

A close-up photograph of several bright green, serrated leaves on a thin brown branch, set against a blurred background of more green foliage and a bright sky. The leaves are the primary visual element, occupying the upper and middle portions of the frame.

# **Development of a Municipal Vulnerability Index**

Final Tool Presentation  
February 20, 2024



Welcome

# Agenda

- Welcome and Introductions (5:00pm - 5:15pm)
- Background and Purpose (5:15pm - 5:25pm)
- Tool Development Process (5:25pm - 5:40pm)
- Tool Walk-Through and Use Cases (5:40pm - 6:10pm)
- Questions (6:10pm - 6:30pm)

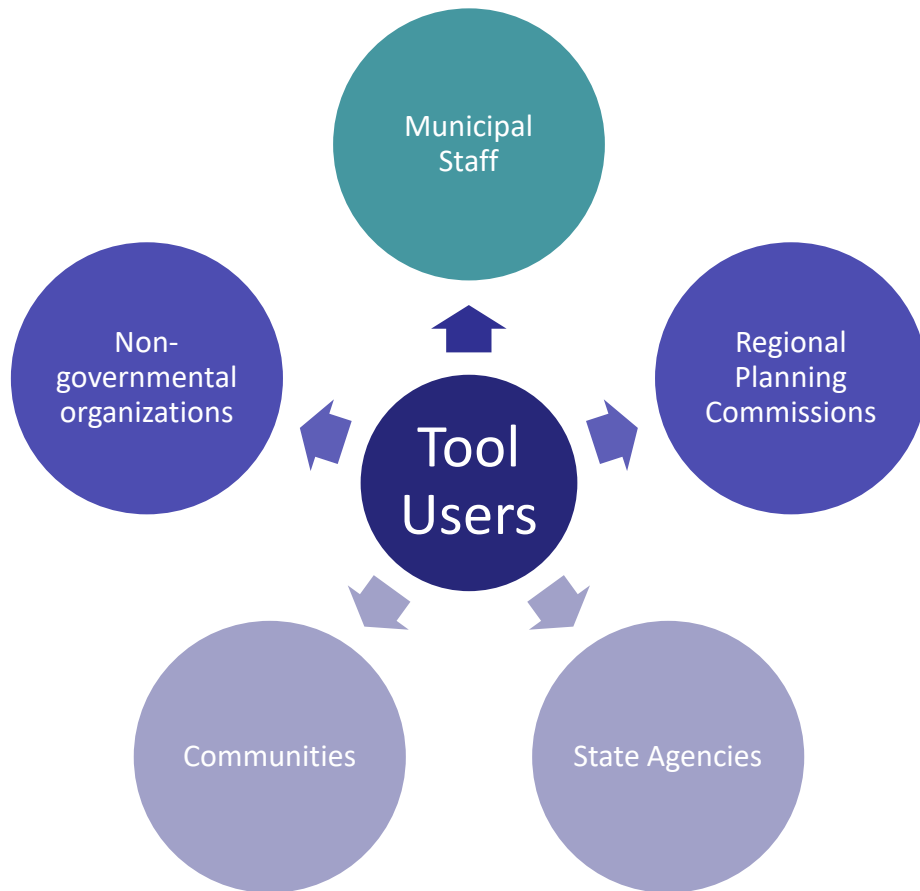
# Background and Purpose

# Background and Purpose



- Vermont's 2020 The Global Warming Solutions Act requires the Climate Action Plan include strategies to:
  - Reduce greenhouse gas emissions
  - Help communities prepare for the impacts of climate change
  - Consider opportunities for carbon sequestration
- Mandates the development of a Municipal Vulnerability Index (MVI)
  - Indicate municipalities' vulnerability to climate change based on a range of social, economic, and biophysical factors

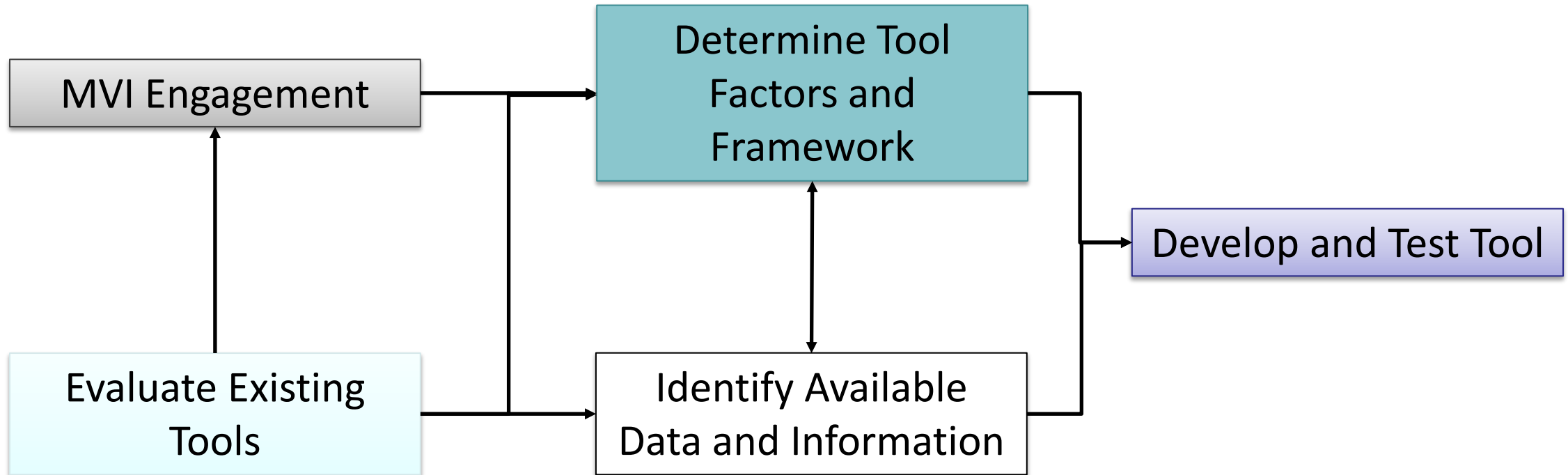
# Background and Purpose



- Updateable, web-based geospatial mapping tool
- Inform climate adaptation and hazard mitigation planning and decision-making
- Provides visual understanding of where current vulnerabilities exist and the factors that contribute to those vulnerabilities.

