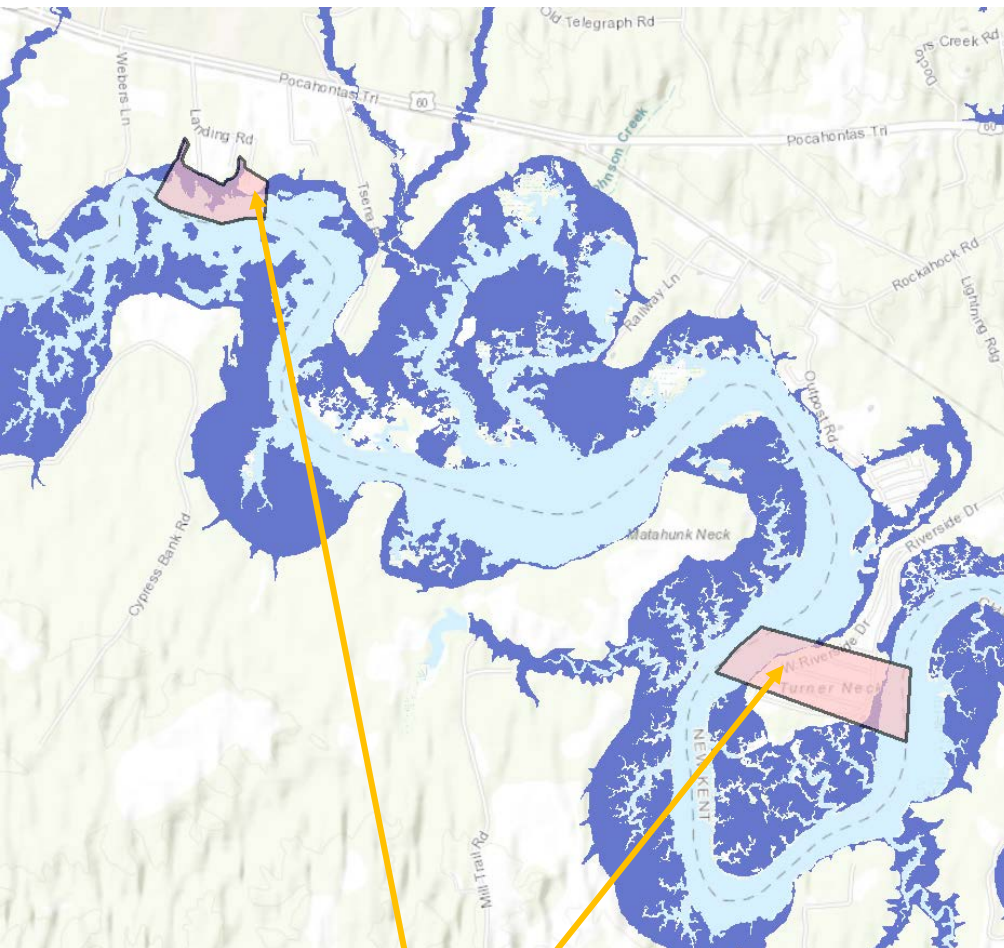
Sussex  
County



  
NRI High  
Risk for  
Flood

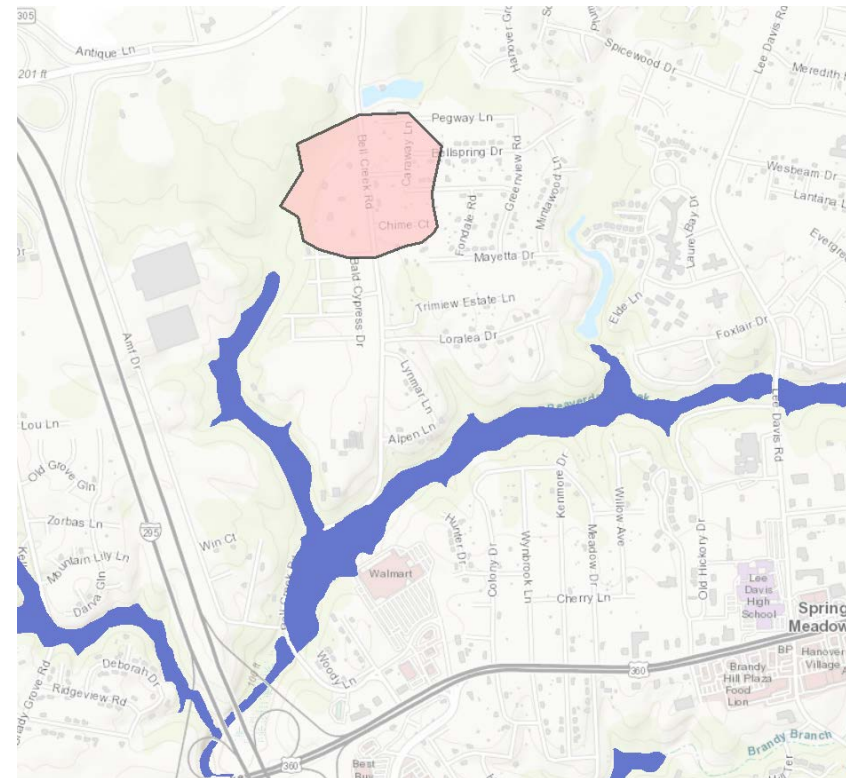


## New Kent County

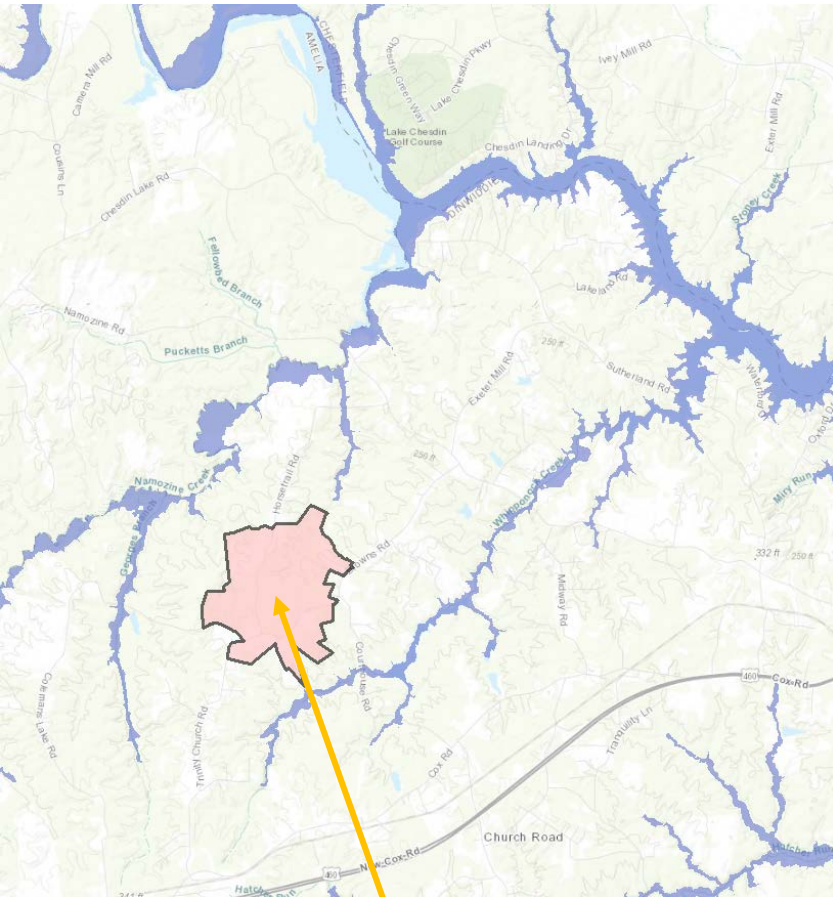


  
NRI Moderate  
Risk for Flood

## Hanover County

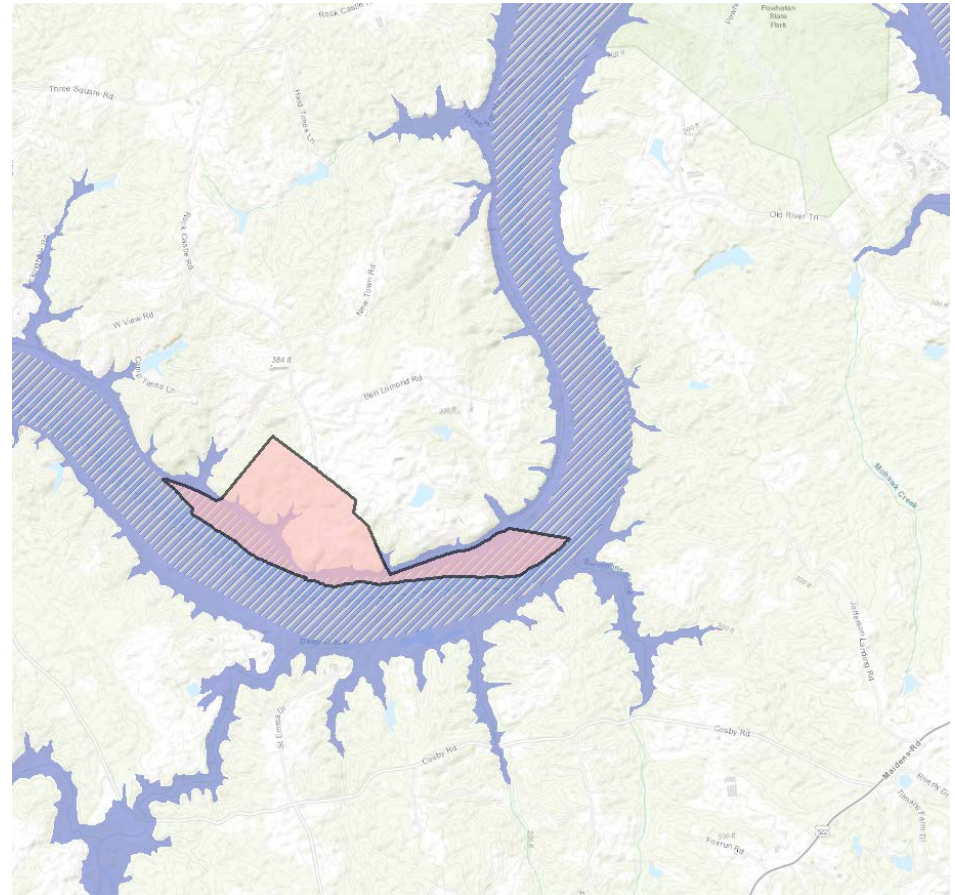


## Dinwiddie County

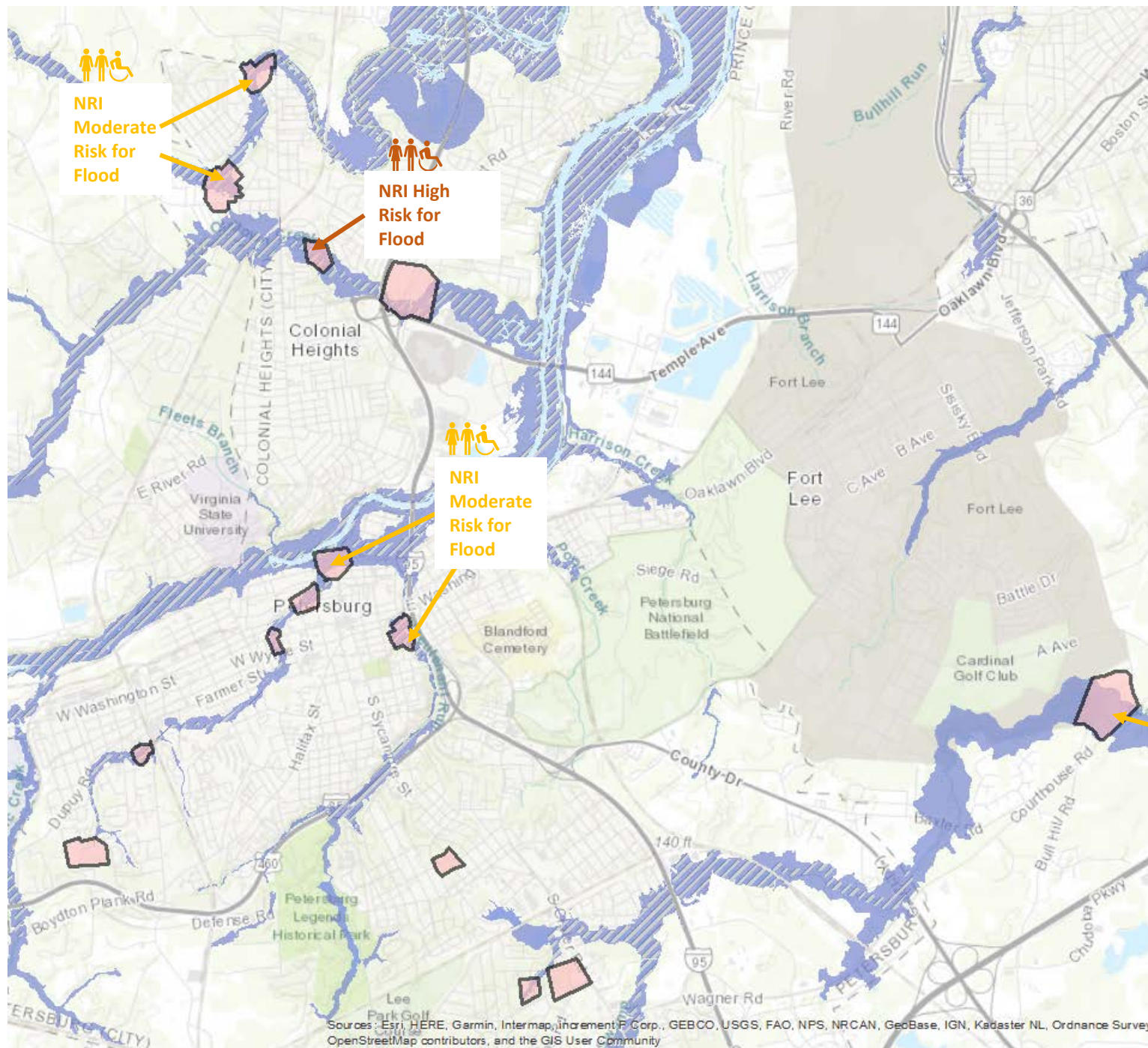


  
**NRI Moderate  
Risk for Flood**

## Goochland County





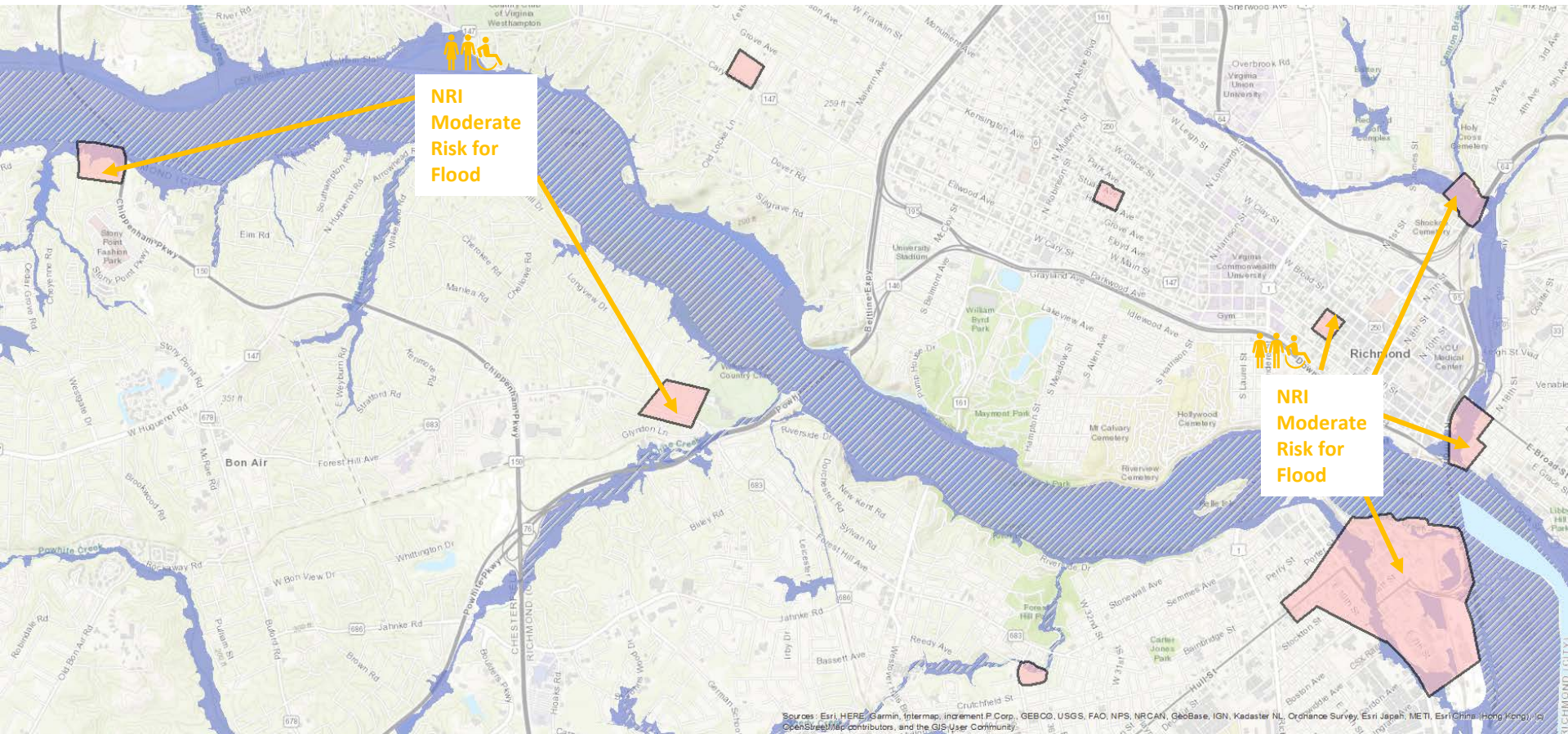


Petersburg  
Colonial Heights

**NRI  
Moderate  
Risk for  
Flood**

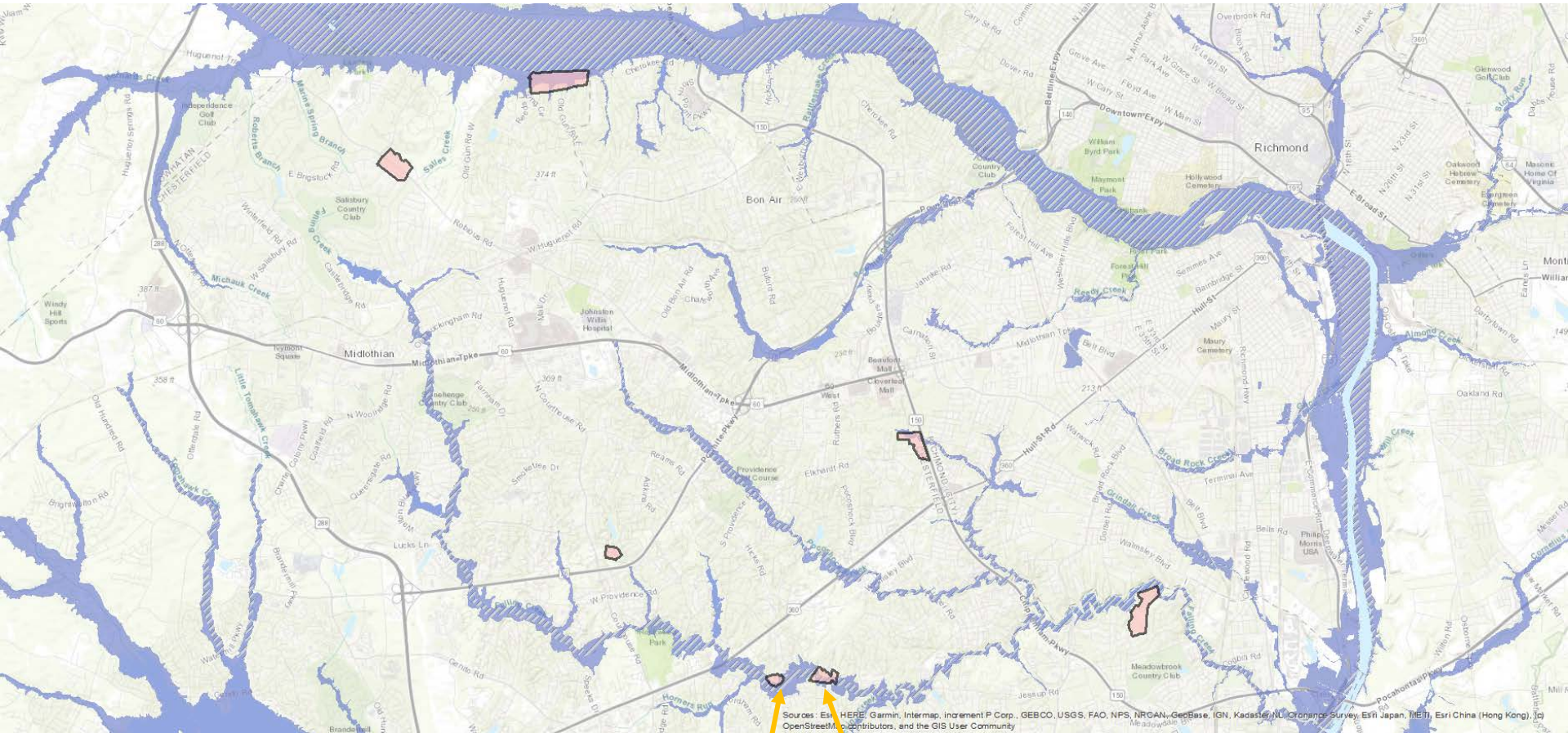


# Richmond





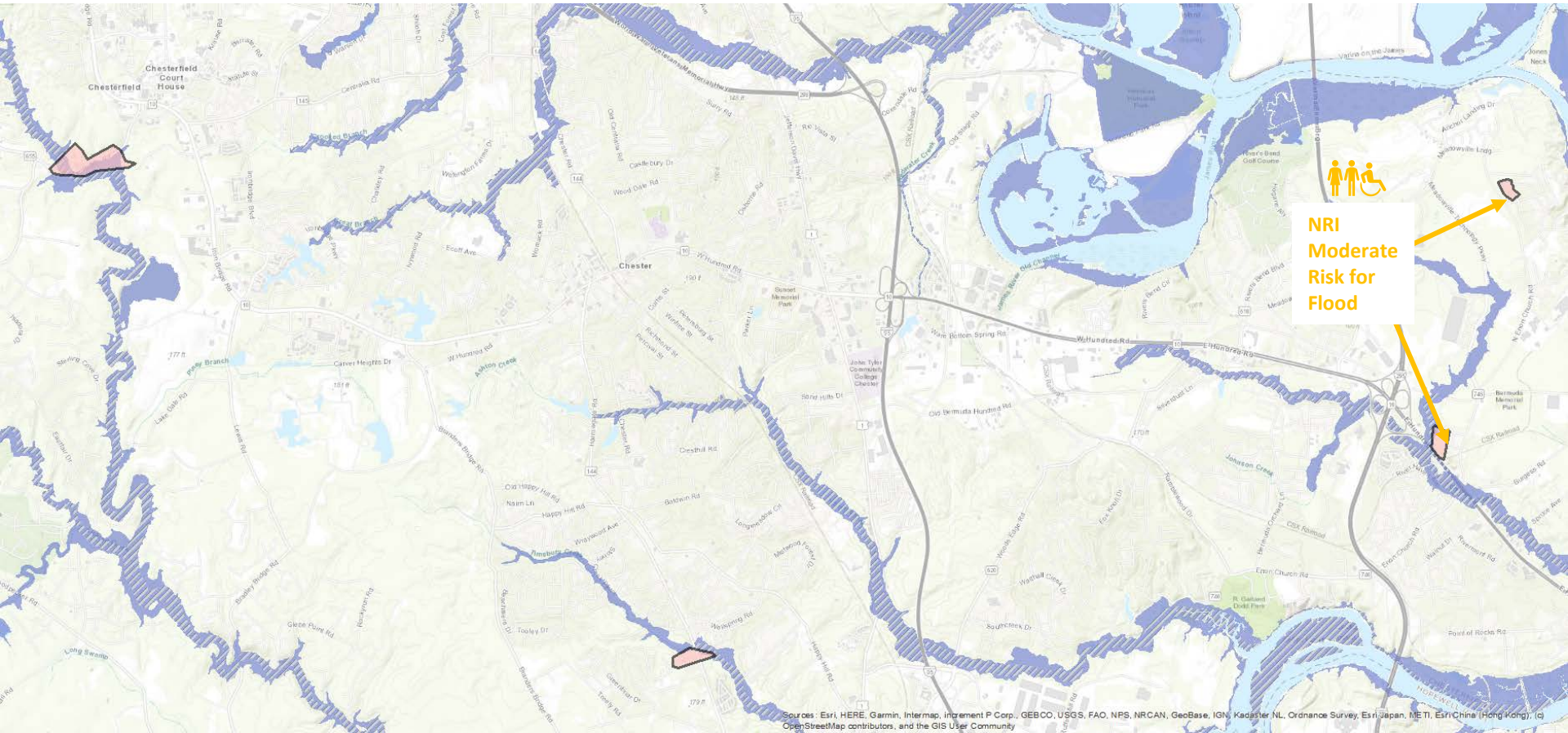
# Chesterfield County North



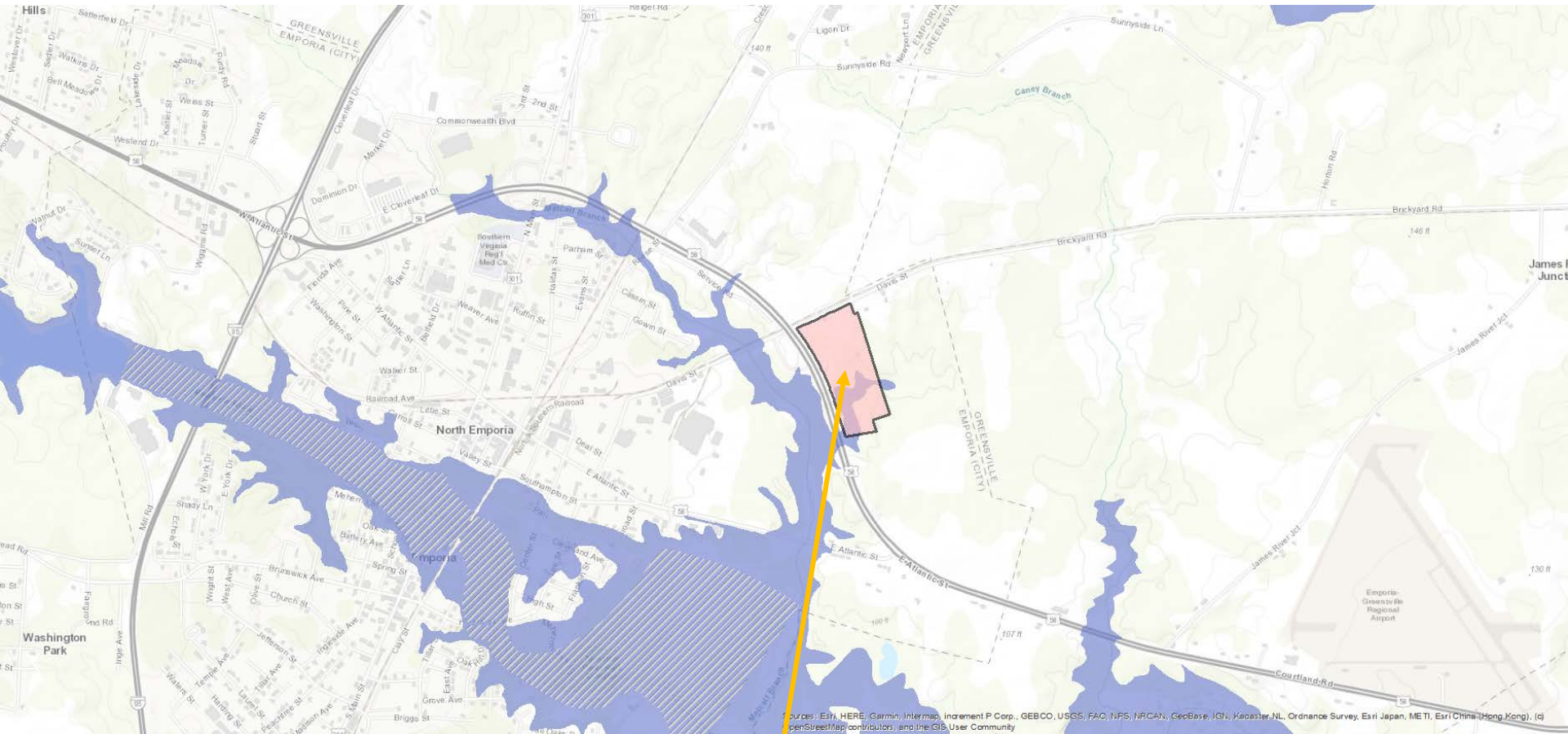
  
NRI  
Moderate  
Risk for  
Flood



# Chesterfield County South



# Emporia



**NRI**  
**Moderate**  
**Risk for**  
**Flood**

Henrico County – preparing their own maps



Impoundment Failure



# Impoundment Failure

## Causes:

- Prolonged rainfall or flooding
- Inadequate spillway capacity;
- Internal erosion caused by embankment or foundation leakage or earth movement
- Improper maintenance
- Improper design or construction
- Negligent operation
- Failure of upstream dams
- High winds, wave action and erosion
- Intentional criminal acts

Potential climate  
change impacts

Potential climate  
change impacts

Potential climate  
change impacts

# Virginia Dam Classification System

Hazard Potential	Description	Inspection
High (Class I)	Failure will cause probable loss of life or serious economic damage (to buildings, facilities, major roadways, etc.)	Annual, with inspection by P.E. every 2 years.
Significant (Class II)	Failure may cause loss of human life or appreciable economic damage (to buildings, secondary roadways, etc.)	Annual, with inspection by P.E. every 3 years.
Low (Class III)	Failure would result in no expected loss of human life, and cause no more than minimal economic damage	Annual, with inspection by P.E. every 6 years.