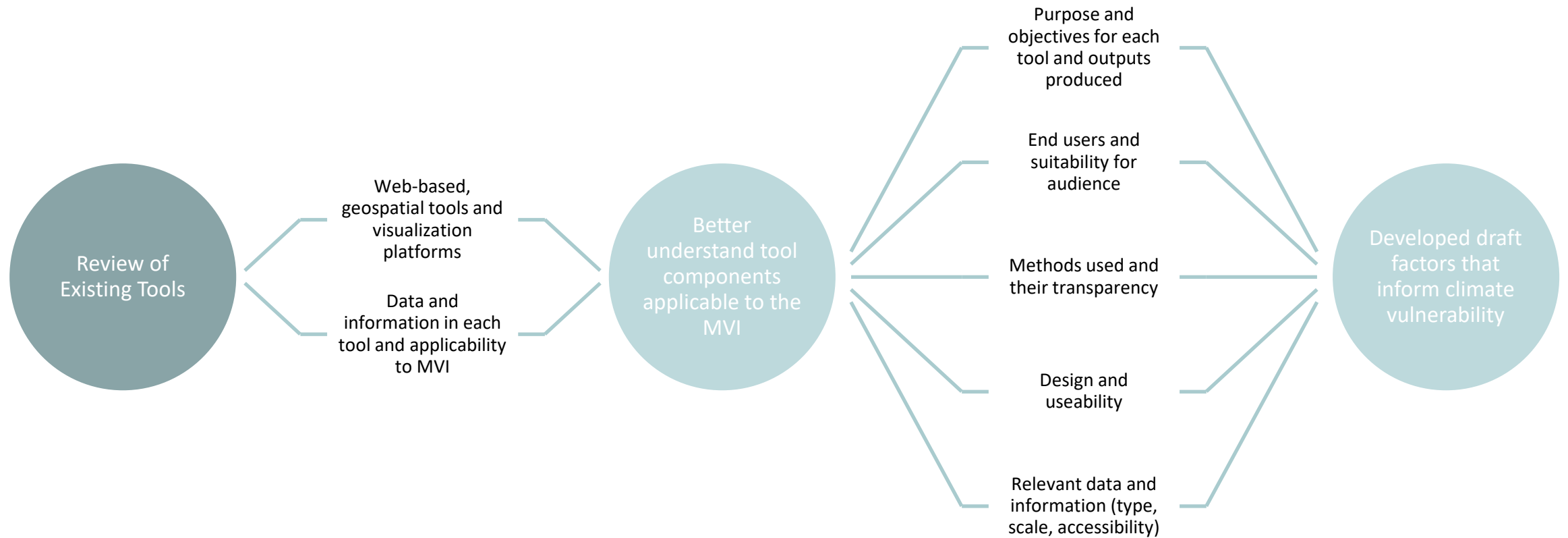
# Tool Development

# Tool Development Steps

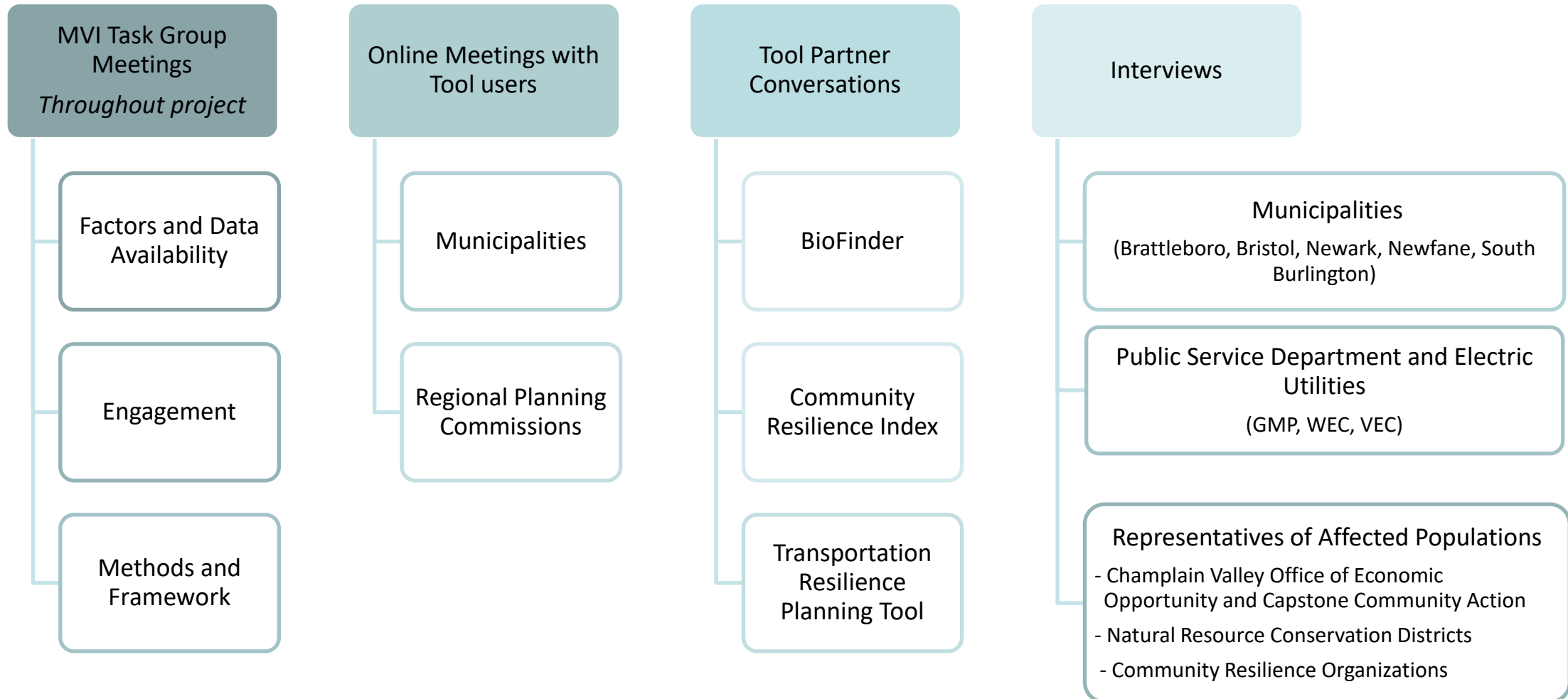




# Evaluation of Existing Tools



# Engagement



# Engagement: Information Learned

- Refine and prioritize climate vulnerability factors
- Determine best available data and information for factors
- Inform tool use, features, functions
- Develop considerations for tool implementation (e.g., staff capacity, training)

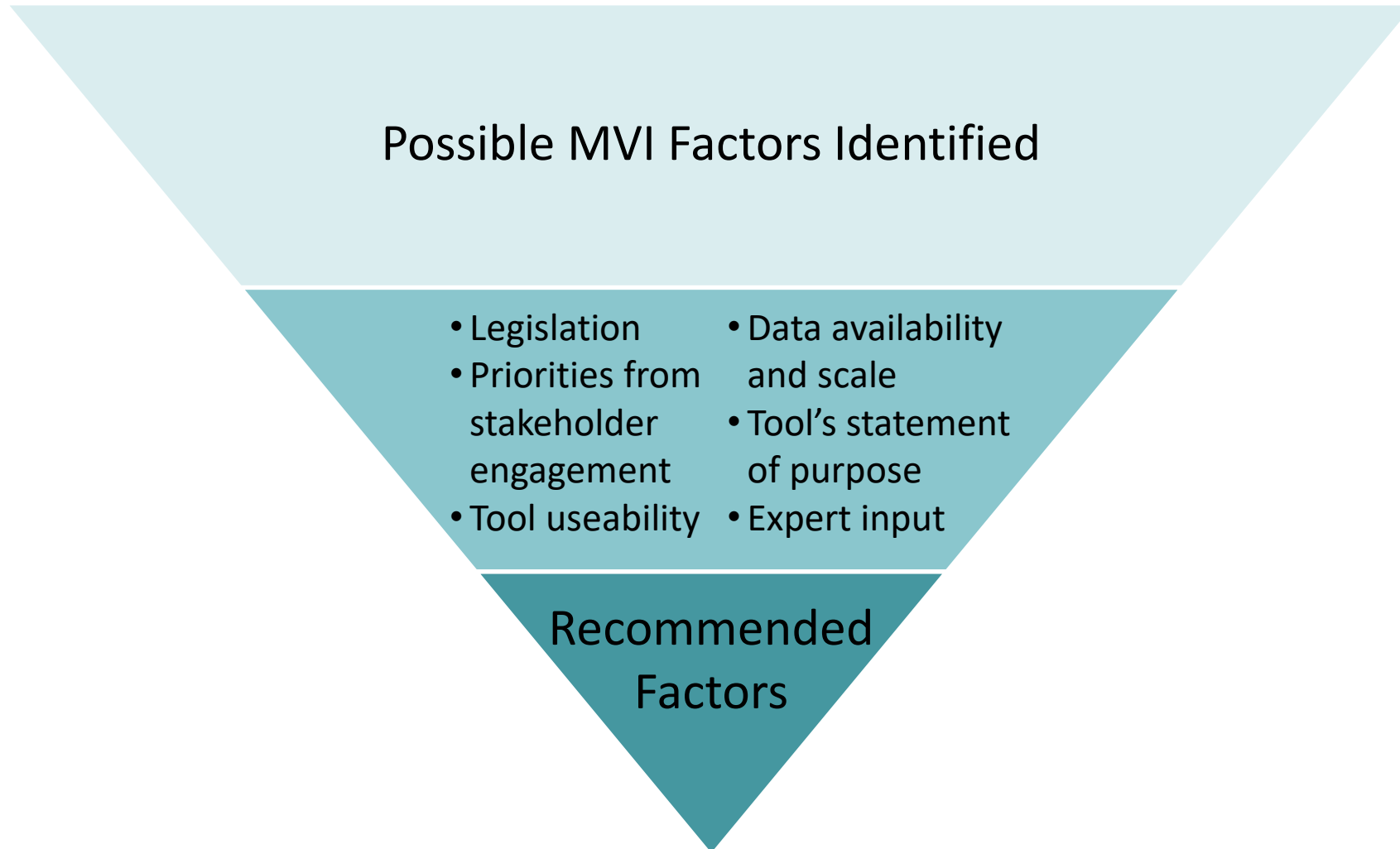
# Climate Vulnerability Domains and Factors