# Richmond-Crater High Hazard Dams

Jurisdiction	Dam Name	Year Built	EAP Status (last approval)	Downstream Impacts
Chesterfield County	Cosby Dam	1956	Expired (11/15/2014)	
	Lake Crystal Dam			
	Lake Salisbury Dam	1973	Expired (11/30/2010)	1,870 homes, 6 roads, 2 dams downstream
	Margaret Dam	1961	Expired (3/9/2007)	25 roadways, 208 homes
	Swift Creek Dam	1936	Current (1/3/2018)	32 homes, 1 business, 1 road
	Swift Creek Reservoir Dam	1965	Current (4/8/2019)	2,000 homes, 400 businesses, 1 road
	Wake Lake Dam	2019	Expired (10/21/2019)	24 houses, 4 businesses, 1 golf course, 8 roads
	Woodland Pond	1970	Current (8/23/2019)	9 homes, 1 golf course, 3 roads
Chesterfield County, City of Richmond	Falling Creek Reservoir Dam	1952	Current (3/31/2018)	
Chesterfield & Dinwiddie County	Brasfield Dam	1968		

# Richmond-Crater High Hazard Dams

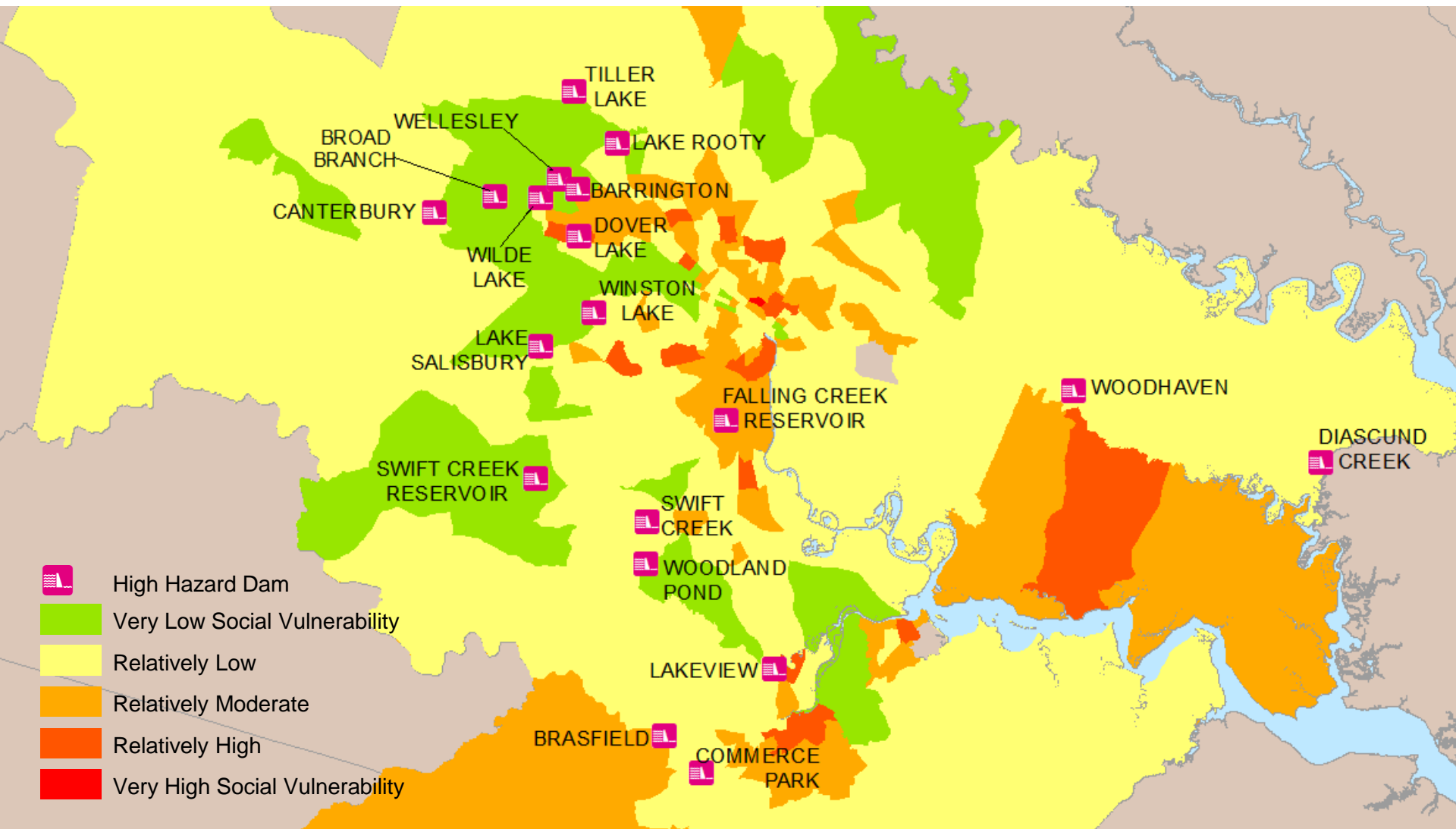
Jurisdiction	Dam Name	Year Built	EAP Status (last approval)	Downstream Impacts
Dinwiddie County	Commerce Park Dam	1900	Expired (1/9/2013)	52 homes, 1 business, 3 roads
Richmond	Winston Lake Dam	2008	Current (12/15/2017)	2 homes, 2 roads
Goochland County	Broad Branch Dam	1992	Current (5/26/2015)	5 homes, 4 roads
	Dover Lake Dam	1958	Expired (6/1/2012)	3 homes, 1 railroad, 1 road
Hanover County, Henrico County	Tiller Lake Dam	2000	Expired (1/1/2010)	8 homes
Henrico County	Barrington Dam		Current (11/4/2014)	13 homes, 2 downstream dams
	Canterbury Dam	1965	Current (9/15/2015)	200 homes, 5 businesses, 1 road
	Echo Dam	1900	Current (7/31/2019)	73 homes, 1 park, 3 roads including I-295
	Lake Overton Dam	1970	Expired (9/8/2005)	
	Lake Rooty Dam		Expired (5/15/2014)	8 homes
	Wellesley Dam	1987	Expired (10/1/2011)	19 homes, 1 downstream dam



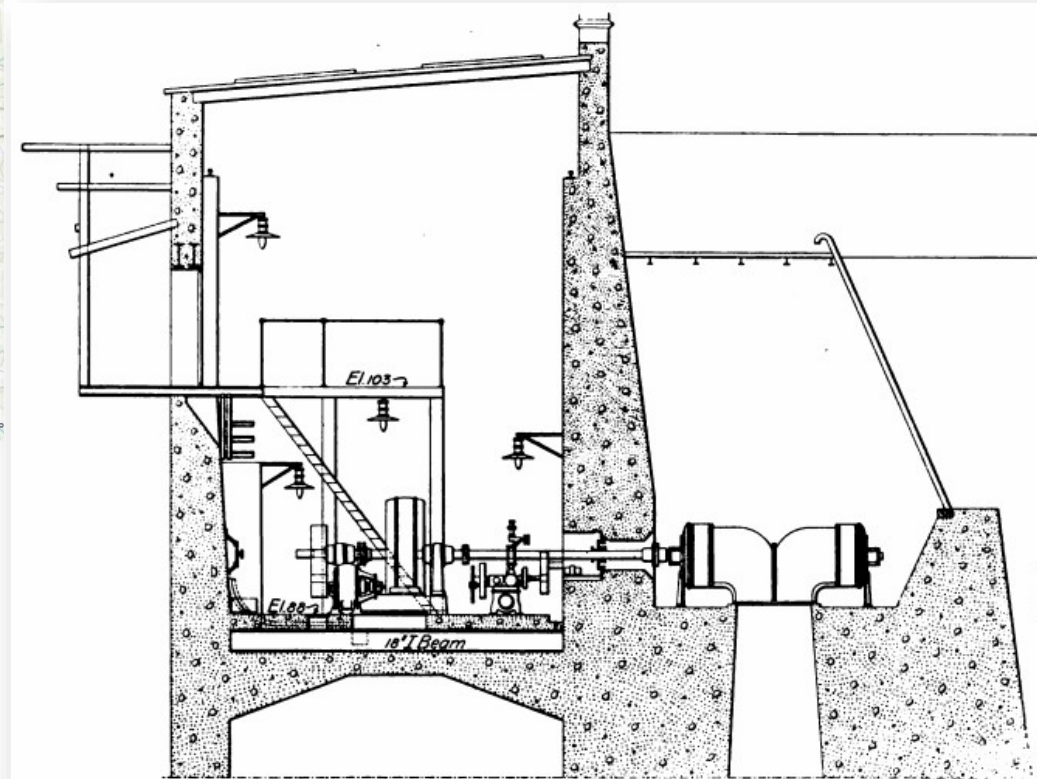
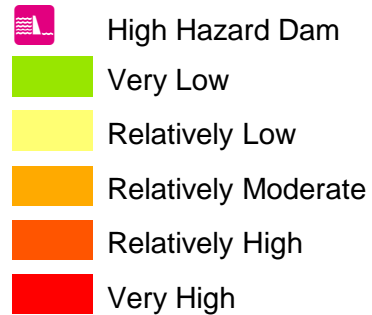
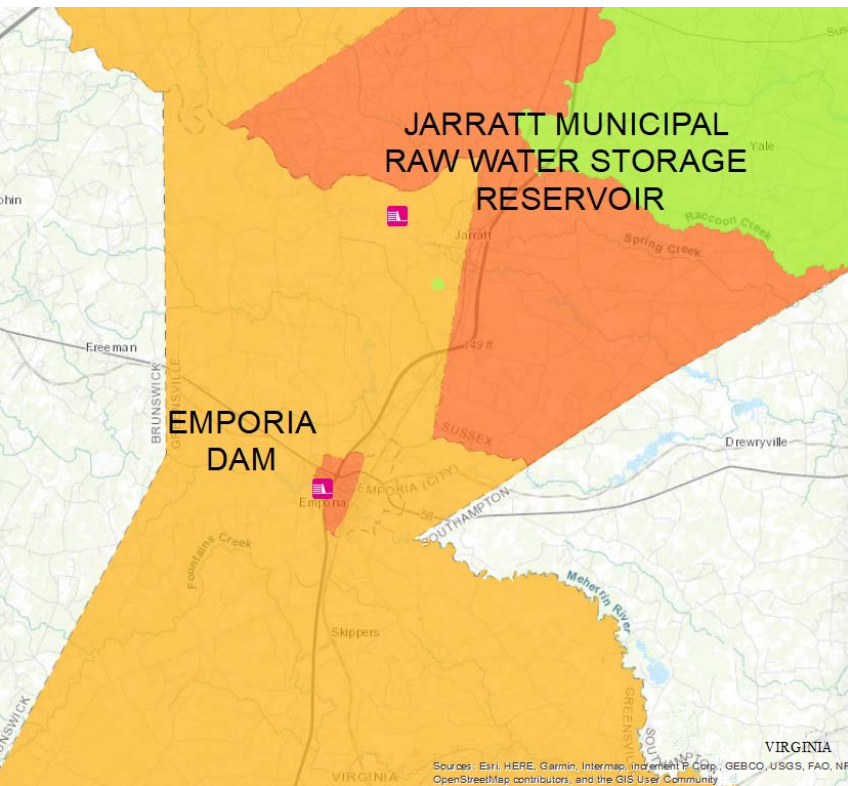
# Richmond-Crater High Hazard Dams