Social	Community	Economic and Jobs	Built and Physical Environment	Infrastructure	Natural Environment	Hazards
<ul style="list-style-type: none"><li>• Population</li><li>• Income</li><li>• Elderly residents</li><li>• Children</li><li>• People with disabilities</li><li>• Single parent households</li><li>• Linguistic isolation</li><li>• No vehicle</li><li>• No internet</li><li>• Rentership</li><li>• Adult Asthma</li><li>• Ethnicity</li><li>• Energy and transportation burden</li><li>• Hosing cost burden</li><li>• Access to healthy foods</li></ul>	<ul style="list-style-type: none"><li>• Limited municipal staff capacity</li><li>• Emergency Relief and Assistance Fund (ERAF) rates</li><li>• Designated areas</li><li>• Plan and regulation status</li><li>• Historic districts</li></ul>	<ul style="list-style-type: none"><li>• Outdoor worker</li><li>• Agriculture</li><li>• Tourism Industry</li></ul>	<ul style="list-style-type: none"><li>• Emergency services</li><li>• Mobile homes</li><li>• Other household types</li><li>• Other site types</li><li>• Housing age</li><li>• Critical assets</li></ul>	<ul style="list-style-type: none"><li>• Roads, bridges, and culverts</li><li>• Airports</li><li>• Public transit</li><li>• Power lines</li><li>• Drinking water infrastructure</li><li>• Wastewater infrastructure</li><li>• Electric substations</li><li>• Power plants</li><li>• Impervious surfaces</li></ul>	<ul style="list-style-type: none"><li>• Municipal tree inventory</li><li>• Toxic or contaminated sites</li><li>• Conserved and protected lands</li><li>• Community and species-scale priorities</li><li>• Landscape-scale priorities</li></ul>	<ul style="list-style-type: none"><li>• Drought</li><li>• Extreme precipitation</li><li>• Fluvial Erosion-river corridors</li><li>• Hail</li><li>• Ice storms</li><li>• Invasive species</li><li>• Inundation flooding (FEMA)</li><li>• Inundation flooding (Lake Champlain)</li><li>• Landslides</li><li>• Snow storms</li><li>• High temperatures</li><li>• Low temperatures</li><li>• Wildlife</li><li>• Wind</li></ul>

# Identify Data and Information

- Currently available data to measure factors
  - Data used by other, relevant tools
  - Sources suggested by Task Group and others engaged
- Downscaled to be meaningful at municipal level
  - County sub-division level
- Vermont-specific, where possible
- Relevant vulnerability analyses already conducted (e.g., transportation resilience planning, mobile homes in flood plains)
- Non-spatial data included as written narratives

# Finalizing Tool Factors



# Methods and Framework

- Flexible user-guided approach
- Geospatial data layers represent factors
- Outputs layered geospatial information rather than single vulnerability metric or score
- Users can select a location and conduct their own assessment of vulnerability for each hazard
- Indicates where a municipality is above the State threshold for non-geospatial factors

# Methods and Framework (2)

- Integrates existing datasets
- Underlying data for each of the factors and hazards is accessible to provide more details
- Tool designed to be updateable



# Flexible, User-Guided Approach: Benefits

- More tailored to a multi-hazard, multi-asset tool
- Can help drive municipal action by providing specific locations and details of vulnerabilities
- Will not mask high consequence vulnerabilities within a single hazard or asset
- Can be easier to use in plan development and project review
- Simplifies changes to data and outputs in future updates

# Flexible, User-Guided Approach: Limitations

- Requires users to select hazards, domains, and factors of interest rather than receiving a single output or score for each municipality
- User understanding of information is more important to determine which areas to explore to identify the highest vulnerability
- Does not provide an opportunity to compare vulnerability and resilience across municipalities by a single score

# Tool Testing

- Questionnaire implemented using Qualtrics online survey software platform
- 11 of 29 invited individuals participated (38%)
- Participants were given two written scenario exercises to practice using the tool
- Asked a series of 9 core questions to elicit feedback on tool:
  - Aesthetics
  - Functions/Features
  - Ease of Use
  - Suggested Improvements
- Feedback incorporated or captured in final report for future iterations

# Tool Walk-Through and Use Cases



# Vermont Municipal Vulnerability Index

Find address or place

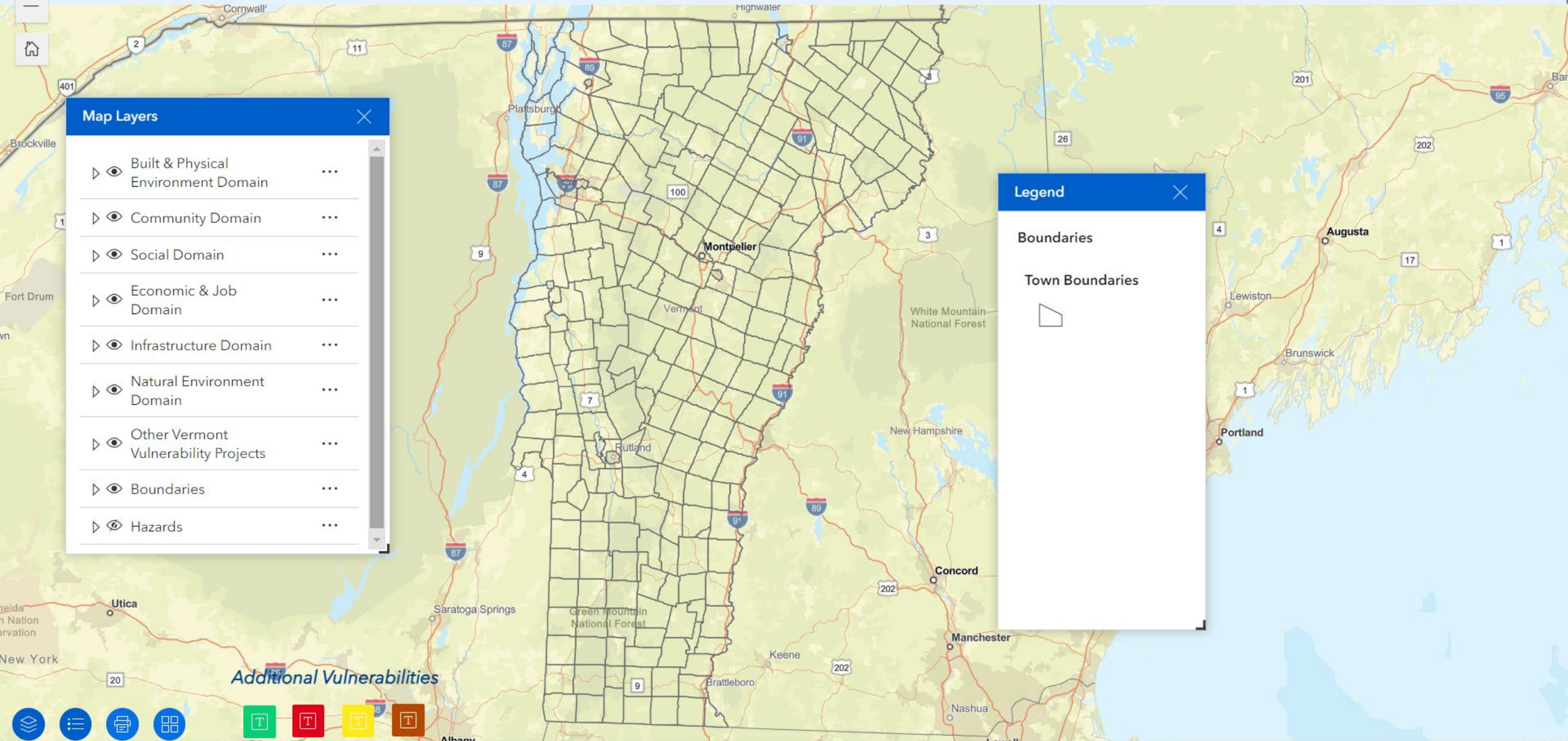
**Map Layers**

- Built & Physical Environment Domain
- Community Domain
- Social Domain
- Economic & Job Domain
- Infrastructure Domain
- Natural Environment Domain
- Other Vermont Vulnerability Projects
- Boundaries
- Hazards

**Legend**

**Boundaries**

Town Boundaries



Additional Vulnerabilities





# Vermont Municipal Vulnerability Index

Find address or place



## Map Layers

- ▶  Built & Physical Environment Domain ...
- ▶  Community Domain ...
- ▶  Social Domain ...
- ▶  Economic & Job Domain ...
- ▶  Infrastructure Domain ...
- ▶  Natural Environment Domain ...
- ▶  Other Vermont Vulnerability Projects ...
- ▶  Boundaries ...
- ▶  Hazards ...