Jurisdiction	Dam Name	Year Built	EAP Status (last approval)	Downstream Impacts
Petersburg	Wilcox Dam	1900	Current (10/30/2020)	113 homes, 2 businesses, 1 hospital, 1 railroad, 10 roads, 1 downstream dam
Powhatan County	Mill Quarter Lake Dam	1974	Expired (7/15/2012)	44 homes, 1 business, 1 road
	Upper Powhatan Dam	1810	Expired (5/9/2008)	2 roads, 1 dam downstream
Colonial Heights	Lakeview Dam	1920	Current (1/1/2018)	
Emporia, Greenville County	Emporia Dam	1908	Expired (1/31/2012)	
Greenville County	Jarratt Municipal Raw Water Storage Reservoir Dam	2018	Current (6/2/2020)	5 homes, 2 roads, 1 dam downstream
James City County, New Kent County	Diascund Creek Dam	1961	Current (8/18/2016)	208 homes, 25 roads
New Kent County	Woodhaven Dam	1961	Current (8/7/2020)	10 homes, 1 railroad, 2 roads

# Richmond-Crater High Hazard Dams and Social Vulnerability



# Richmond-Crater High Hazard Dams and Social Vulnerability



Emporia Dam powerhouse  
Source: *The Engineering Record*, 1910



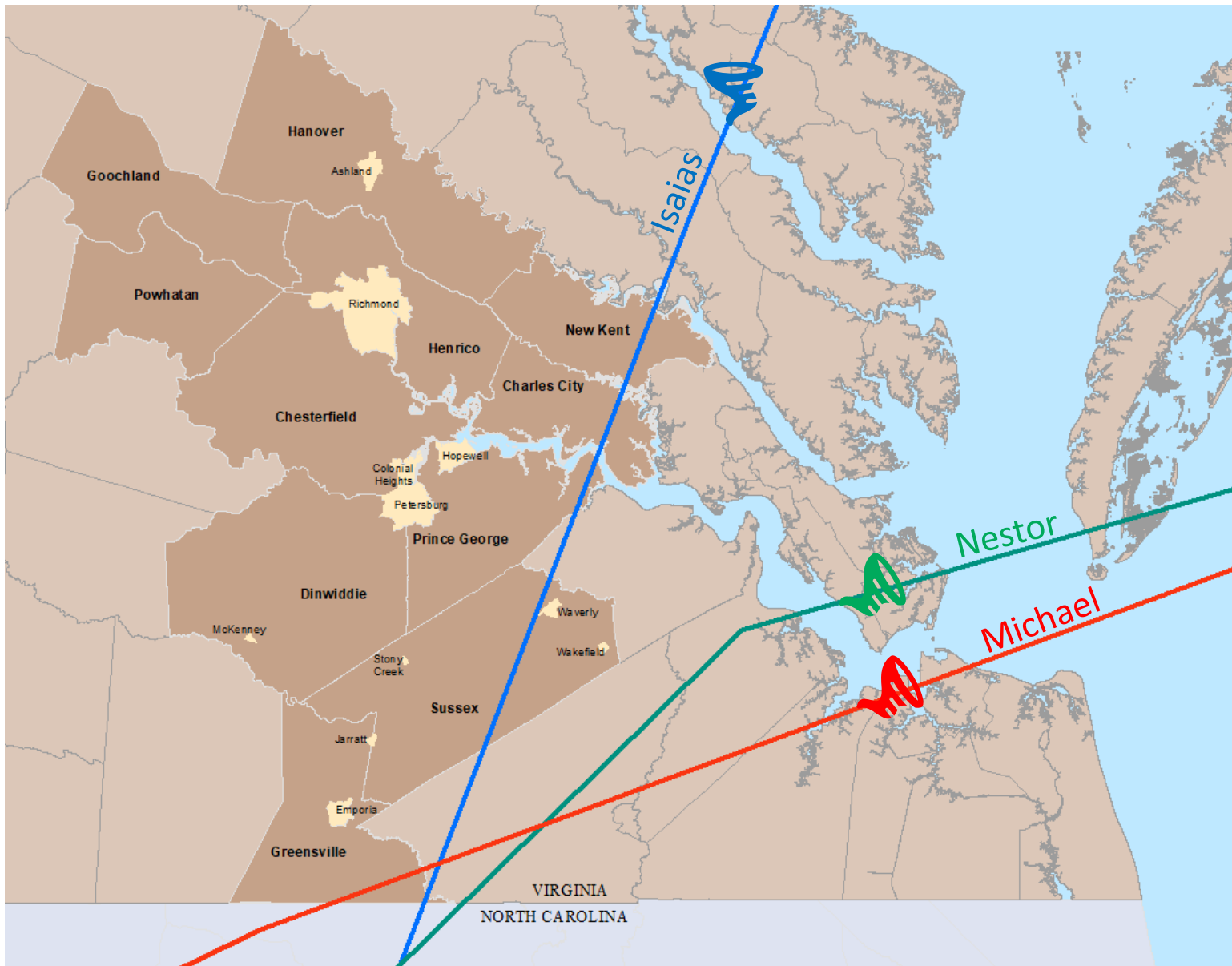
# Tropical Storms

- Property damage, power & phone outages, tree damage, structural damage to roofs
- Significant events since previous plan was adopted:

Date	Name	Wind Speed (mph)	Storm Category
October 12, 2018	Michael	52-58 mph	Extra-tropical storm
October 20, 2019	Nestor	46 mph	Extra-tropical storm
August 4, 2020	Isaias	69 mph	Tropical storm

# Tropical Storms

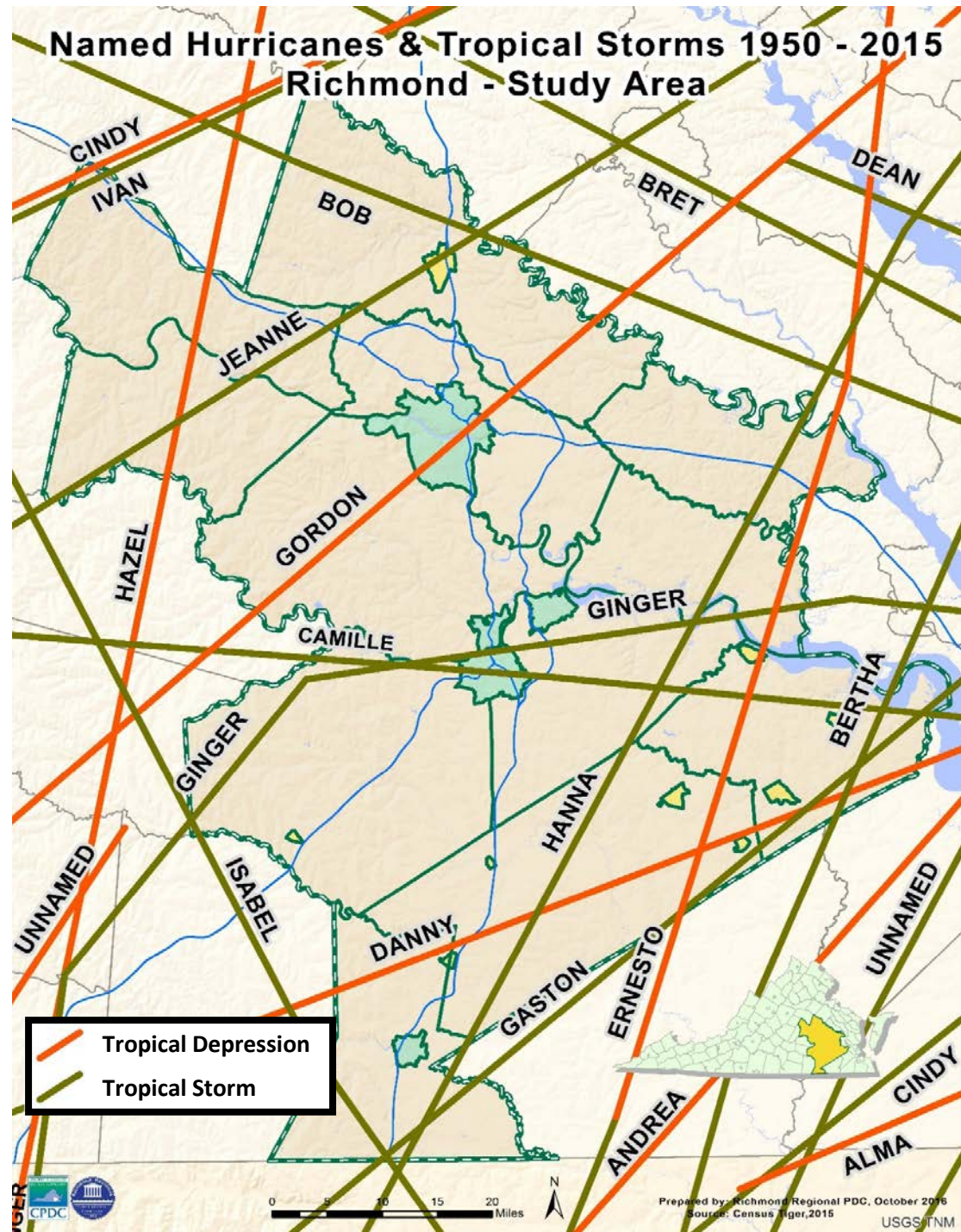
Storms Since previous plan





# Tropical Storms

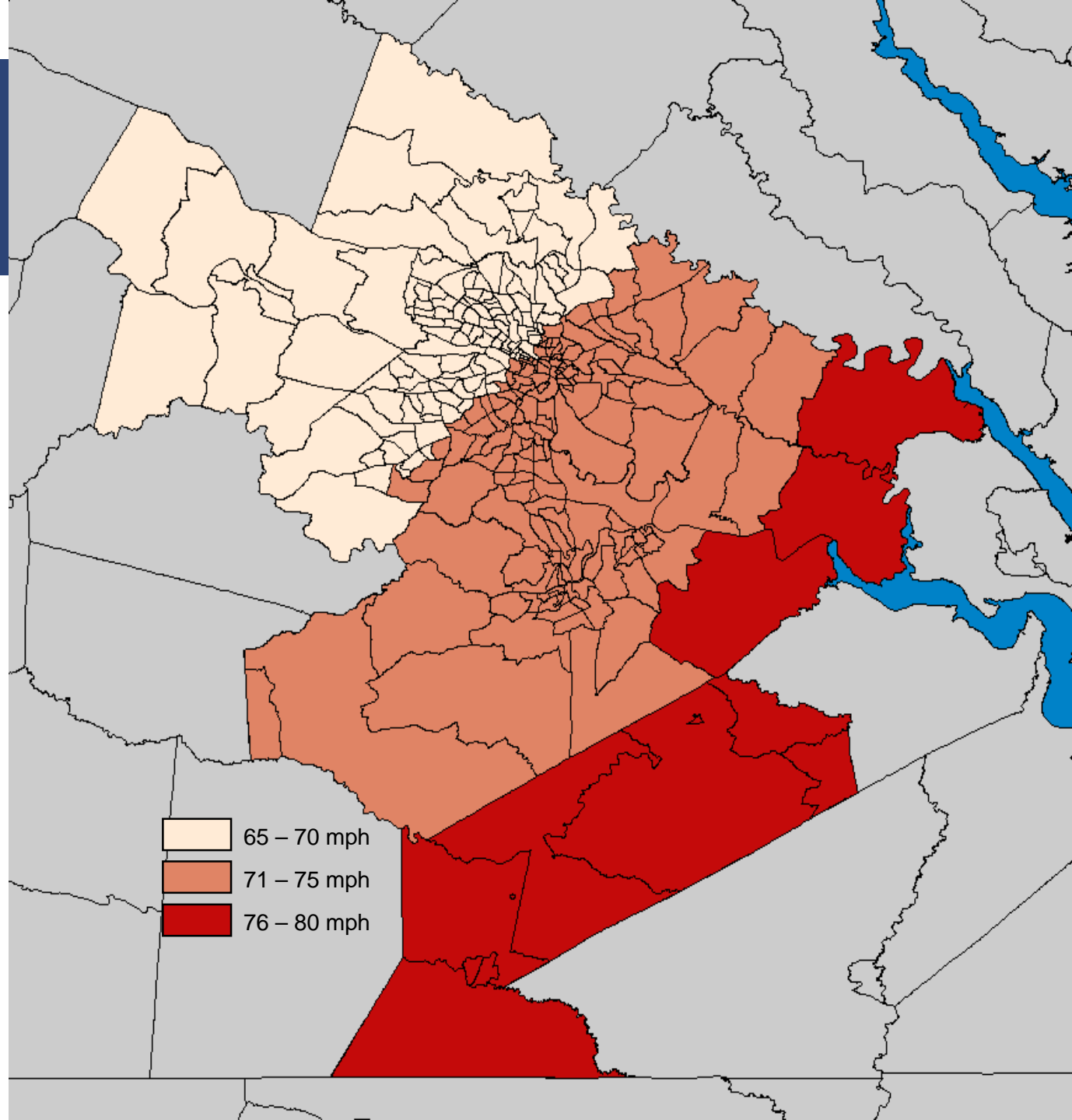
Historical Storm Tracks  
through or near the  
Richmond-Crater  
Region, 1950-2015



# Tropical Storms

100-year  
return period  
Peak Gust  
(mph)  
By Census  
Tract

HAZUS  
Level 1





# Tropical Storms

## Probabilistic Loss Estimates

### 100-YEAR WIND EVENT, Plan RVA

Community	Building Damage	Contents & Inventory Damage	Total*
Goochland Co	\$2,860,000	\$1,297,000	\$4,157,000
Hanover Co	\$9,861,000	\$5,123,000	\$14,985,000
Henrico Co	\$24,076,000	\$2,623,000	\$26,757,000
New Kent Co	\$2,337,000	\$1,386,000	\$3,723,000
Powhatan Co	\$5,715,000	\$3,128,000	\$8,843,000
Richmond	\$14,589,000	\$1,380,000	\$16,109,000

\* Also includes income losses from relocation, lost wages, and lost rental income.





# Tropical Storms

## Probabilistic Loss Estimates

### 100-YEAR WIND EVENT, Crater

Community	Building Damage	Contents & Inventory Damage	Total*
Charles City	\$969,000	\$532,000	\$1,501,000
Chesterfield Co	\$49,095,000	\$7,696,000	\$56,850,000
Colonial Heights	\$3,645,000	\$529,000	\$4,198,000
Dinwiddie Co	\$8,111,000	\$2,181,000	\$10,486,000
Emporia	\$953,000	\$279,000	\$1,243,000
Greensville Co	\$1,562,000	\$571,000	\$2,134,000
Hopewell	\$3,641,000	\$843,000	\$4,512,000
Petersburg	\$6,891,000	\$1,429,000	\$8,533,000
Prince George Co	\$8,093,000	\$2,298,000	\$10,415,000
Sussex Co	\$3,185,000	\$1,012,000	\$4,286,000

\* Also includes income losses from relocation, lost wages, and lost rental income.

# Tropical Storms

## Probabilistic Loss Estimates, ANNUALIZED LOSSES

PlanRVA	Total
Goochland Co	\$201,000
Hanover Co	\$1,347,000
Henrico Co	\$2,059,000
New Kent Co	\$441,000
Powhatan Co	\$265,000
Richmond	\$1,235,000

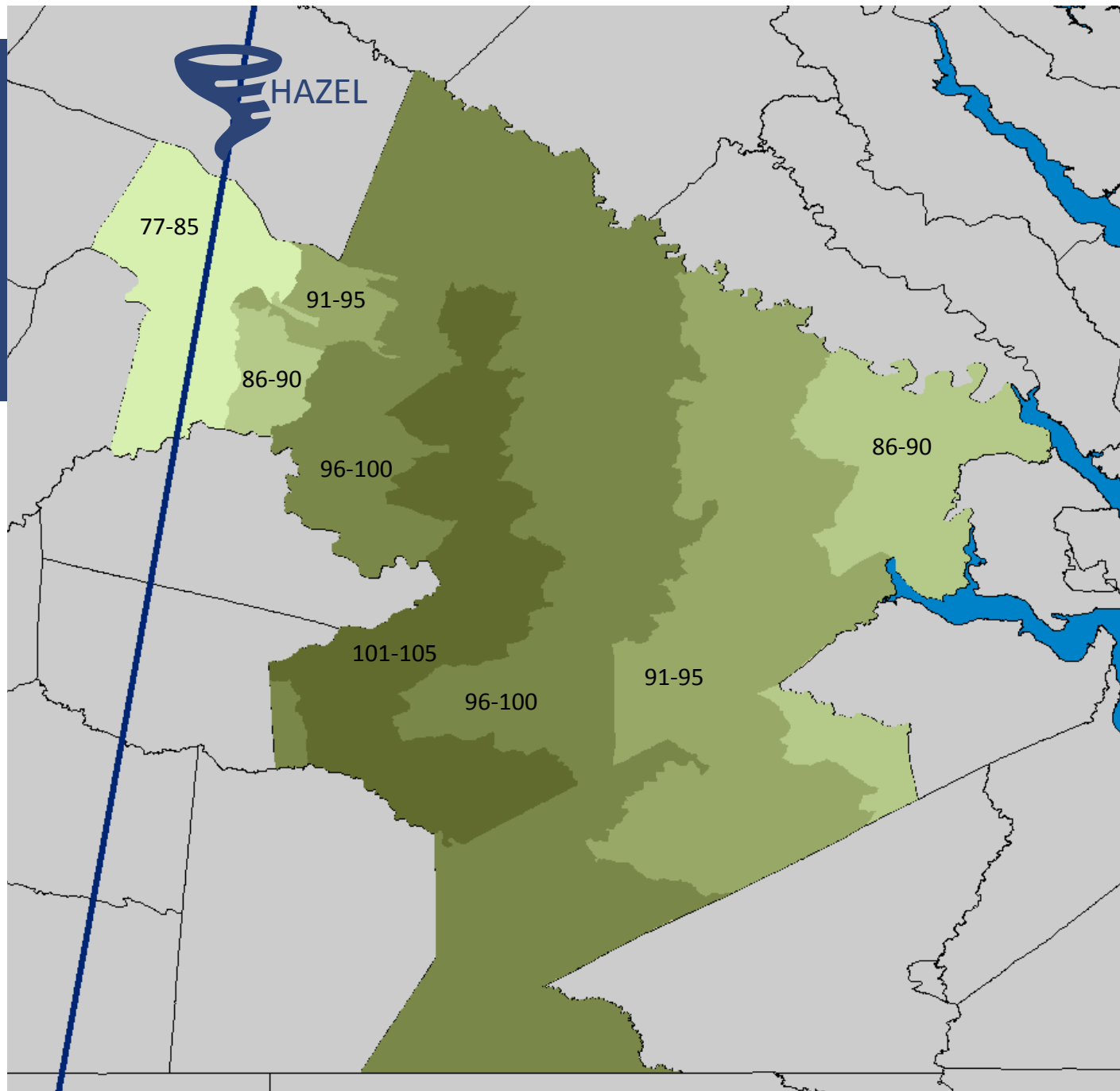
Crater	Total
Charles City	\$125,000
Chesterfield Co	\$2,271,000
Colonial Heights	\$174,000
Dinwiddie Co	\$252,000
Emporia	\$90,000
Greensville Co	\$137,000
Hopewell	\$222,000
Petersburg	\$326,000
Prince George Co	\$412,000
Sussex Co	\$147,000

# Bonus model run!

Hurricane  
Hazel, 1954

Peak Gust  
(mph)  
By Census  
Tract

HAZUS  
Level 1



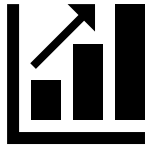
# Tropical Storms

HURRICANE HAZEL – historic storm, current exposure

PlanRVA	Total
Goochland Co	\$38,039,000
Hanover Co	\$309,506,000
Henrico Co	\$652,689,000
New Kent Co	\$32,277,000
Powhatan Co	\$46,596,000
Richmond	\$396,091,000

Crater	Total
Charles City	\$9,818,000
Chesterfield Co	\$634,840,000
Colonial Heights	\$30,533,000
Dinwiddie Co	\$53,295,000
Emporia	\$12,071,000
Greensville Co	\$17,960,000
Hopewell	\$30,207,000
Petersburg	\$55,888,000
Prince George Co	\$43,352,000
Sussex Co	\$9,955,000

# Tropical Storms - Climate Change Impacts



Intensity, frequency & duration of Atlantic hurricanes, and frequency of the strongest hurricanes, have all increased since the early 1980s.