## Legend

### Boundaries

#### Town Boundaries



## Basemap Gallery



Light Gray Canvas



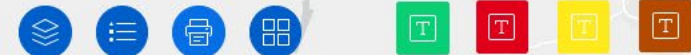
Mid-Century Map



Modern Antique Map

NEW YORK

Additional Vulnerabilities





# Vermont Municipal Vulnerability Index

Find address or place



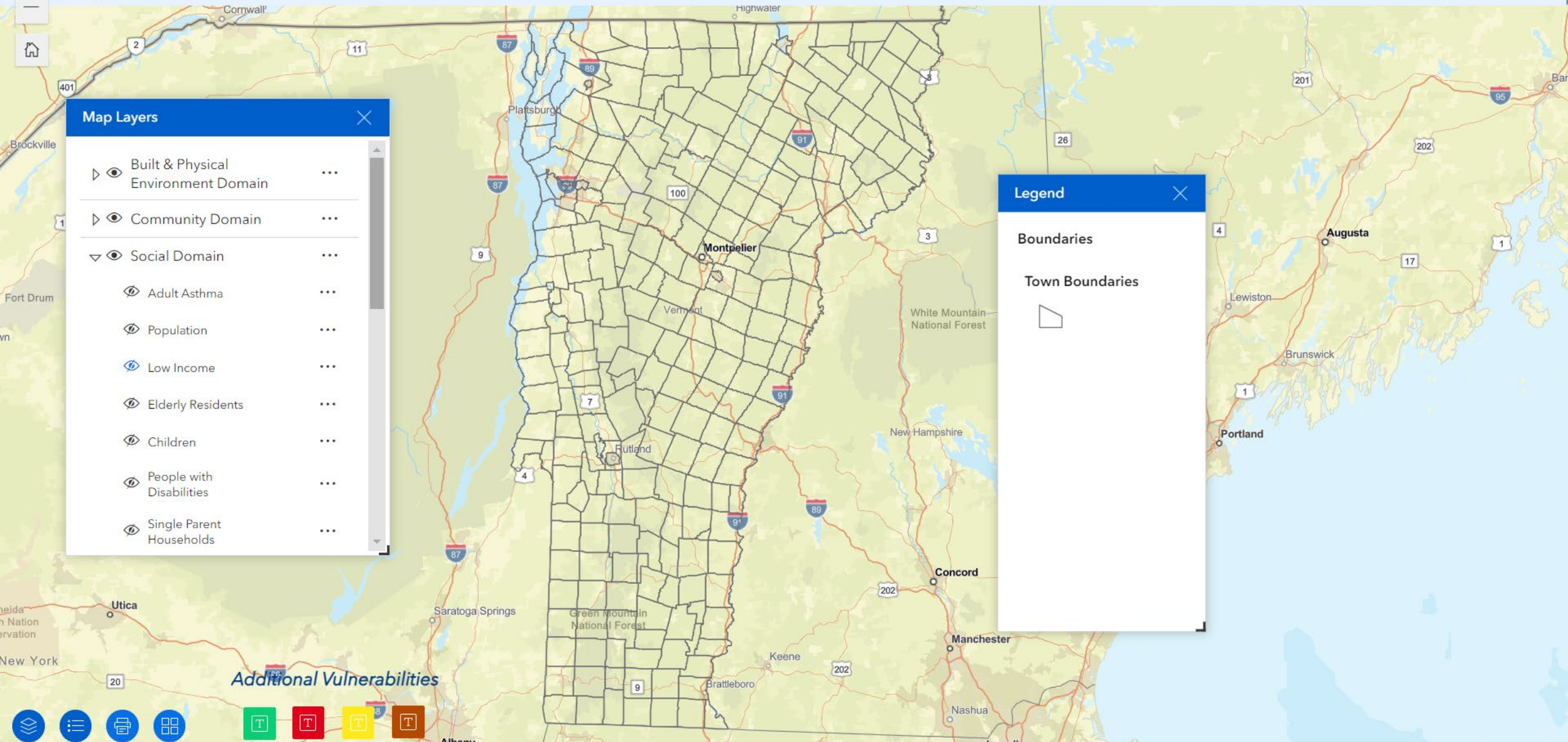
### Map Layers

- Built & Physical Environment Domain ...
- Community Domain ...
- Social Domain ...
  - Adult Asthma ...
  - Population ...
  - Low Income ...
  - Elderly Residents ...
  - Children ...
  - People with Disabilities ...
  - Single Parent Households ...

### Legend

**Boundaries**

**Town Boundaries**



Additional Vulnerabilities



# Vermont Municipal Vulnerability Index

Find address or place



**Map Layers**

- Built & Physical Environment Domain
- Community Domain
- Social Domain
  - Adult Asthma
  - Population
  - Low Income
  - Elderly Residents
  - Children
  - People with Disabilities
  - Single Parent Households