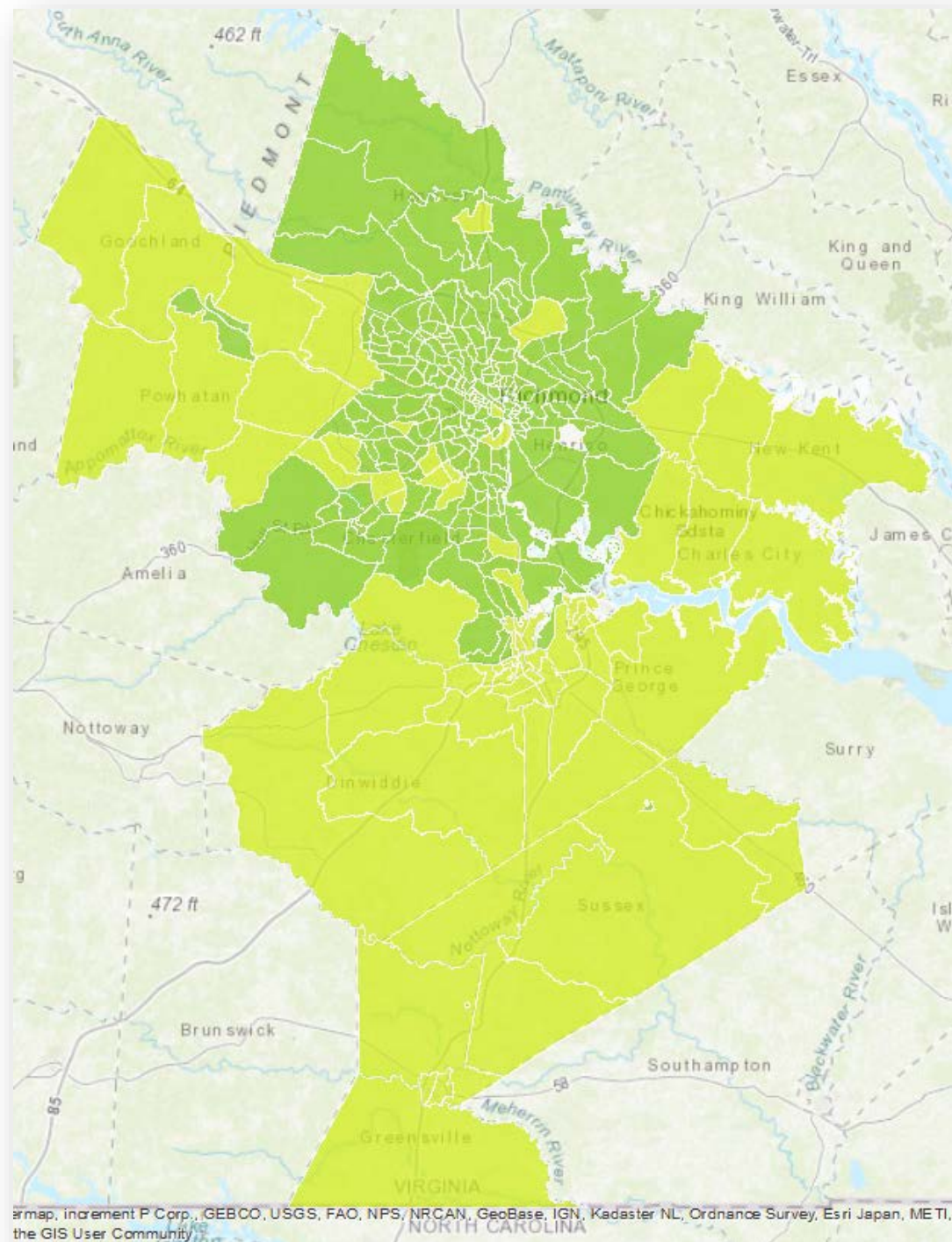
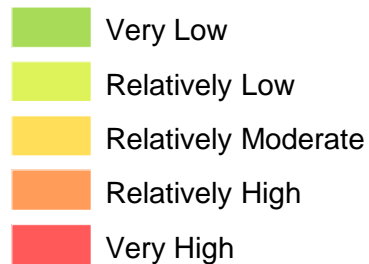
Relative contributions of human & natural causes to these increases remain uncertain.



Hurricane-associated storm intensity and rainfall rates are projected to increase as climate continues to warm.



# Tropical Storms



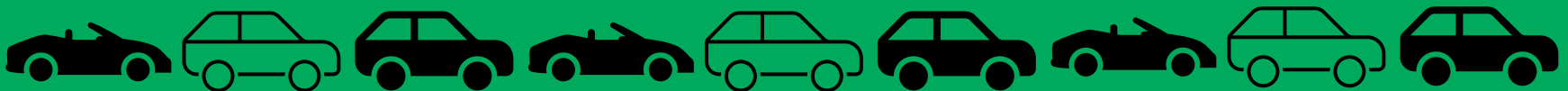
# Tropical Storms - Mass Evacuation

## History

- Hurricane Floyd in '99, 3m people evacuated from coastal NC, SC and VA. Some limited impact in Richmond-Crater region.

## Impacts

- Strains resources & infrastructure, gridlocks roads, overcrowds hospitals/shelters, especially in rural areas.



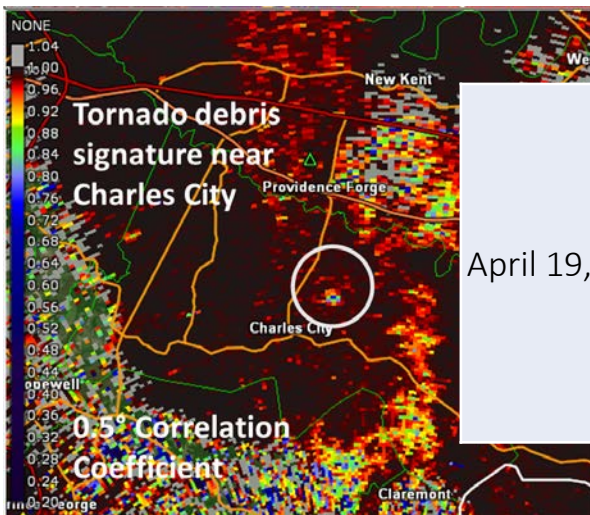


# Major Tornado Outbreaks



Source: National Weather Service, 2019

Charles City  
Rod & Gun Club



April 19, 2019

Gaskins (EF0)  
Dahlia (EF0)  
Skippers (EF1)  
Emporia (EF0)  
Newville (EF0)  
Burrowsville (EF1)  
Ruthville (EF2)

\$293,000

Mostly tree and outbuilding damage, except for the Ruthville tornado, just north of Charles City. This twister caused wall and roof damage to Charles City Rod & Gun Club.

Source: National Weather Service, 2019

# Major Tornado Outbreaks

September 17, 2018	Rockville (EF1) Hallboro (EF1) Richmond (EF1) Bon Air (EF2) Pilkinton (EF0) Richmond (4 EF0s) Atlee (EF0)	\$1.078m property damage	One death and one injury were caused by a tornado outbreak that formed from the remnant low of Florence. Structural damage in Hallsboro, lots of tree damage in Richmond. EF2 in Bon Air damaged homes and businesses and destroyed Old Dominion Flooring Warehouse.  Several EF0 twisters caused tree and power line damage, as well.	Chesterfield County
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Source: National Weather Service, 2018





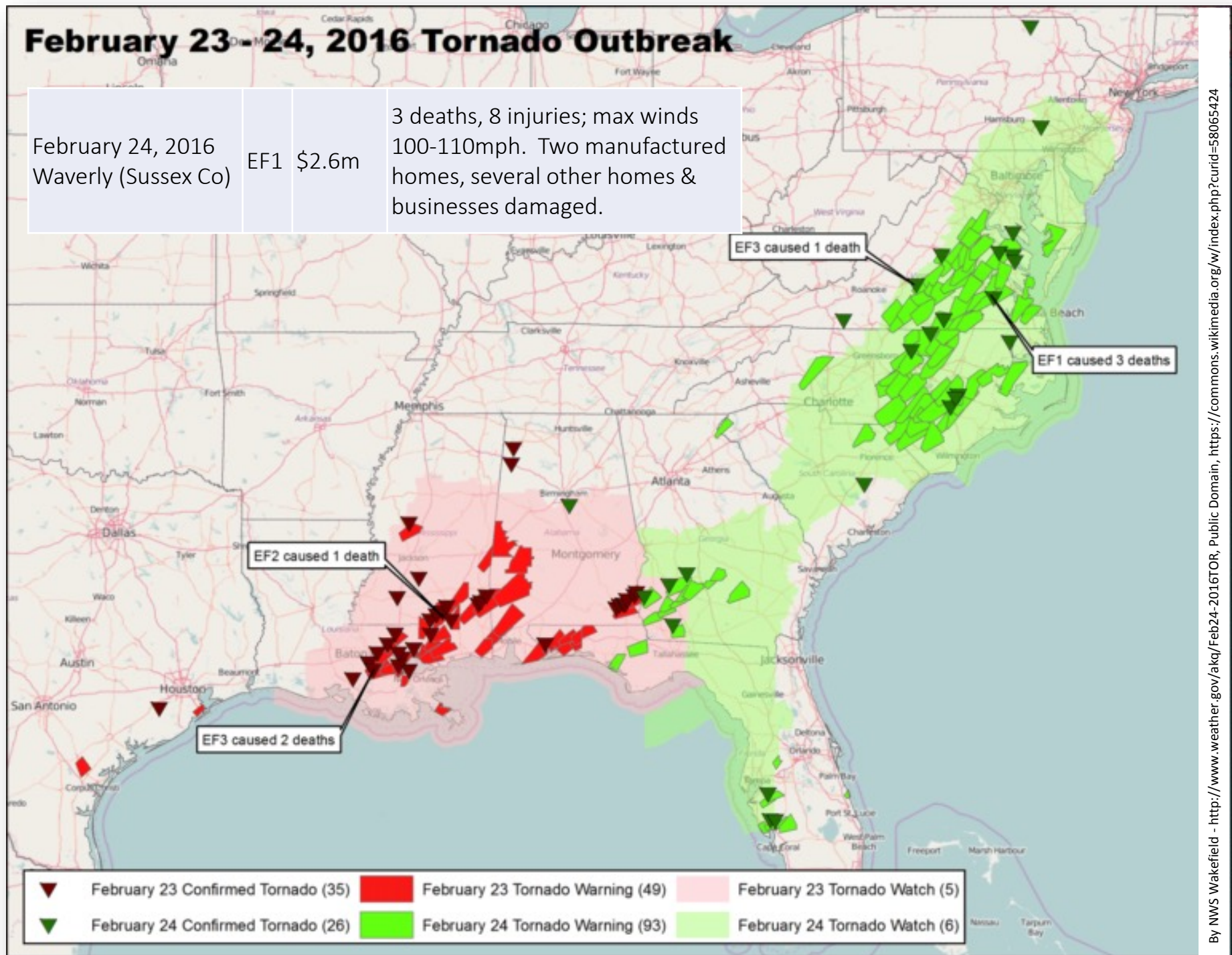
# February 23-24, 2016 Tornado Outbreak

February 24, 2016  
Waverly (Sussex Co)

EF1

\$2.6m

3 deaths, 8 injuries; max winds 100-110mph. Two manufactured homes, several other homes & businesses damaged.

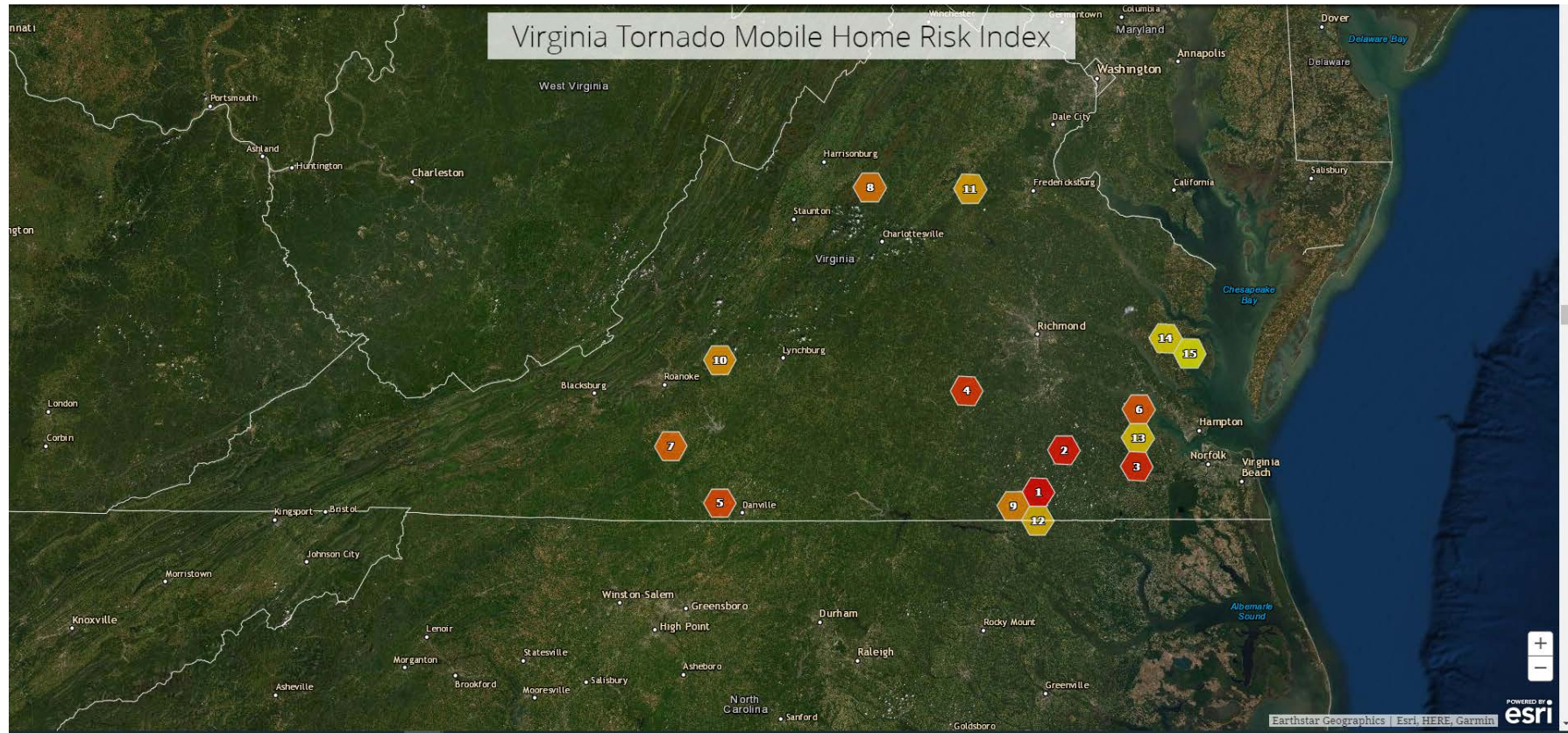


# Tornado Events

Date	Community	Magnitude	Property Damage	Description
June 27, 2015	Hanover County	EF0	\$2000	Weak tornado, minor tree damage
May 5, 2017	Mosely, McKenny, Dinwiddie County	EF0 and 2 EF1s	\$578k property; \$40,000 crops	Mostly tree and crop damage. Trees fell onto homes causing property damage.
October 11, 2018	Lanexa	EF0	\$50,000	Caused damage to four homes.



# Tornadoes & Social Vulnerability

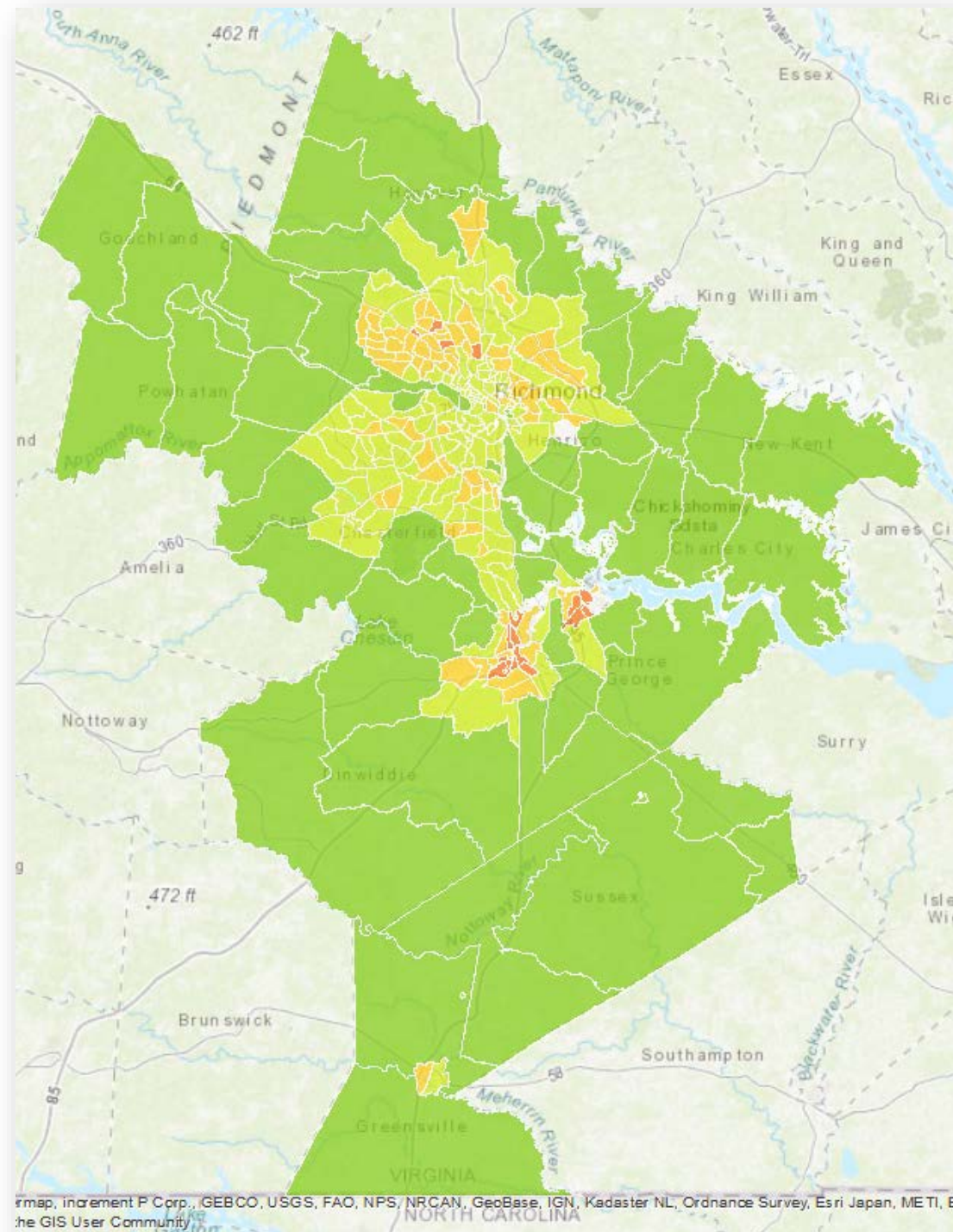
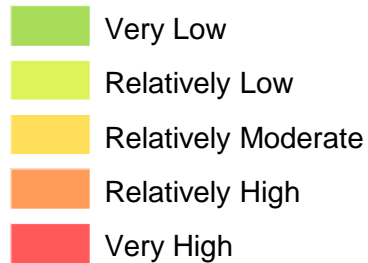


Source: <https://odu-gis.maps.arcgis.com/apps/Cascade/index.html?appid=723e660c2c09447fa8a57d3186dc8d2a>.