**Legend**

**Social Domain**

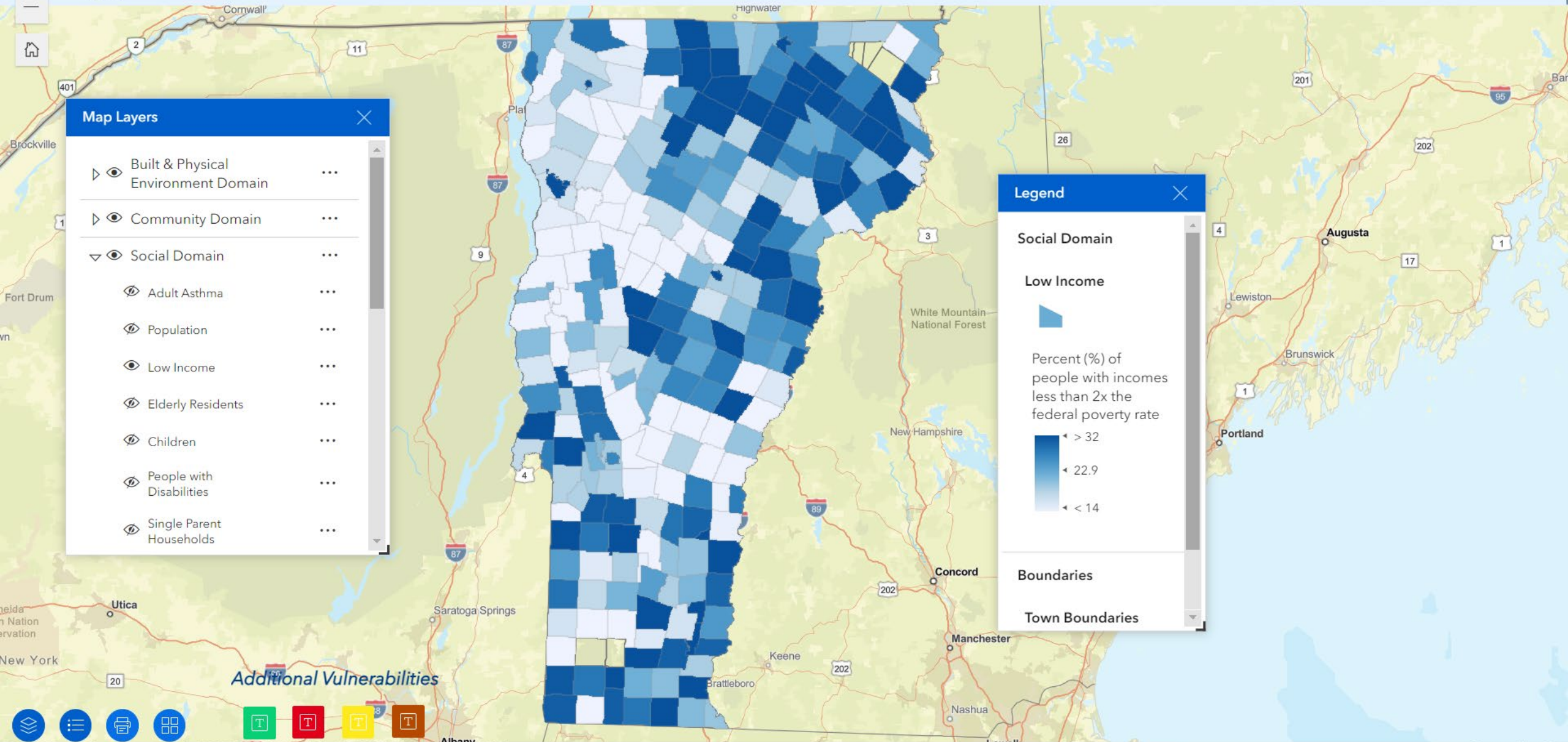
**Low Income**

Percent (%) of people with incomes less than 2x the federal poverty rate

- < 32
- < 22.9
- < 14

**Boundaries**

**Town Boundaries**



Additional Vulnerabilities





# Vermont Municipal Vulnerability Index

Find address or place

**Map Layers**

- ▶ Built & Physical Environment Domain ...
- ▶ Community Domain ...
- ▼ Social Domain ...
  - ▶ Adult Asthma ...
  - ▶ Population ...
  - ▶ Low Income ...
  - ▶ Elderly Residents ...
  - ▶ Children ...
  - ▶ People with Disabilities ...
  - ▶ Single Parent Households ...

**Warren town, Washington County, Vermont**

Zoom to

Low income percentage	32.46%
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Data Source: American Community Survey, U.S. Census Bureau

1 of 2

**Legend**

**Social Domain**

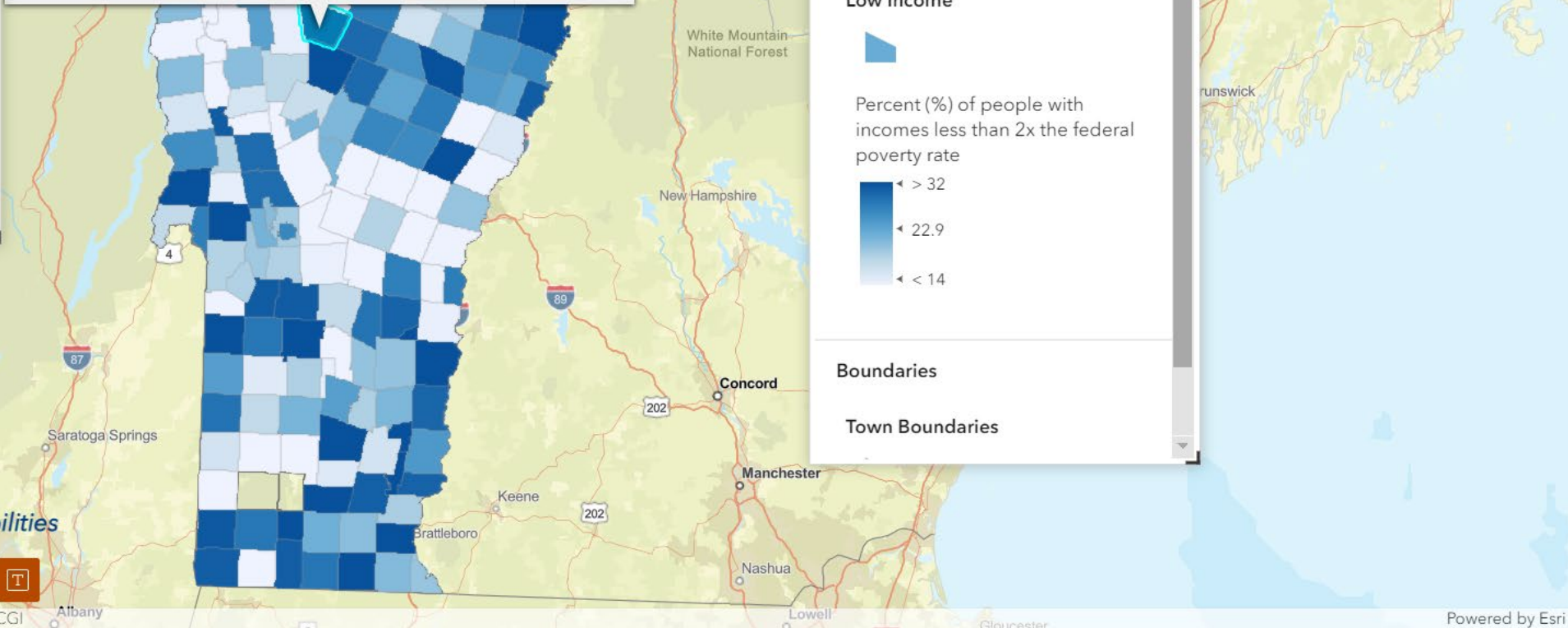
**Low Income**

Percent (%) of people with incomes less than 2x the federal poverty rate

- > 32
- 22.9
- < 14

**Boundaries**

**Town Boundaries**



Additional Vulnerabilities



# Vermont Municipal Vulnerability Index

Find address or place



**Map Layers**

- ▶ Built & Physical Environment Domain
- ▶ Community Domain
- ▼ Social Domain
  - ▶ Adult Asthma
  - ▶ Population
  - ▶ Low Income
- ▲ Increase transparency
- ▼ Decrease transparency
- ⓘ Details
- ↑ Export
  - Export to JSON
  - Export to CSV**
  - Export to GeoJSON
- ▶ Elderly Residents