- Ongoing research concerning spatial variability and trends in tornado occurrence.
- Overlaid areas of increased tornado activity with areas of high manufactured home percentages to identify high risk areas



# Tornadoes

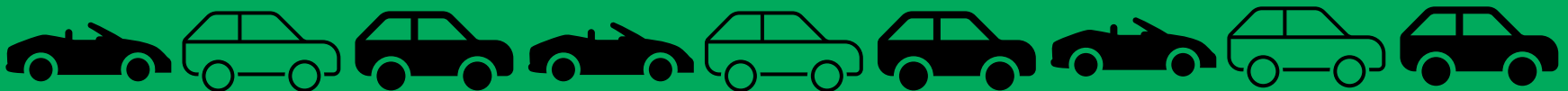


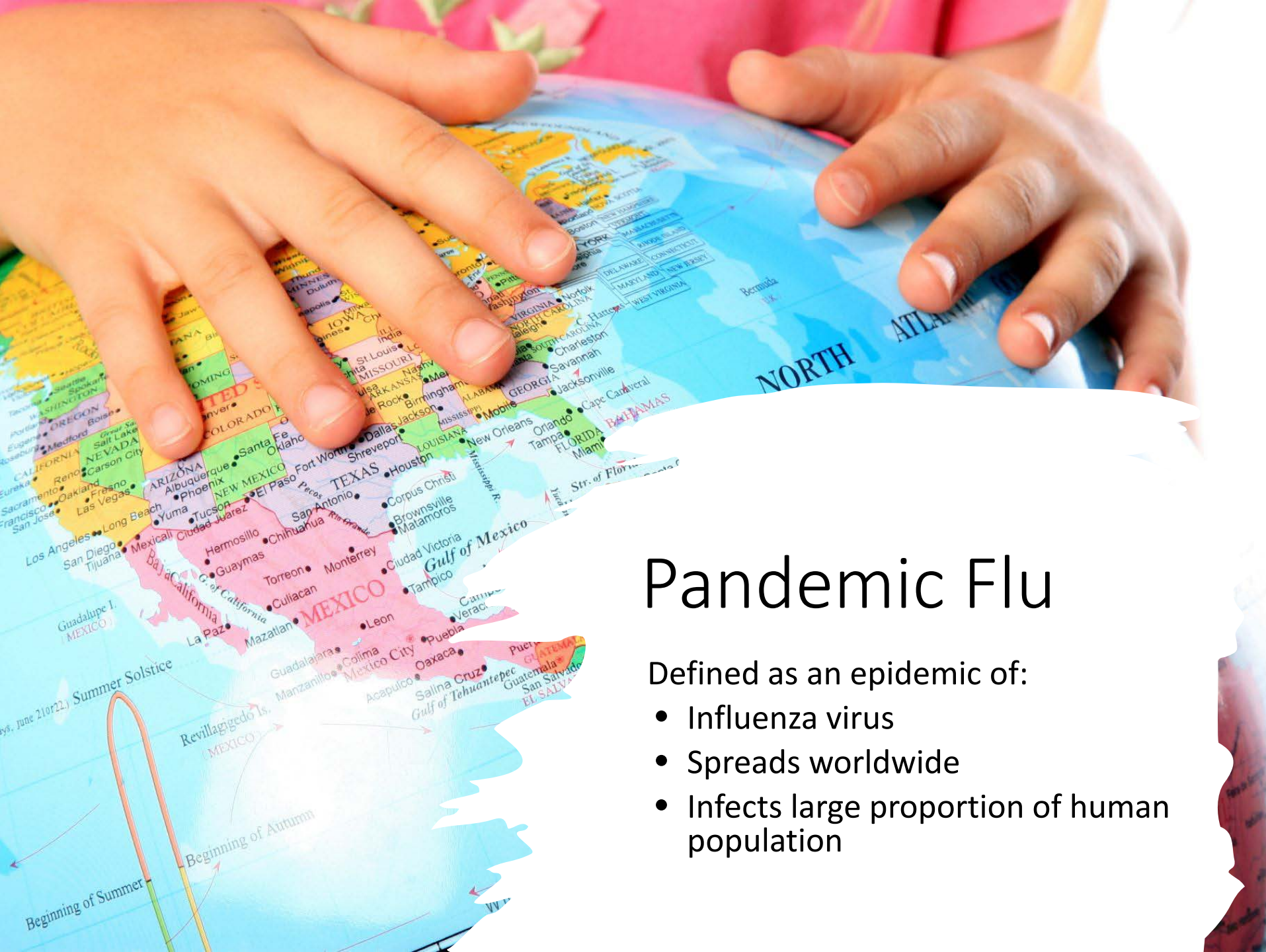
# TORNADO

## Climate change impacts

- Could cause prolonged tornado outbreaks, versus individual events
- Changes in population could impact number of people in harm's way
- Increase in atmospheric heat and moisture could increase favorable conditions for thunderstorms and tornadoes

Mass evacuation: not likely to be a factor





# Pandemic Flu

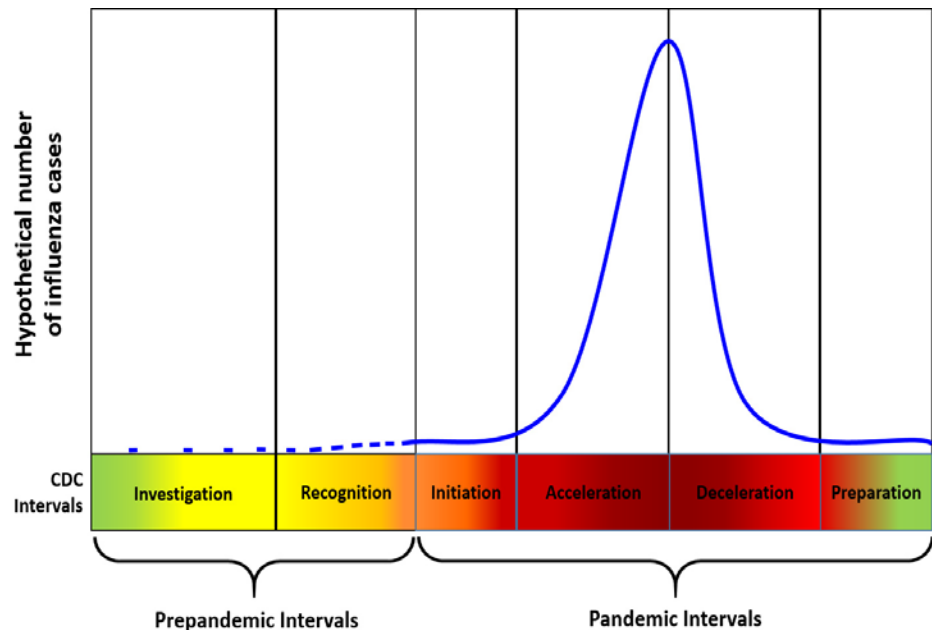
Defined as an epidemic of:

- Influenza virus
- Spreads worldwide
- Infects large proportion of human population



Interval	Description
1) Investigation	Monitoring & investigation of cases in humans
2) Recognition	Control outbreak, treat sick
3) Initiation	Pandemic wave begins when virus has ability to spread person to person
4) Acceleration	Focus on non-pharma interventions and medications to reduce spread/prevent death
5) Deceleration	Pandemic wave slows down when cases consistently decrease; reduce non-pharma interventions
6) Preparation	Monitor for future waves

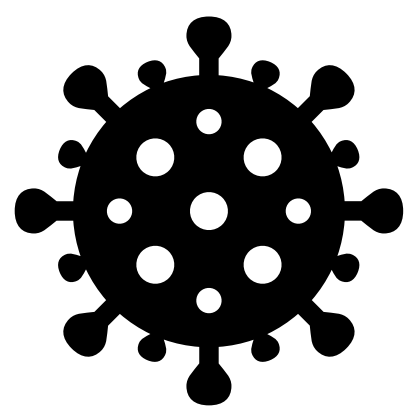
# Pandemic Flu



# Pandemic Flu

Time Period	Moniker	Impacts
1918-1920	Spanish Flu	<ul style="list-style-type: none"><li>• 20-40% of world population ill</li><li>• 50 million people died; 675,000 in U.S.</li><li>• High mortality among healthy 20-50 year olds</li></ul>
1957-1958		<ul style="list-style-type: none"><li>• Rapid vaccine development</li><li>• Schoolchildren brought it home</li><li>• 69,800 deaths in U.S., mostly among elderly</li></ul>
1968-1969	Hong Kong Flu Virus	<ul style="list-style-type: none"><li>• Improved medical care, antibiotics &amp; immunity from '57 pandemic</li><li>• Hit during holiday break for schools</li><li>• Returned in 1970 and 1972</li></ul>
2009-2010	H1N1 (Swine Flu)	<ul style="list-style-type: none"><li>• New strain of virus from Spanish Flu</li><li>• Number of deaths worldwide uncertain; estimated at 284,000</li><li>• Risk of serious illness not as high as seasonal flu</li></ul>

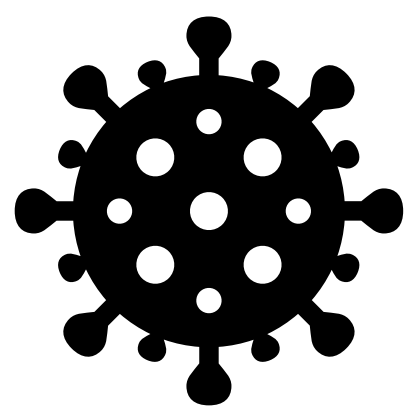




# Pandemic Flu – COVID 19 or SARS-CoV-2

## COVID 19 - Plan RVA

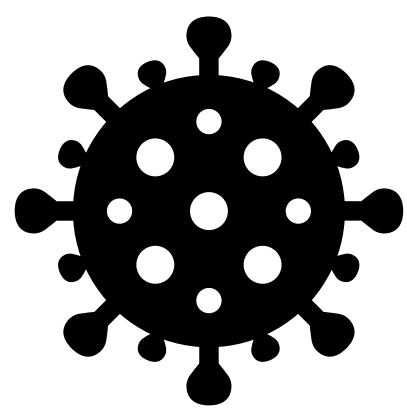
Community	Cases	Hospitalizations	Deaths
Goochland Co	1,345	47	23
Hanover Co	7,550	265	149
Henrico Co	23,737	988	582
New Kent Co	1,412	33	14
Powhatan Co	1,814	55	14
Richmond	16,096	756	255



# Pandemic Flu – COVID 19 or SARS-CoV-2

## COVID 19 - Crater

Community	Cases	Hospitalizations	Deaths
Charles City	461	35	15
Chesterfield Co	25,916	885	404
Colonial Heights	1,568	70	57
Dinwiddie Co	2,017	85	42
Emporia	663	50	42
Greensville Co	1,541	52	25
Hopewell	2,409	101	64
Petersburg	3,587	153	79
Prince George Co	3,298	52	25
Sussex Co	1,145	46	21



# Pandemic Flu – COVID 19 or SARS-CoV-2

## **SOCIAL VULNERABILITY is a factor of:**

- financial health
- physical health
- mental health
- other aspects of where and how a person lives
- access to virus testing
- healthcare for those who contract the virus
- access to medications and vaccinations

All affected by nature and  
characteristics of the virus



## Regional Snowfall Index (RSI)

Category	RSI Raw Score	Description
5	>18	Extreme
4	10-18	Crippling
3	6-10	Major
2	3-6	Significant
1	1-3	Notable
0	0-1	

## Winter Weather

- Property damage (roof collapse & frozen pipes)
- Power, phone outages, and closures of streets, highways, schools, businesses, and nonessential government operations
- Tree damage from ice accumulation
- Transportation accidents
- Snow removal costs

# Recent Winter Storms

January 5-8, 2017	Low pressure tracking northeast just off the Southeast and Mid Atlantic Coasts produced between three inches and twelve inches of snow across central, south central, and interior southeast Virginia. Laurel reported 2.5 inches of snow. Ginter Park and Glen Allen reported 2.0 inches of snow.	RSI  2
December 8-10, 2017	Low pressure tracking northeast just off the Southeast and Mid Atlantic Coasts produced between three inches and twelve inches of snow across central, south central, and interior southeast Virginia. Reports ranged from 7 to 12 inches across the study area.	2
January 3-5, 2018	Strong low pressure tracking northward just off the East Coast produced between one inch and four inches of snow across Central and South Central Virginia.	1



No damages reported.



# Recent Winter Storms

March 11-15, 2018	Snowfall totals ranged from one to three inches across the Richmond-Crater region.	RSI 1
March 20-22, 2018	Low pressure tracking east northeast off the Mid Atlantic Coast produced between one inch and four inches of snow across portions of central and south central Virginia, and the Middle Peninsula. Snow totals ranged from 1 to five inches in the region.	1
January 30 – February 3, 2021	Powhatan County and Oilville in Goochland County had snow totals between 1 to 4 inches, but snow accumulation elsewhere in the region was between .5 inch to 3 inches.	1

No damages reported.

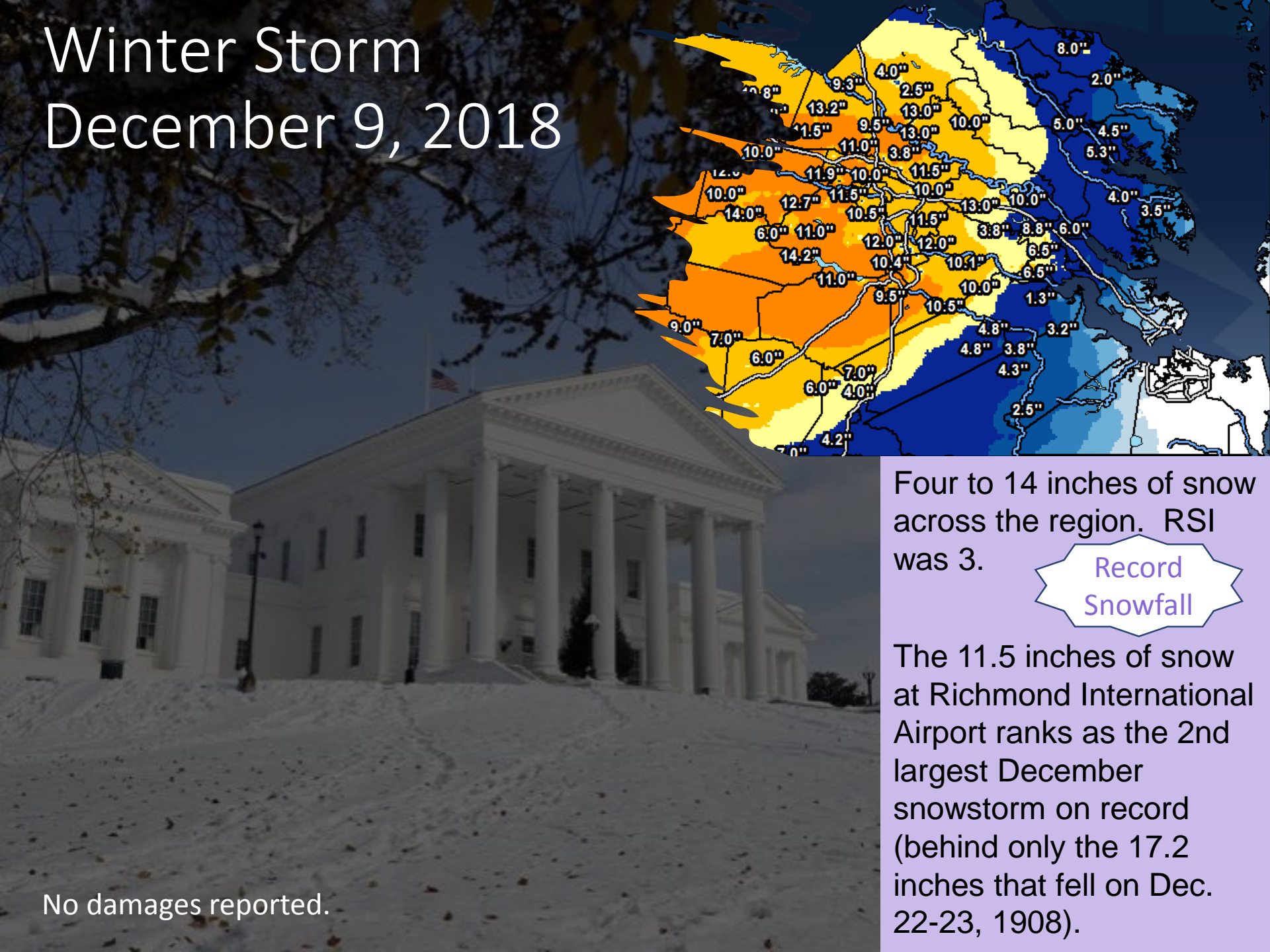
Winter Storm  
December 9, 2018

Four to 14 inches of snow across the region. RSI was 3.

**Record Snowfall**

The 11.5 inches of snow at Richmond International Airport ranks as the 2nd largest December snowstorm on record (behind only the 17.2 inches that fell on Dec. 22-23, 1908).

No damages reported.



Four to 14 inches of snow across the region. RSI was 3.

Record  
Snowfall

The 11.5 inches of snow at Richmond International Airport ranks as the 2nd largest December snowstorm on record (behind only the 17.2 inches that fell on Dec. 22-23, 1908).

No damages reported.



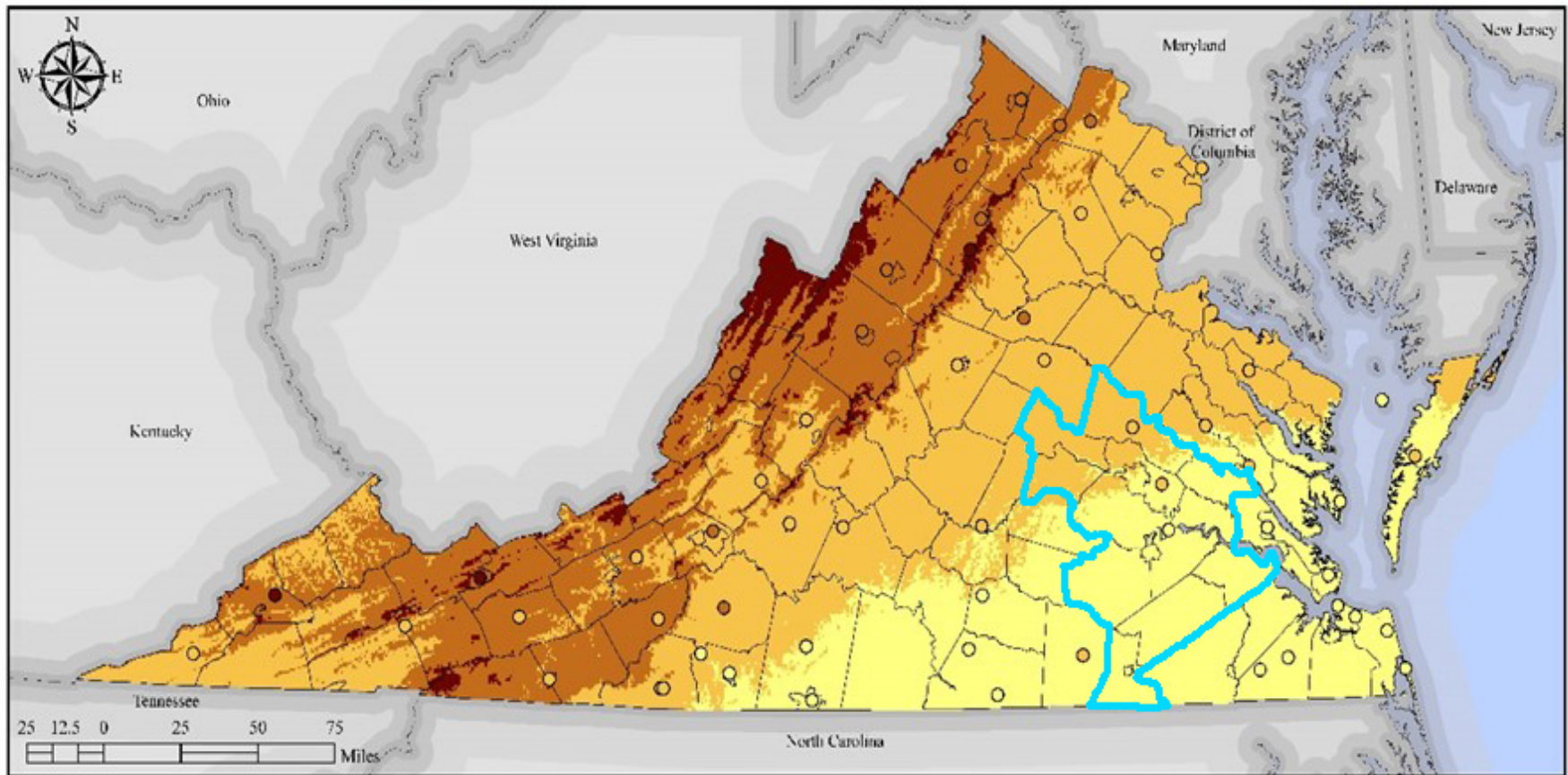


February 2021

#### Chesterfield County

- 2/12/21, 1-2" of snow fell
- 2/13/21, .25-.35" freezing rain
  - Hundreds of trees down created hazardous conditions
  - Power outages for 57,103 customers
  - Warming stations opened
- 2/18/21, freezing rain forecast & low overnight temps
- Damages still being counted; over 3200 man-hours for County staff

# Average Number of Days with at Least 3 Inches of Snowfall



**DATA SOURCES:**  
CGIT analysis of NCDC data  
VGIN Jurisdictional Boundaries  
ESRI State Boundaries

**LEGEND:**  
Avg. Annual Frequency

0 - 0.25
0.251 - 0.5
0.51 - 0.75
0.751 - 1

## HAZARD IDENTIFICATION:

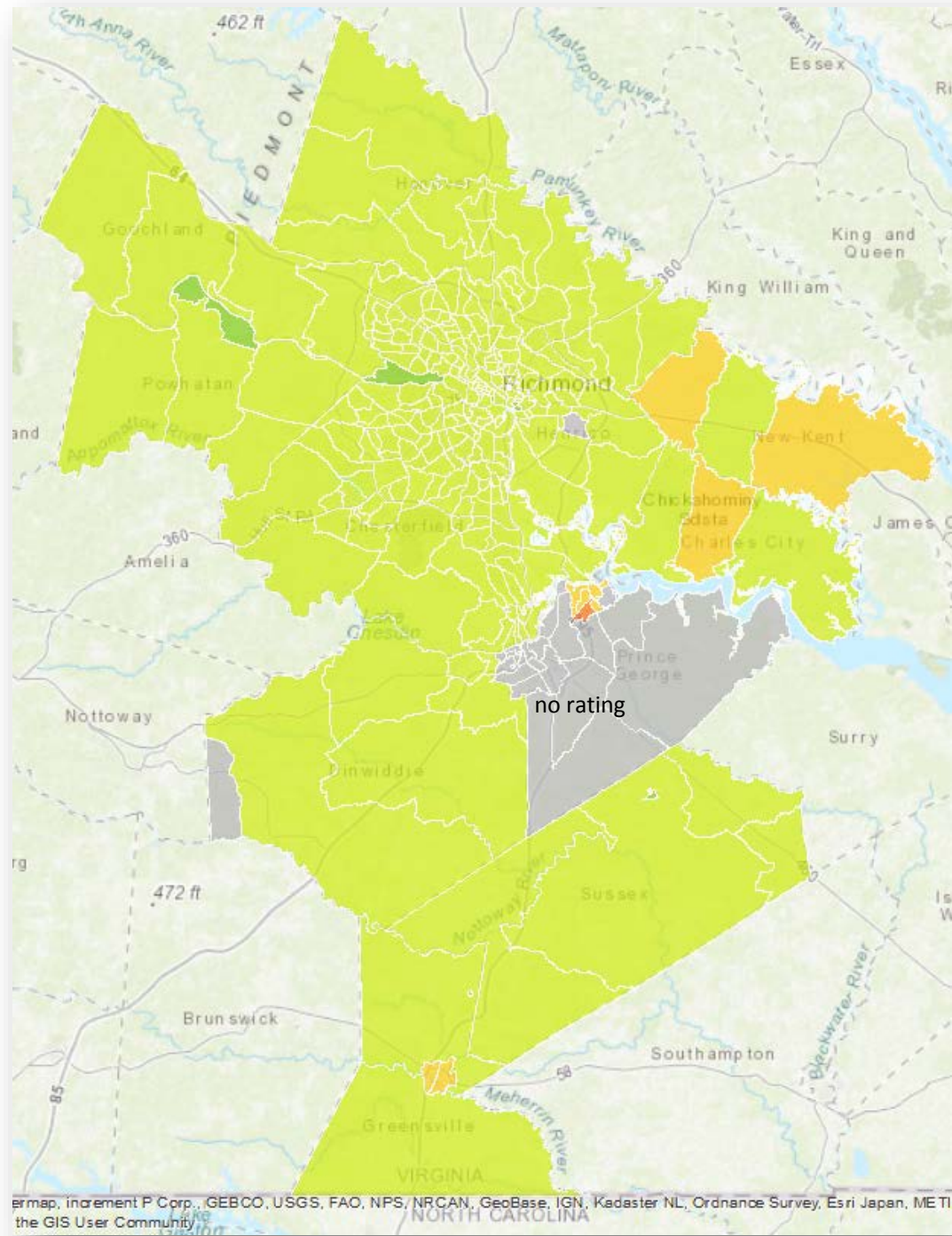
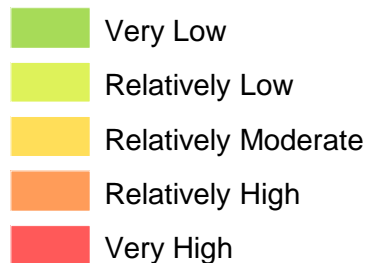
Winter weather statistics were estimated from daily NCDC weather station reports from 1960 - 2000; the values at the weather stations are symbolized with small round dots, and a statewide regression fit depicts the overall trend in the weather station statistics. Average annual frequency ranges from zero to one: zero means that the condition never occurs in a year, one means that it always occurs in a year. These results depict general trends, and local conditions may vary widely.

**PROJECTION:** VA Lambert Conformal Conic  
North American Datum 1983

DISCLAIMER: Absence of available hazard data is intended to be used at regional or national scales. The purpose of this data sets are to give general indication of areas that are to susceptible to hazards. In order to identify potential risk in the Commonwealth available data has been used beyond the original intent.



# Winter Weather







## Recent Wildfire History, 2015- 2020

- 239 events in VDOF database for 2015-2020
- Only VDOF-response fires, and only those with locational data
- 1,294 acres burned

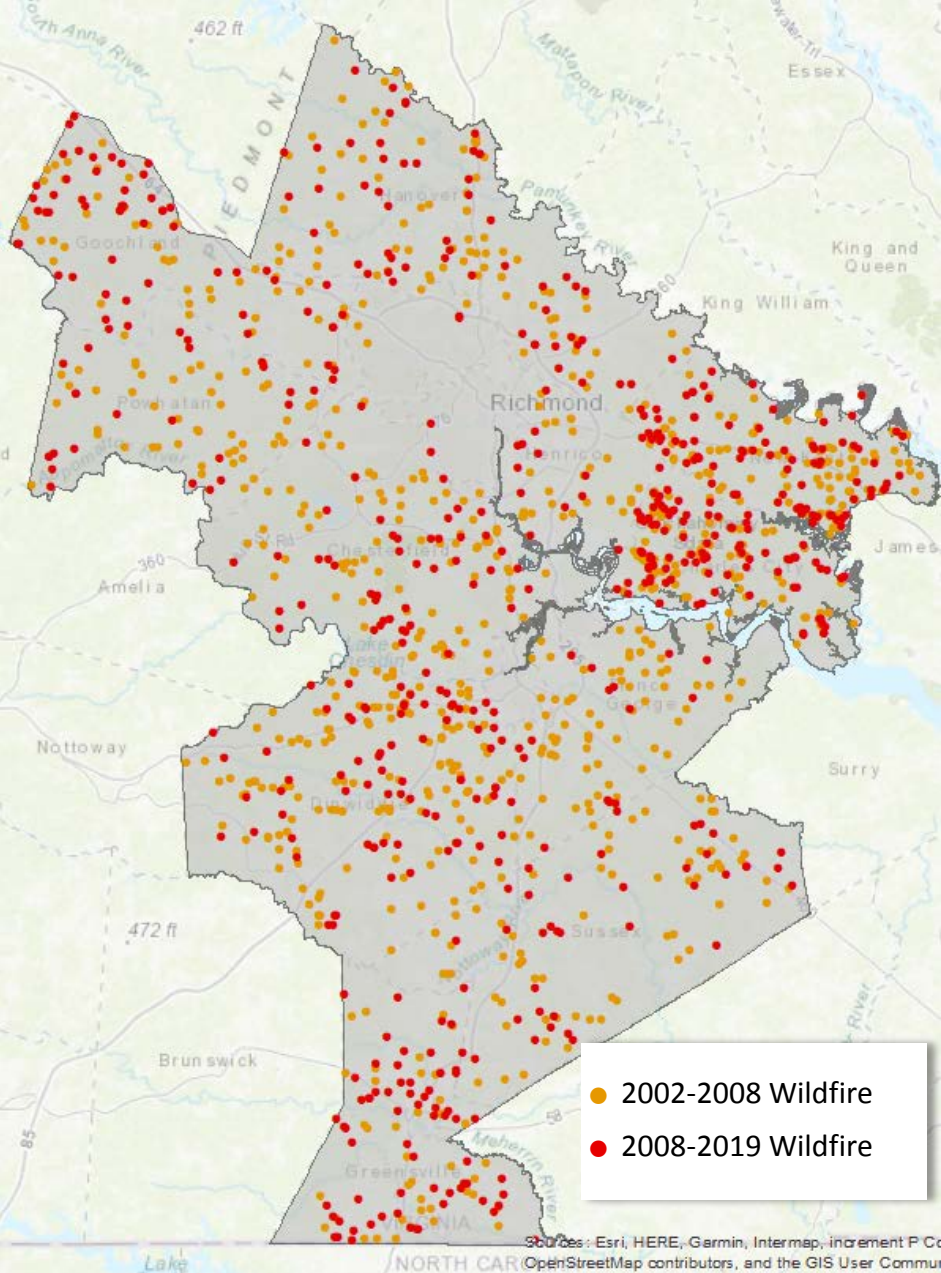
# Wildfire History, 2015-2020

<b>PlanRVA</b>	<b>Number of Wildfires</b>	<b>Damages</b>	<b>Annualized Damages (2005 – 2020)</b>
Goochland Co	18	\$6,700	\$21,603
Hanover Co	26	\$207,215	\$32,725
Henrico Co	3	\$17,000	\$26,840
New Kent Co	35	\$700	\$8,583
Powhatan Co	11	\$82,985	\$8,339
Richmond	2	\$100	\$7

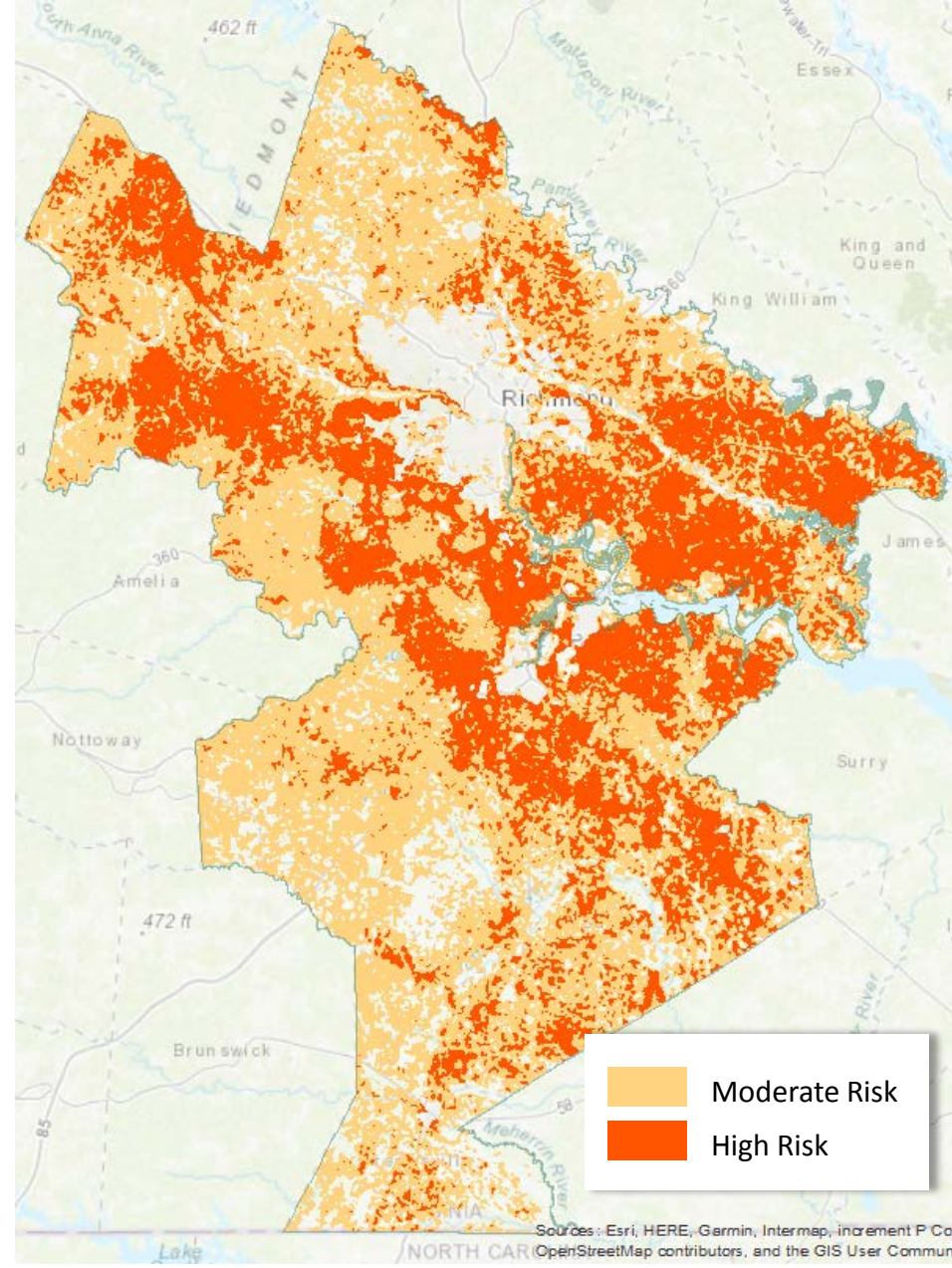
# Wildfire History, 2015-2020

Crater	Number of Wildfires	Damages	Annualized Damages (2005 – 2020)
Charles City	40	\$65,950	\$21,610
Chesterfield Co	19	\$142,650	\$15,336
Colonial Heights	0	\$0	\$0
Dinwiddie Co	29	\$64,950	\$75,597
Emporia	0	\$0	\$0
Greensville Co	30	\$77,900	\$15,147
Hopewell	0	\$0	\$0
Petersburg	1	\$0	\$0
Prince George Co	7	\$2,600	\$1,047
Sussex Co	17	\$28,550	\$5,057





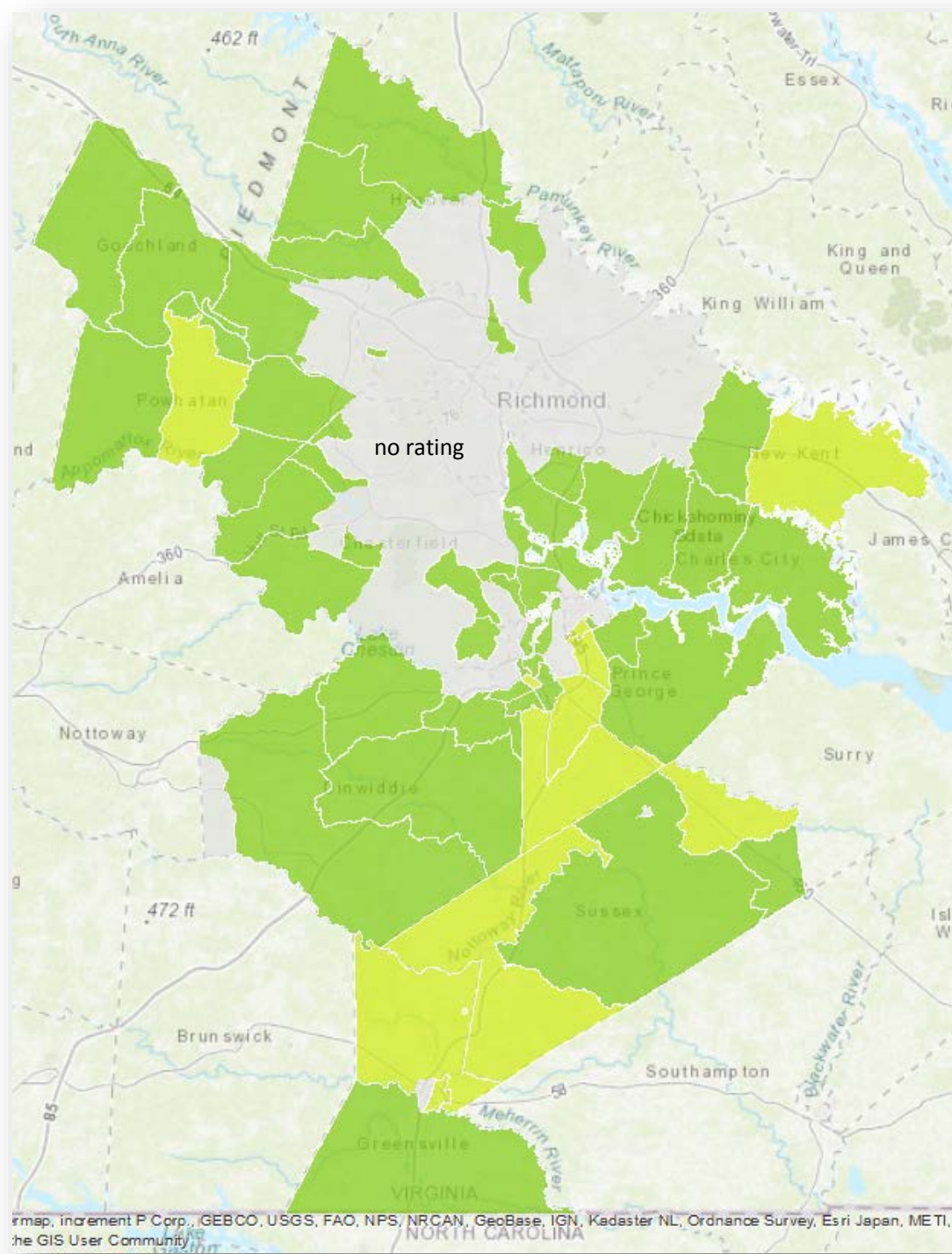
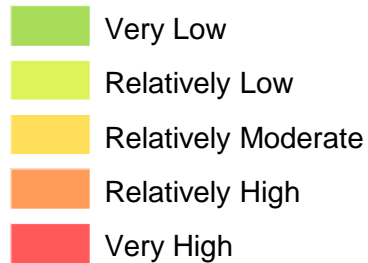
Wildfire History, 2002-2019