**Legend**

**Social Domain**

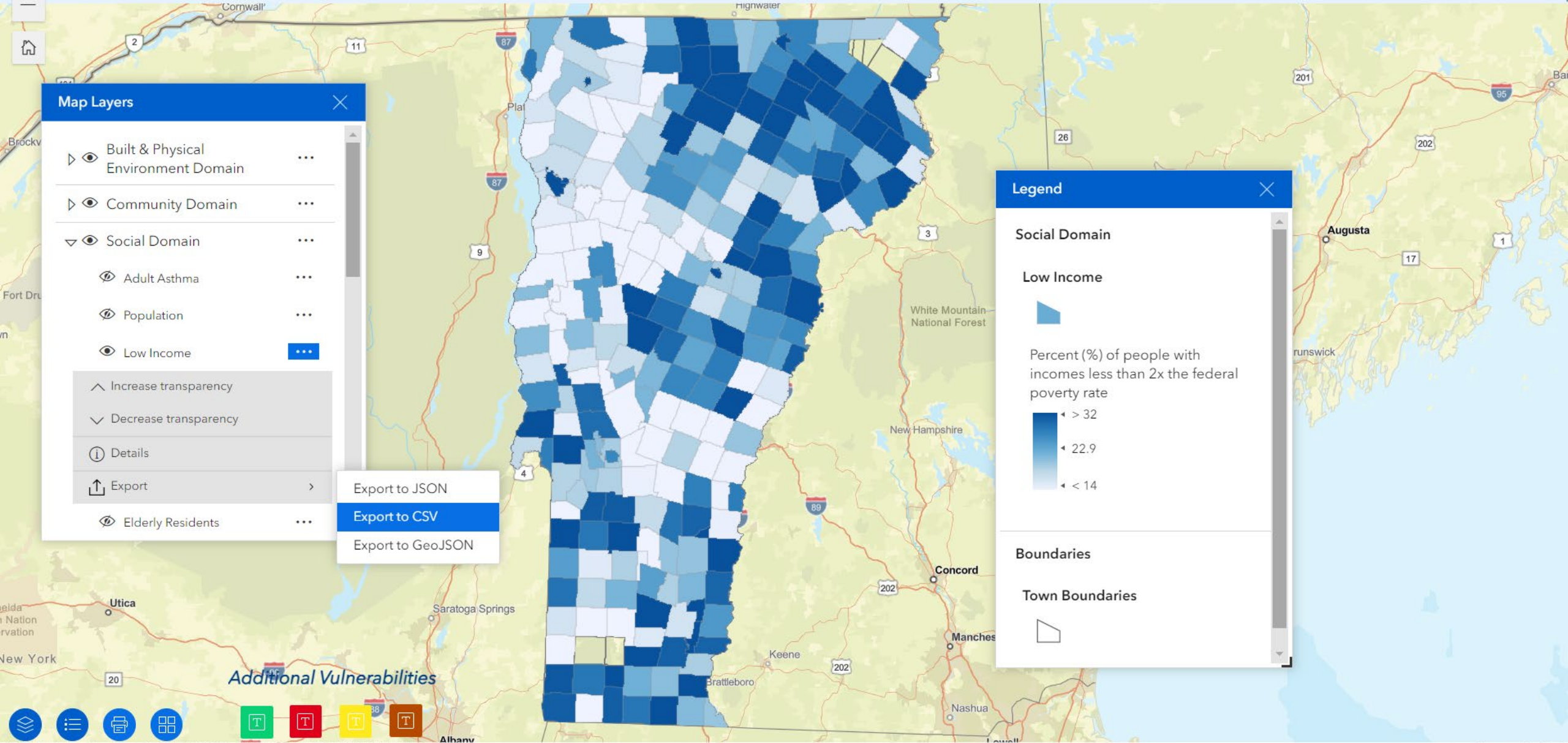
**Low Income**

Percent (%) of people with incomes less than 2x the federal poverty rate

- ▶ > 32
- ◀ 22.9
- ◀ < 14

**Boundaries**

**Town Boundaries**



Additional Vulnerabilities



# Vermont Municipal Vulnerability Index

Find address or place

**Map Layers**

- ▶ Built & Physical Environment Domain ...
- ▶ Community Domain ...
- ▶ Social Domain ...
- ▶ Economic & Job Domain ...
- ▶ Infrastructure Domain ...
- ▶ Natural Environment Domain ...
- ▶ Other Vermont Vulnerability Projects ...
- ▶ Boundaries ...
- ▶ Hazards ...

**Granville town, Addison County, Vermont**

Zoom to

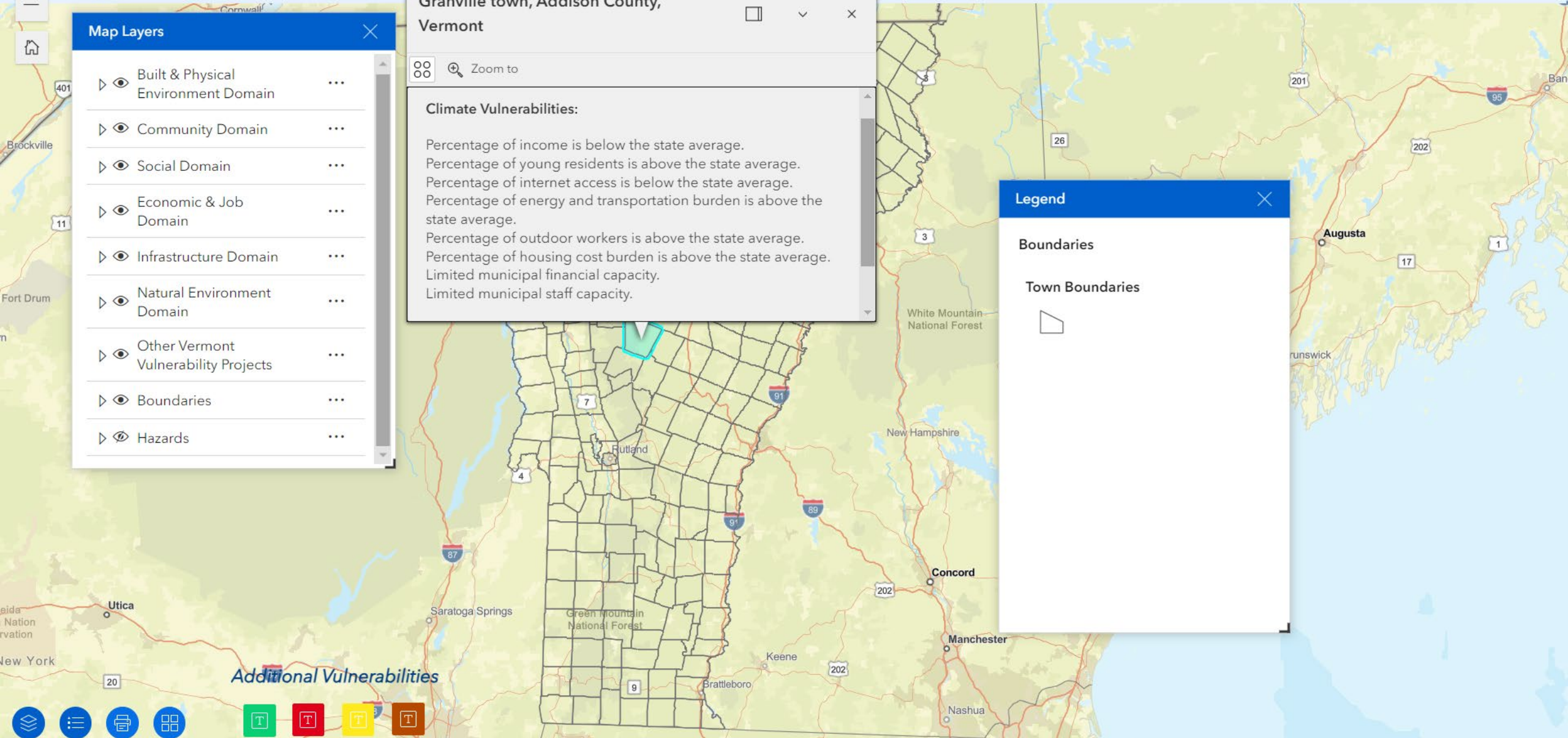
**Climate Vulnerabilities:**

- Percentage of income is below the state average.
- Percentage of young residents is above the state average.
- Percentage of internet access is below the state average.
- Percentage of energy and transportation burden is above the state average.
- Percentage of outdoor workers is above the state average.
- Percentage of housing cost burden is above the state average.
- Limited municipal financial capacity.
- Limited municipal staff capacity.