Wildfire Risk Assessment



# Wildfire

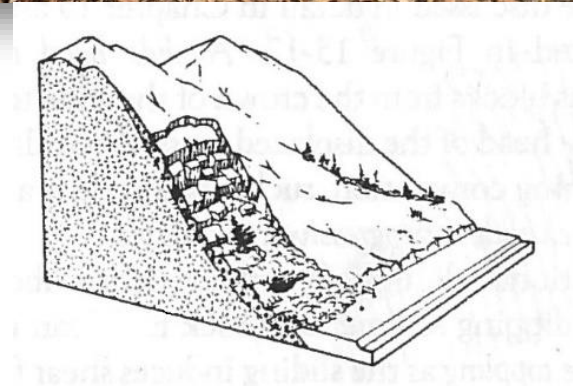




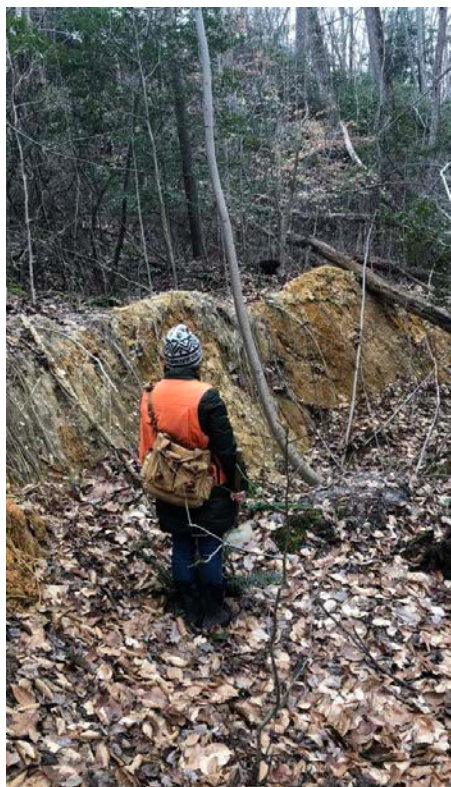
# Mass Movement - Landslides



2019 - New Kent County, Chickahominy River,  
translational debris slide

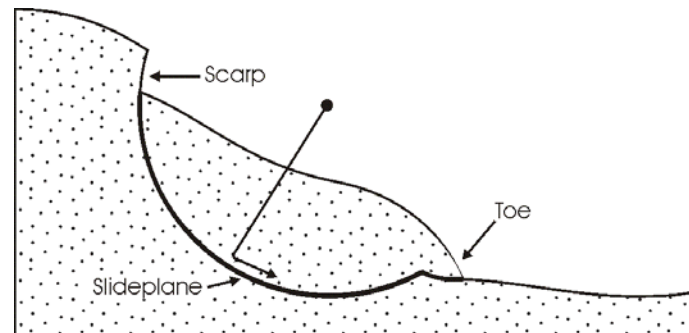




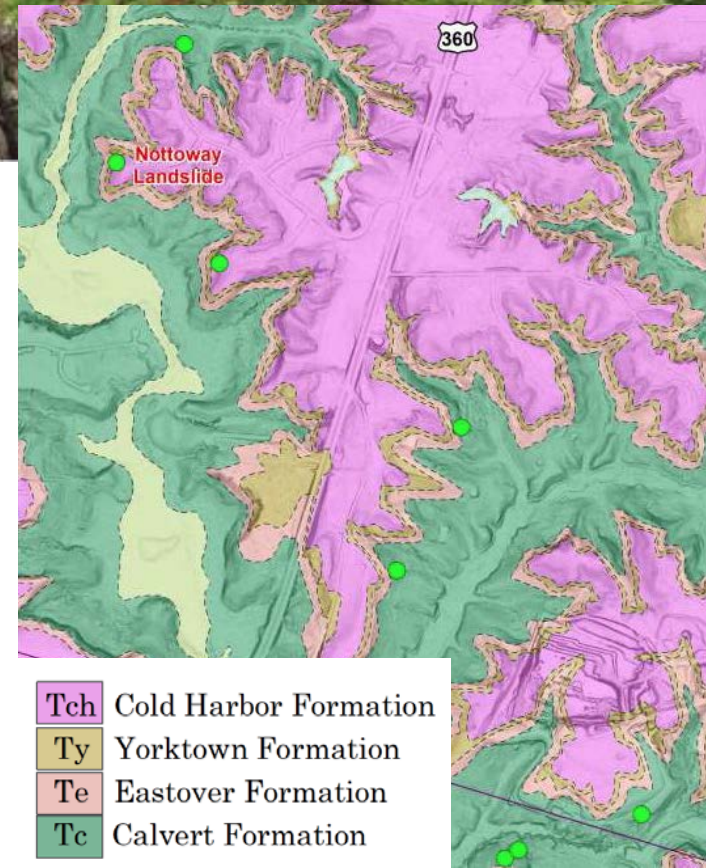


# Mass Movement - Landslides

Henrico County – currently active rotational landslide  
undermining walking trail and blocking stormwater drainage







OUTSIDE STUDY AREA, BUT CAUSE IS REGIONWIDE:

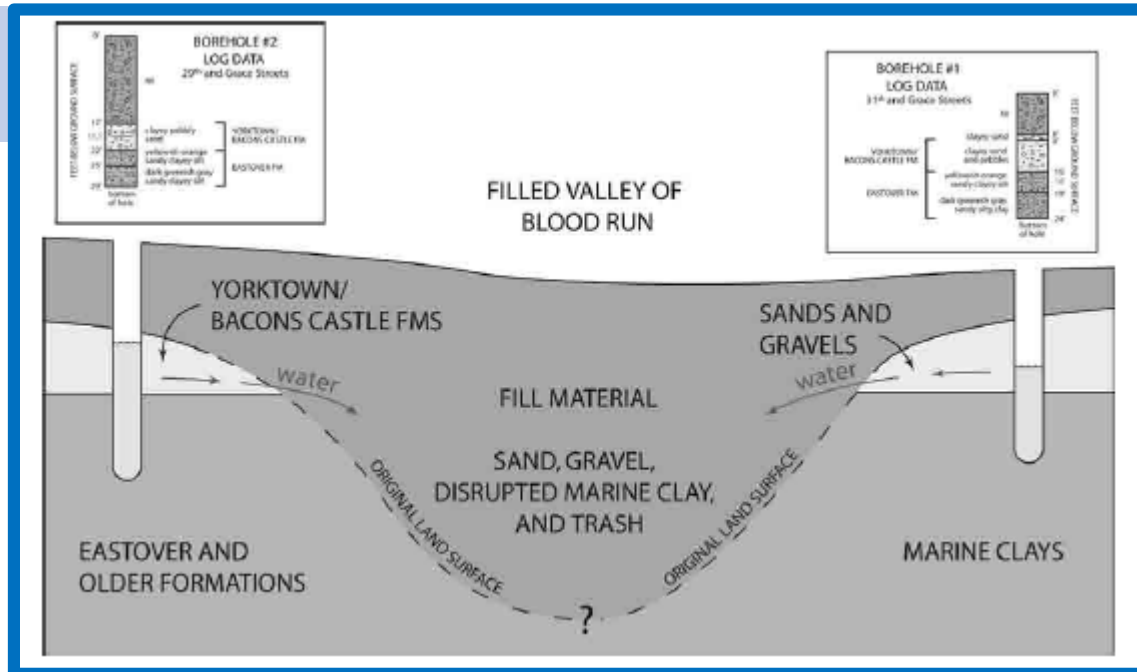
June 3, 2018, Nottoway Lane, King William County – rotational debris slide-flow

- Contact between Eastover and Yorktown Formations prone to landslide during heavy rain
- Slope stability possibly endangered by runoff from development, including driveways & concrete storm drain

# Mass Movement - Landslides

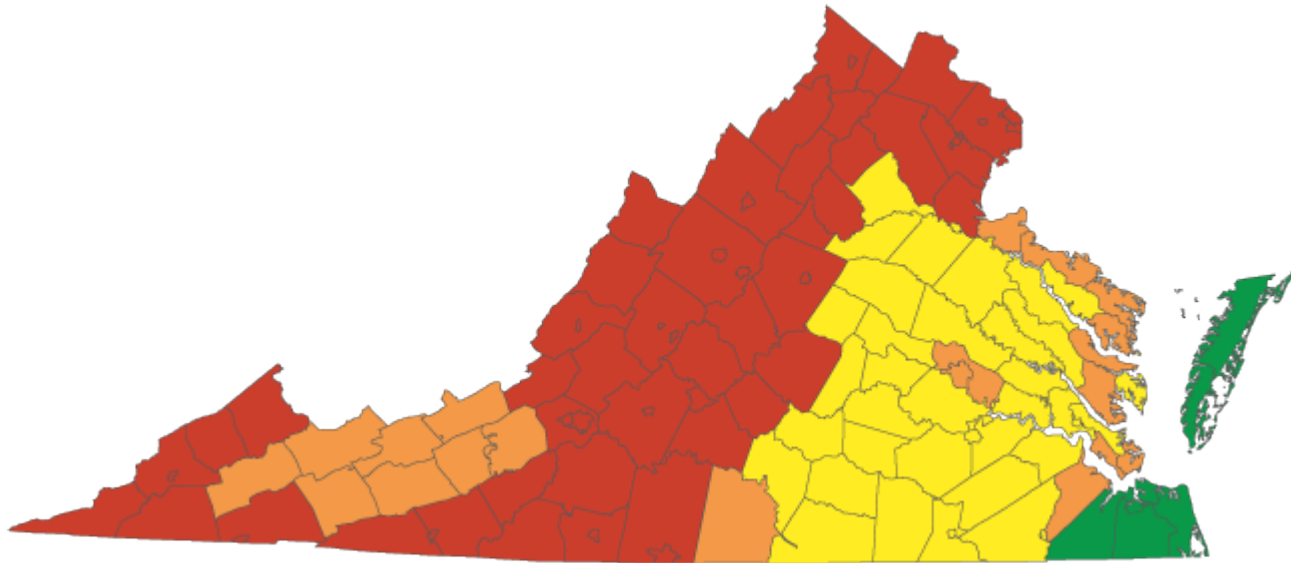


The Chimborazo Hill Landslide  
Richmond – Fall 2004, post TD Gaston



# Mass Movement

Counties in Virginia that are susceptible to landslides.



VA DMME

*Red = high potential*

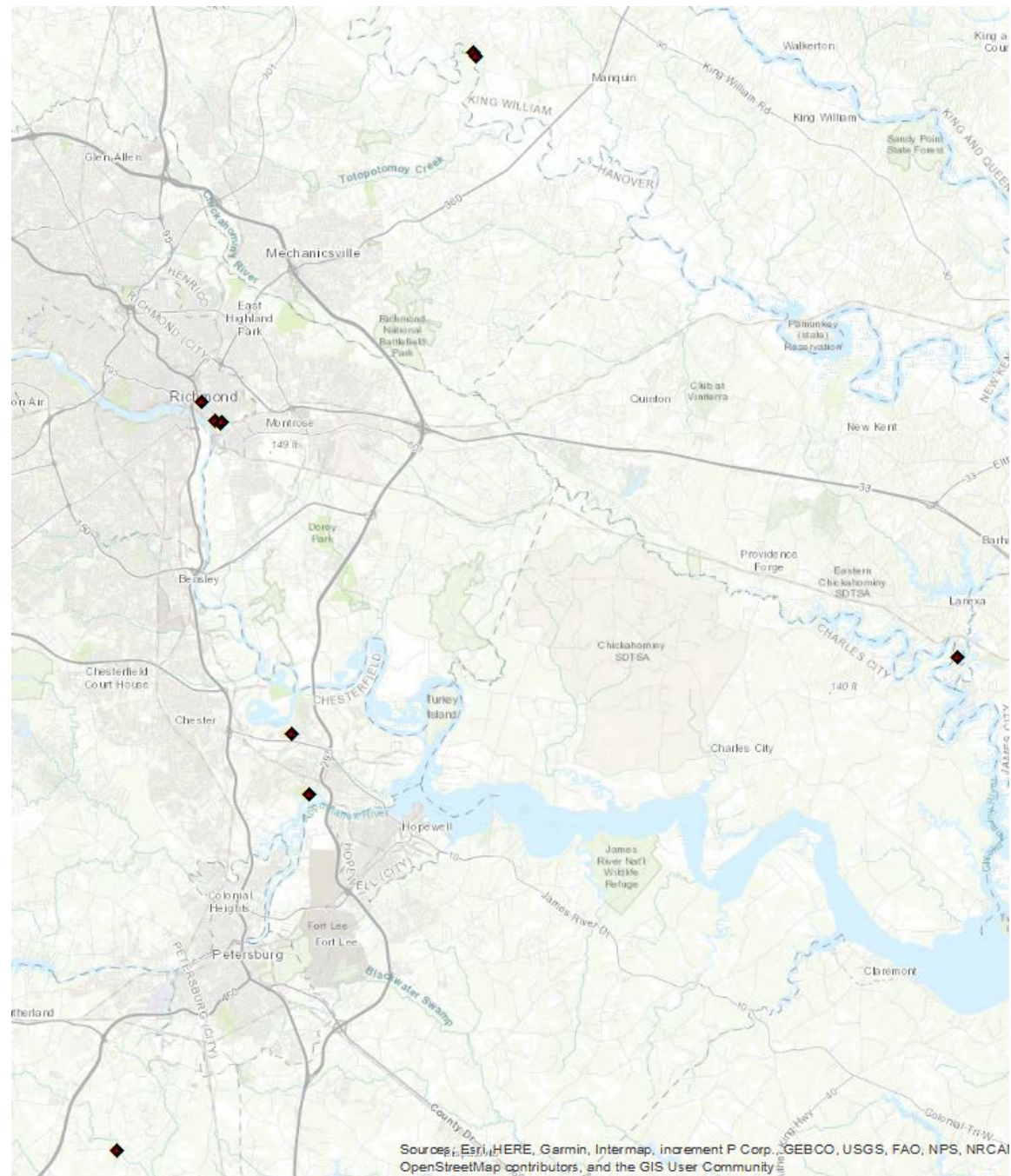
*Orange = moderate potential*

*Yellow = moderate to low potential*

*Green = low potential*



# Mass Movement – Landslides Reported to VDMME



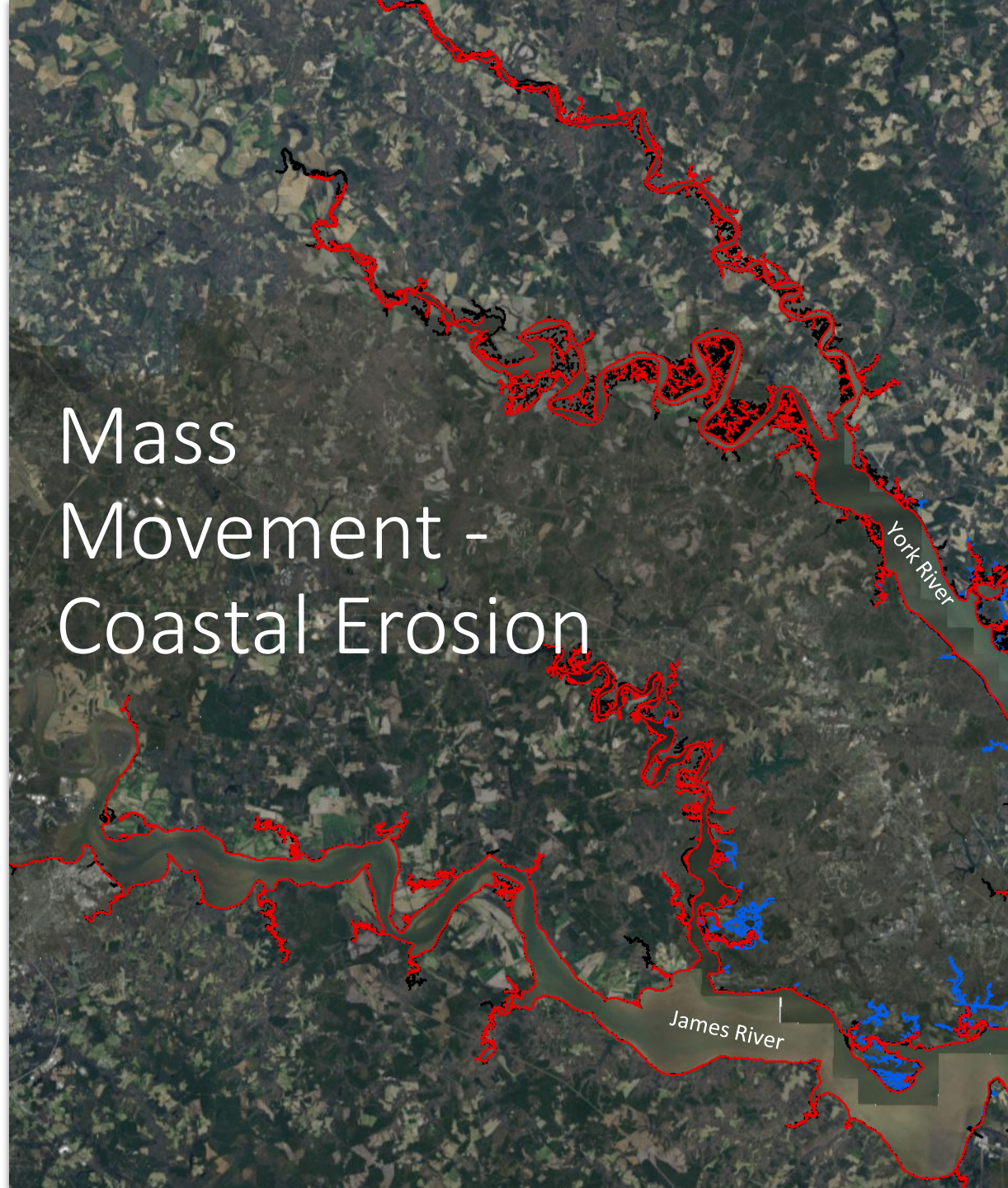




# Mass Movement - Coastal Erosion

Map viewer online can be used  
to zoom in on areas of interest  
at:

[https://www.vims.edu/research/  
departments/physical/programs/  
ssp/shoreline\\_evolution/gis\\_ma  
ps/index.php](https://www.vims.edu/research/departments/physical/programs/ssp/shoreline_evolution/gis_maps/index.php)

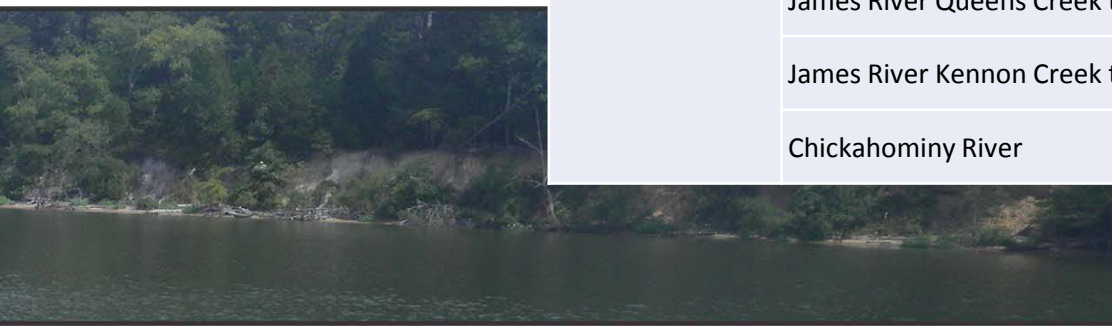


# Rate of Coastal Shoreline Change (1937 – 2009)

Compiled from VIMS Shoreline Management Plans

Jurisdiction	Reach Name	Average End Point Rate of Change (ft/yr)	Category
Prince George County	Reach 1: Appomattox River – Harrison Creek to James River	-0.4	Very Low Erosion
	Reach 2: James River – City Point to Coggins Point	0.0	Very Low Accretion
	Reach 3: James River – Coggins Point to Windmill Point	-0.1	Very Low Erosion
	Reach 4: James River – Windmill Point to Kennon Marsh	-0.4	Very Low Erosion
	Reach 5: James River – Kennon Marsh to Upper Chippokes Creek	-0.4	Very Low Erosion
	Reach 6: Upper Chippokes Creek	-0.8	Very Low Erosion
Charles City County	James River Turkey Island Creek to Epps Island	-0.1	Very Low Erosion
	James River Epps Island to Herring Creek	-0.3	Very Low Erosion
	Herring Creek	-0.4	Very Low Erosion
	James River Herring Creek to Queens Creek	-0.5	Very Low Erosion
	Queens Creek	-0.3	Very Low Erosion
	James River Queens Creek to Kennon Creek	-0.4	Very Low Erosion
	James River Kennon Creek to Tomahund Creek	-0.1	Very Low Erosion
	Chickahominy River	-0.6	Very Low Erosion

James River, Reach 4



# Radon Exposure

## What is Radon?

- Colorless, odorless naturally-occurring gas
- Forms by radioactive decay of uranium, thorium or radium
- In Virginia, found in mostly granite & shales (or associated soils & groundwater)

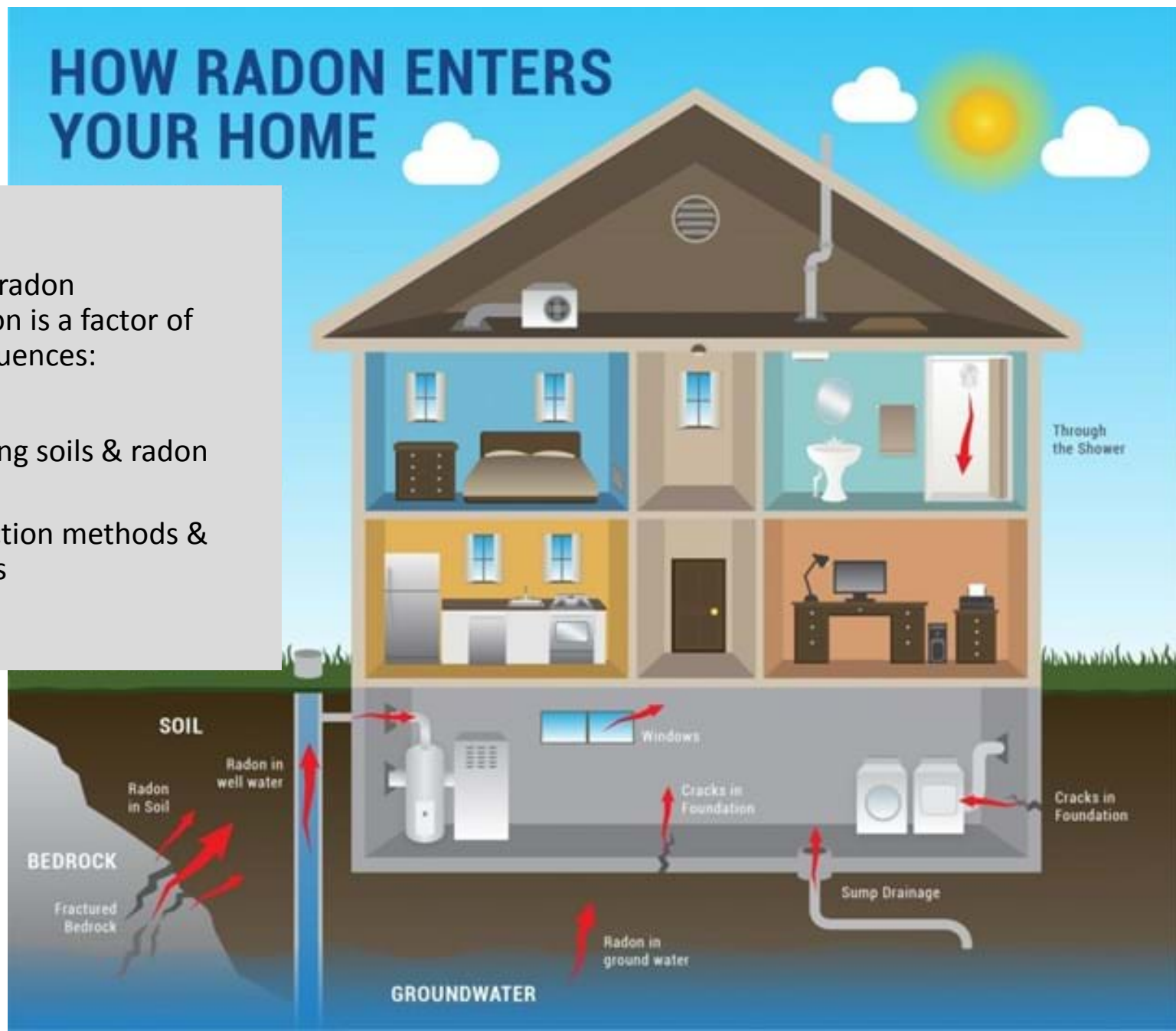




# HOW RADON ENTERS YOUR HOME

A building's radon concentration is a factor of invisible influences:

- Location
- Underlying soils & radon content
- Construction methods & materials

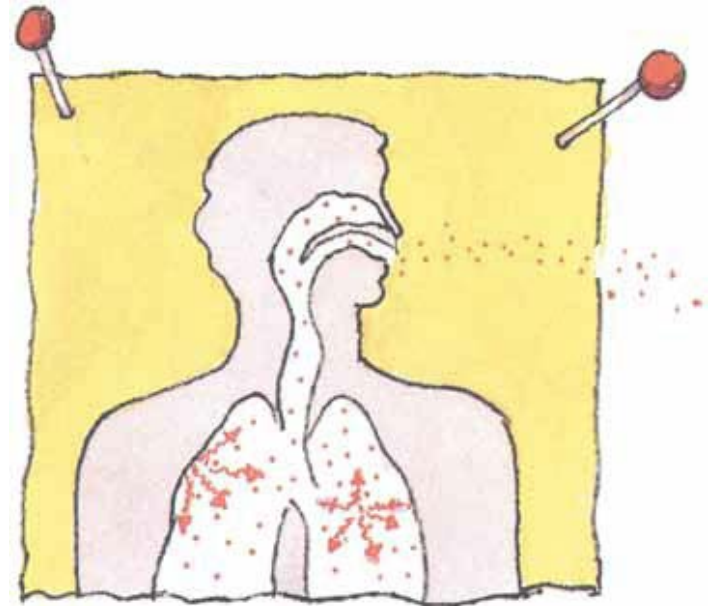
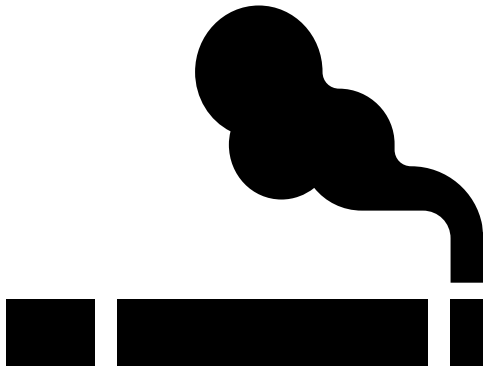




# Radon Exposure

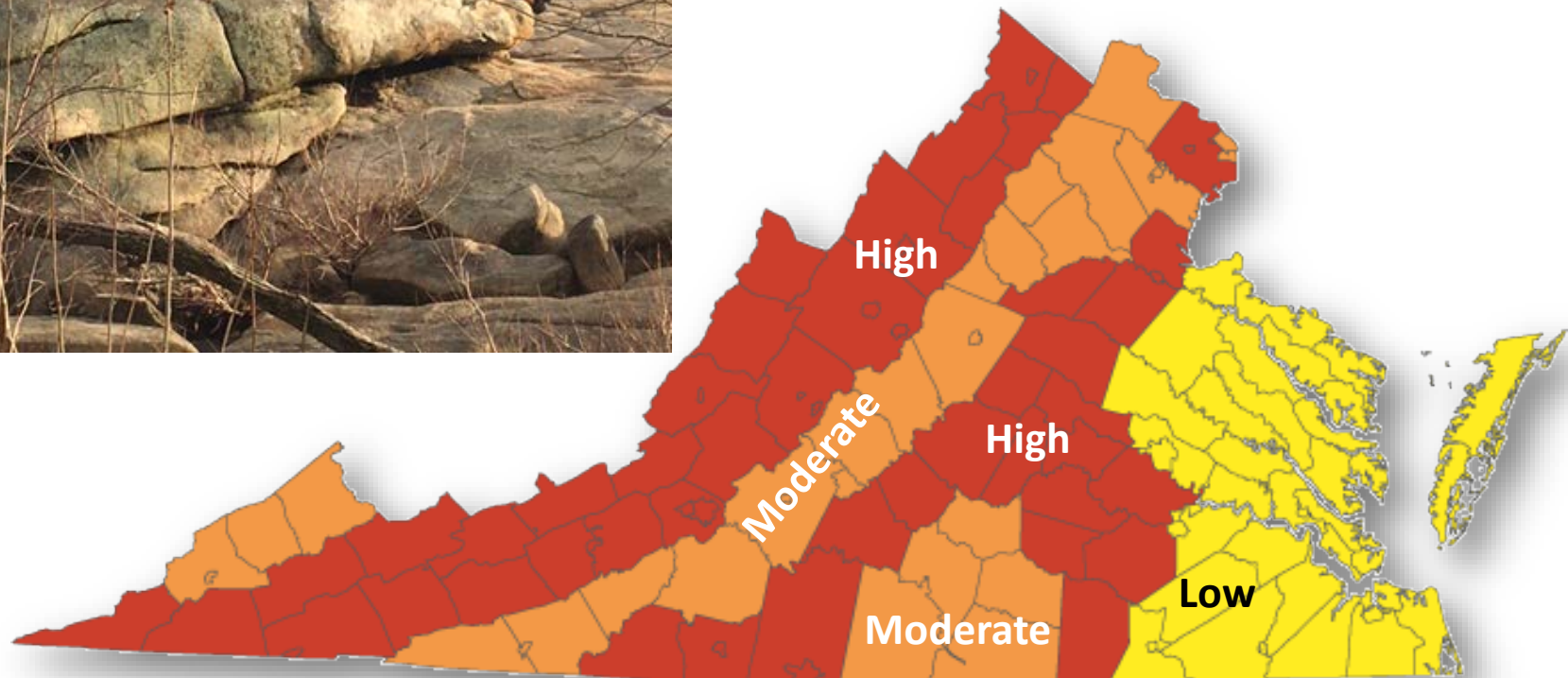
A person's exposure is a factor of:

- How much time is spent in the building and where
- Smoking habits
- Heating & cooling methods
- Combinations of these factors

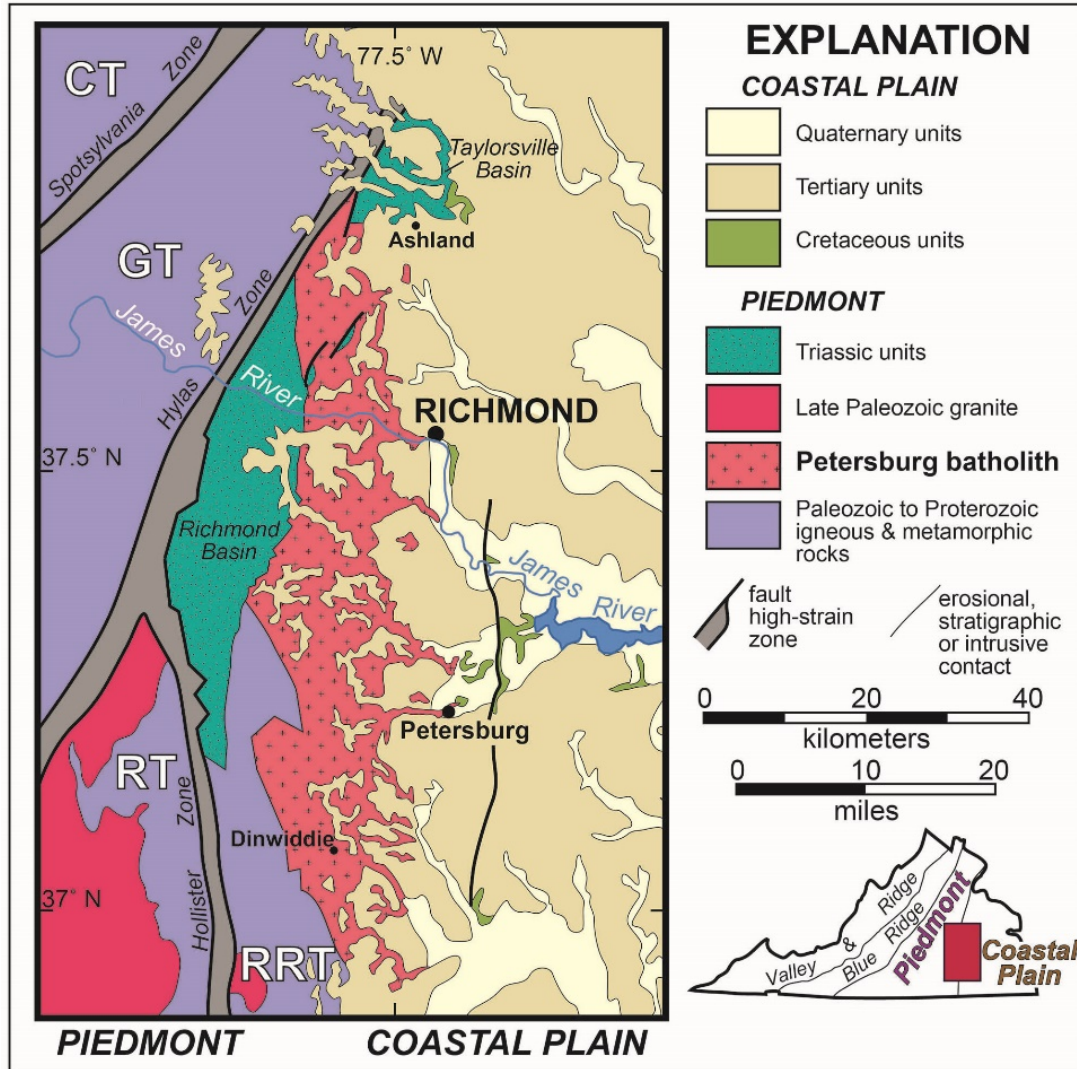


# Radon Exposure

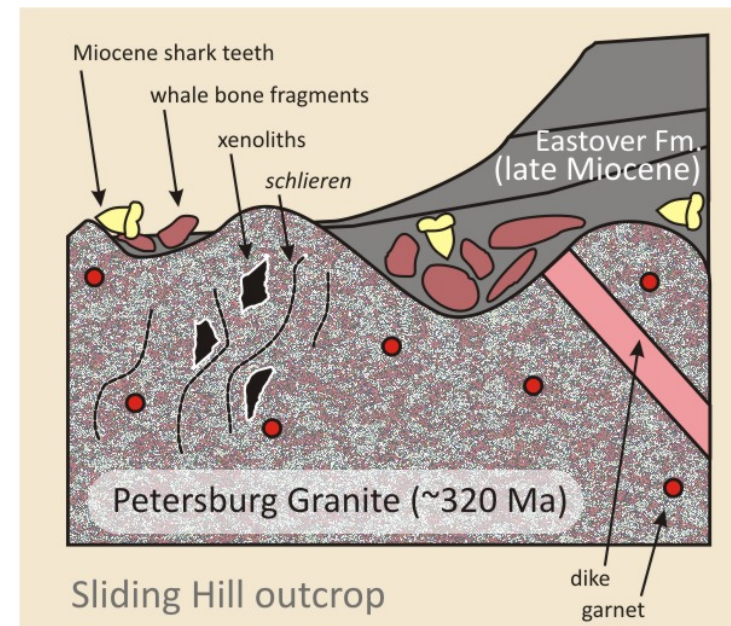
U.S. EPA Map of Radon Zones in Virginia, 1993



# Radon Exposure



The Petersburg Granite was selected for graduate study by student at W&M as a possible source of radon. The mineral zircon was found in the granite, which can have uranium and thorium incorporated into its crystal structure.



# Damages & Frequency

Hazard	NCEI Annual Frequency	NCEI Annualized Damages	Other Damages & Notes
Floods	9.59	\$99,000	\$3,877,630,847 100-year flood damages (HAZUS)
Tropical Storms/Wind	1.37	\$241,300	\$9.7 million annual damage (HAZUS)
Tornadoes	1.97	\$1,488,825	
Thunderstorms	3.22	\$17,601	
Winter Storms	0.06-0.75	\$9,324	
<u>Drought</u>	<u>0.40</u>	<u>\$1,765,040</u>	
Extreme Heat	0.01	\$0	
Wildfire	n/a	n/a	\$231,896 annual damage (VDOF) 96.4 events per year
Mass Movements	n/a	n/a	
Radon Exposure	n/a	n/a	more research needed
Pandemic Flu	n/a	n/a	.05 events per year
Impoundment Failure	n/a	n/a	
Earthquake	n/a	n/a	\$4,161,000 annual (HAZUS)

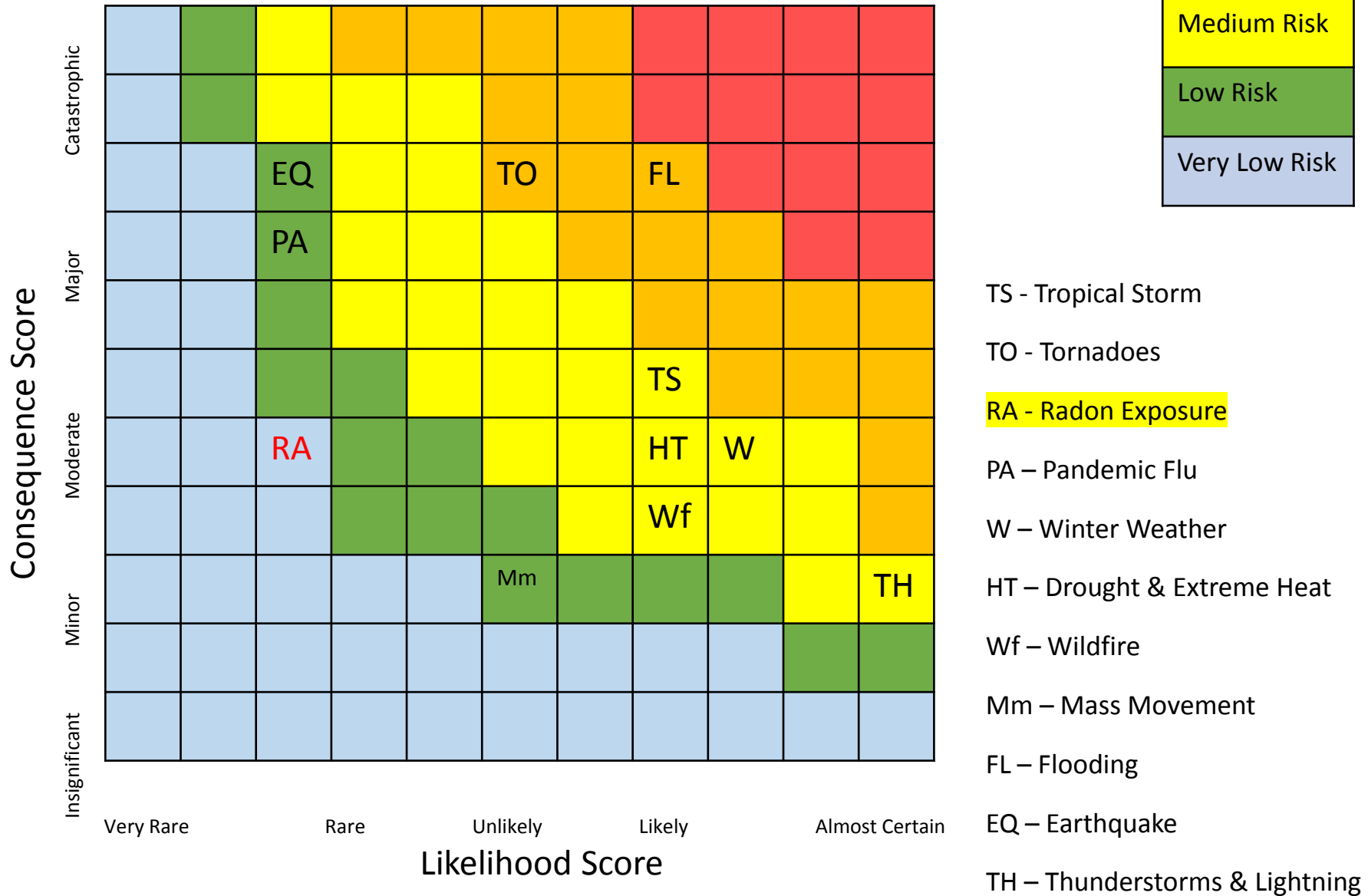


# Re-ranking the Hazards for 2022

## 2017 Hazard Mitigation Plan

Hazard Category	Rank Score	Rank	Rank Category
Hurricanes	2.75	1	Significant
Tornado	2.73	2	Significant
Thunderstorm	2.34	3	Moderate
Flood	2.24	4	Moderate
Winter	2.08	5	Moderate
Drought	1.81	6	Limited
Wind	1.79	7	Limited
Wildfire	1.13	8	Limited
Earthquake	1.13	8	Limited
Landslide	1.13	8	Limited
Karst	1.13	8	Limited
Mass Evacuation	0.63	12	Limited

# Re-ranking the Hazards for 2022



# Next Steps and Schedule

- Hazard Mitigation Planning Committee Work Session #2, late summer 2021
  - Review Capability Assessment
  - Review Goals & Objectives
- Hazard Mitigation Planning Committee Work Session #3, late summer 2021
  - Review and rewrite Mitigation Actions
- Public Meetings on Final Plan, Fall 2021
- Final FEMA approved draft target, April 2022
- Adoption by communities by August 2022





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## Questions and Comments

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