**Legend**

**Boundaries**

**Town Boundaries**



Additional Vulnerabilities



# Vermont Municipal Vulnerability Index

Find address or place

**Map Layers**

- Infrastructure Domain
- Natural Environment Domain
- Other Vermont Vulnerability Projects
  - Manufactured Homes in Flood Areas
  - Transportation Resilience Planning
  - Tactical Basins
- Rivers
- Bridges
- Culverts
- Roads

**Legend**

**Other Vermont Vulnerability Projects**

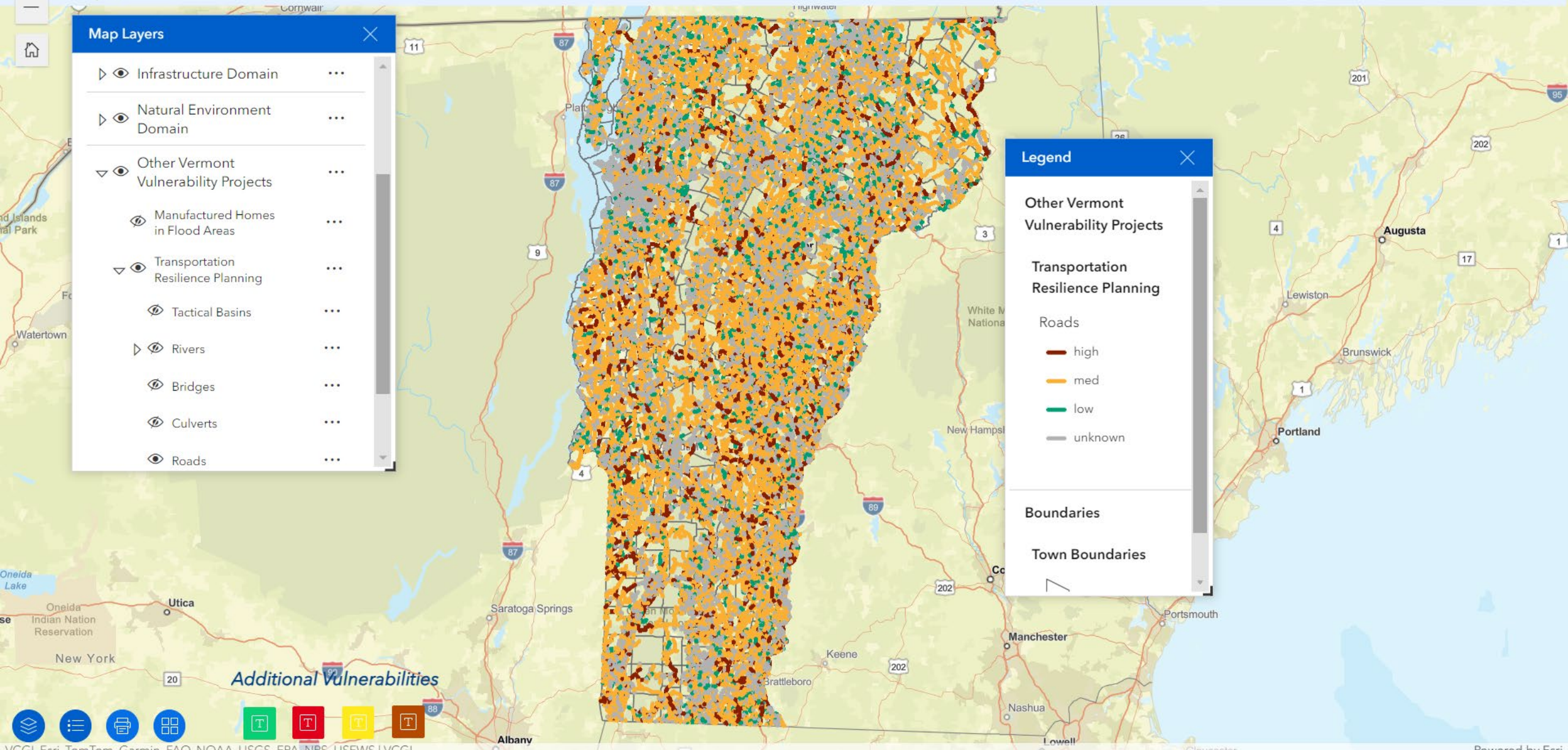
**Transportation Resilience Planning**

Roads

- high
- med
- low
- unknown

**Boundaries**

**Town Boundaries**



Additional Vulnerabilities



# Vermont Municipal Vulnerability Index

Find address or place

### Map Layers

- Vulnerability Projects
- Boundaries
- Hazards
  - Drought
  - Extreme Precipitation Projections (Days with precipitation greater than 2 inches). Data Source: UC San Diego
  - Fluvial Erosion - River Corridors. Data Source: VT DEC
  - Hail
  - Ice Storms

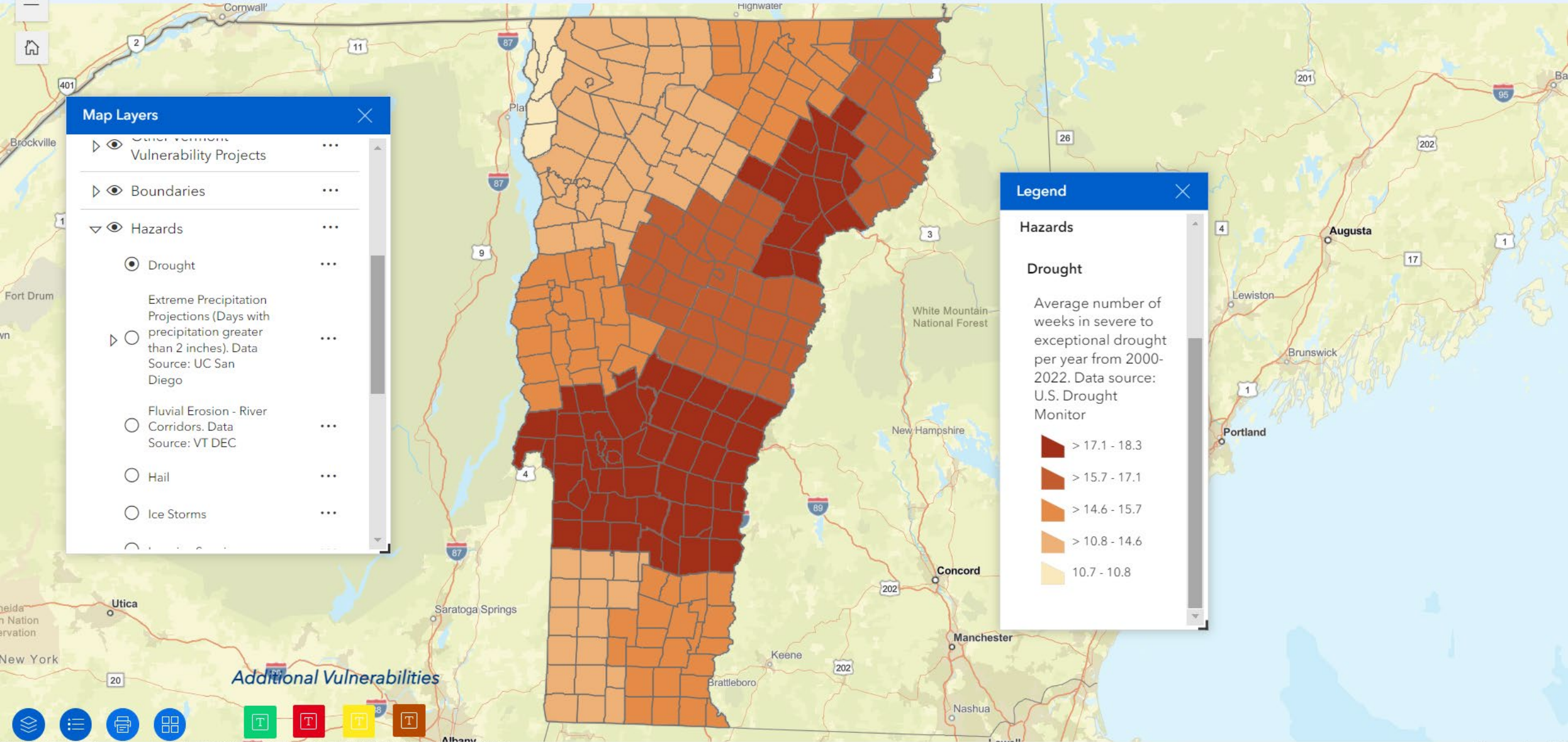
### Legend

#### Hazards

##### Drought

Average number of weeks in severe to exceptional drought per year from 2000-2022. Data source: U.S. Drought Monitor

- > 17.1 - 18.3
- > 15.7 - 17.1
- > 14.6 - 15.7
- > 10.8 - 14.6
- 10.7 - 10.8



Additional Vulnerabilities

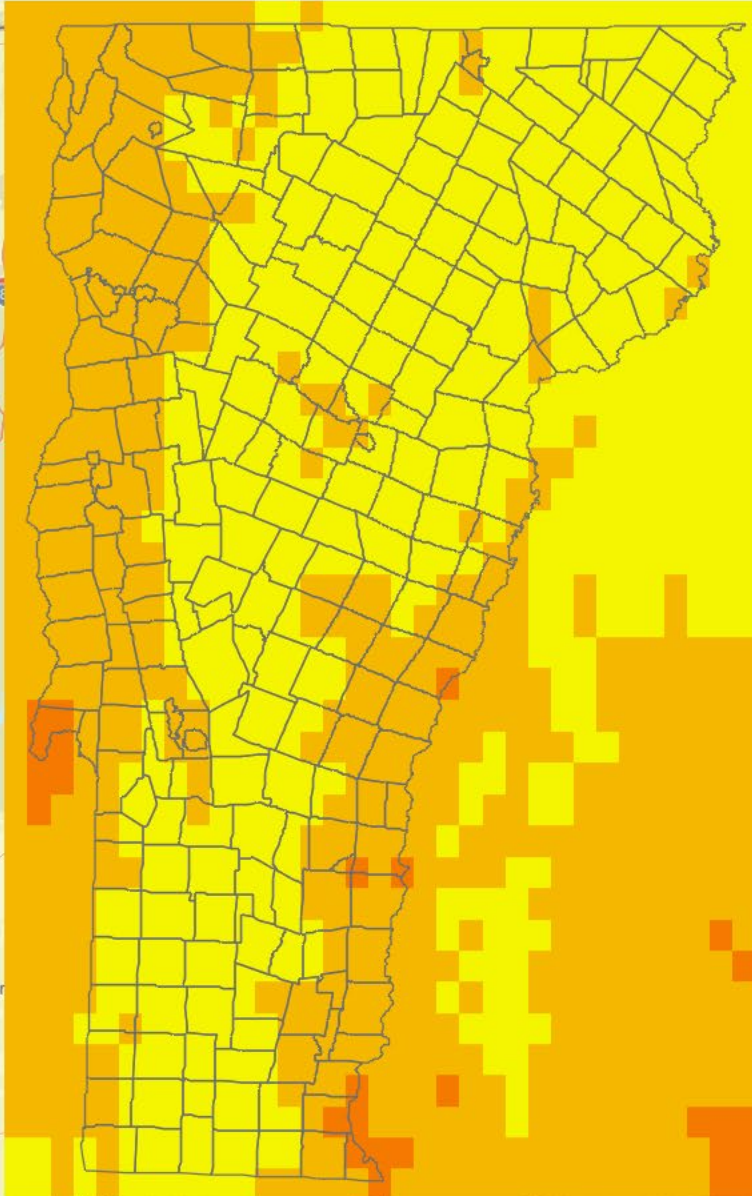


# Vermont Municipal Vulnerability Index

Find address or place

**Map Layers**

- Snow Storms
- High Temperature Projections (Days above 90°F per year). Data Source: UC San Diego
- Middle of the Road (SSP2-4.5): 2015 - 2044
- Middle of the Road (SSP2-4.5): 2045 - 2074
- Middle of the Road (SSP2-4.5): 2075 - 2100
- Fossil-fueled Development (SSP5-8.5): 2015 - 2044



**Legend**

High Temperature Projections (Days above 90°F per year). Data Source: UC San Diego

Middle of the Road (SSP2-4.5): 2045 - 2074

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120

Additional Vulnerabilities

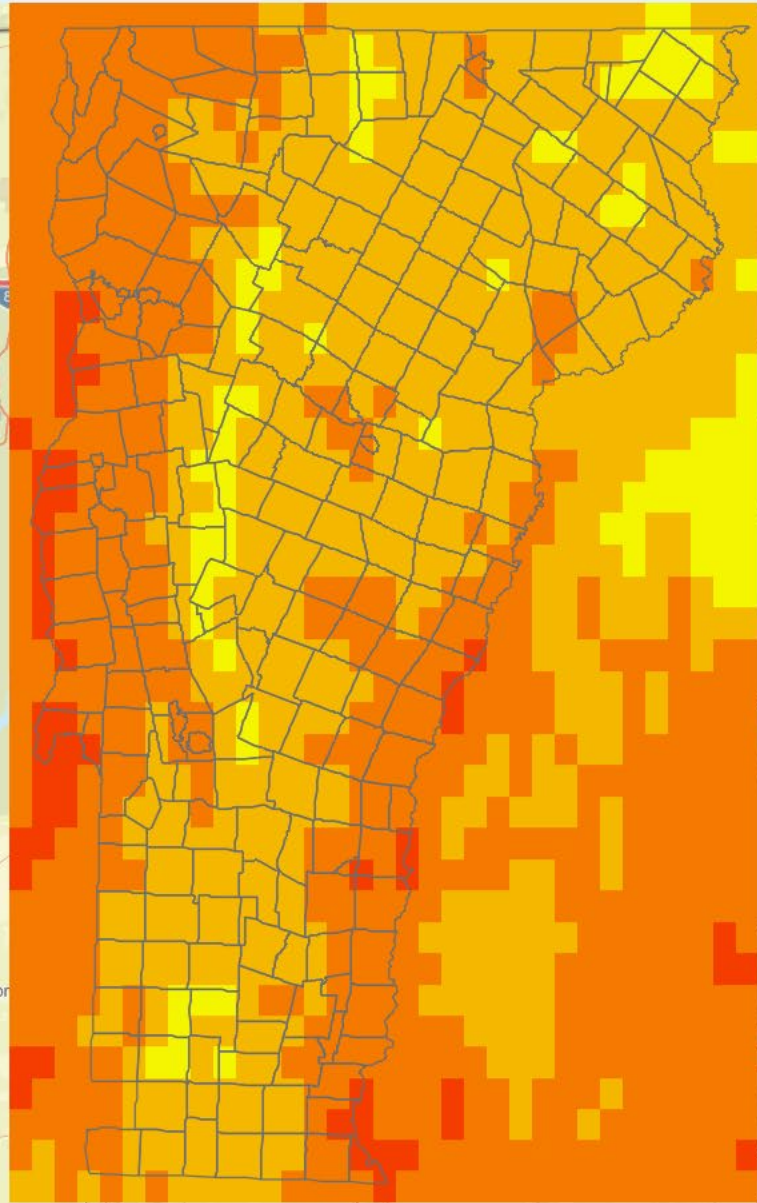


# Vermont Municipal Vulnerability Index

Find address or place

**Map Layers**

- Projections (Days above 90°F per year). Data Source: UC San Diego
- Middle of the Road (SSP2-4.5): 2015 - 2044
- Middle of the Road (SSP2-4.5): 2045 - 2074
- Middle of the Road (SSP2-4.5): 2075 - 2100
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- Fossil-fueled Development (SSP5-8.5): 2045 - 2074



**Legend**

High Temperature Projections (Days above 90°F per year). Data Source: UC San Diego

Fossil-fueled Development (SSP5-8.5): 2045 - 2074

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120

Additional Vulnerabilities



# Vermont Municipal Vulnerability Index

Find address or place

### Map Layers

- Snow Storms
- High Temperature Projections (Days above 90°F per year). Data Source: UC San Diego
- Middle of the Road (SSP2-4.5): 2015 - 2044
- Middle of the Road (SSP2-4.5): 2045 - 2074
- Middle of the Road (SSP2-4.5): 2075 - 2100
- Fossil-fueled Development (SSP5-8.5): 2015 - 2044

### Built & Physical Environment Domain

have a widespread impact across the state. [Vermont Climate Assessment](#)

**Heating and Cooling Centers:** The presence of accessible and well-advertised heating and cooling centers in a community reduces life safety and health risks from extreme heat and extreme cold. It is important to consider location, accessibility, familiarity, and hours of operation when determining the value of heating and cooling centers to a community. Locating them in areas that are familiar to the community, having longer hours of operation, and including other benefits such as internet connections, games, clean water, and other necessities will increase their value and use. [The Role of Cooling Centers in Protecting Vulnerable Individuals from Extreme Heat](#)

### Legend

High Temperature Projections (Days above 90°F per year). Data Source: UC San Diego

Middle of the Road (SSP2-4.5): 2045 - 2074

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120

Additional Vulnerabilities







# Vermont Municipal Vulnerability Index

Burlington, VT, USA

Search result

Burlington, Vermont

## Map Layers

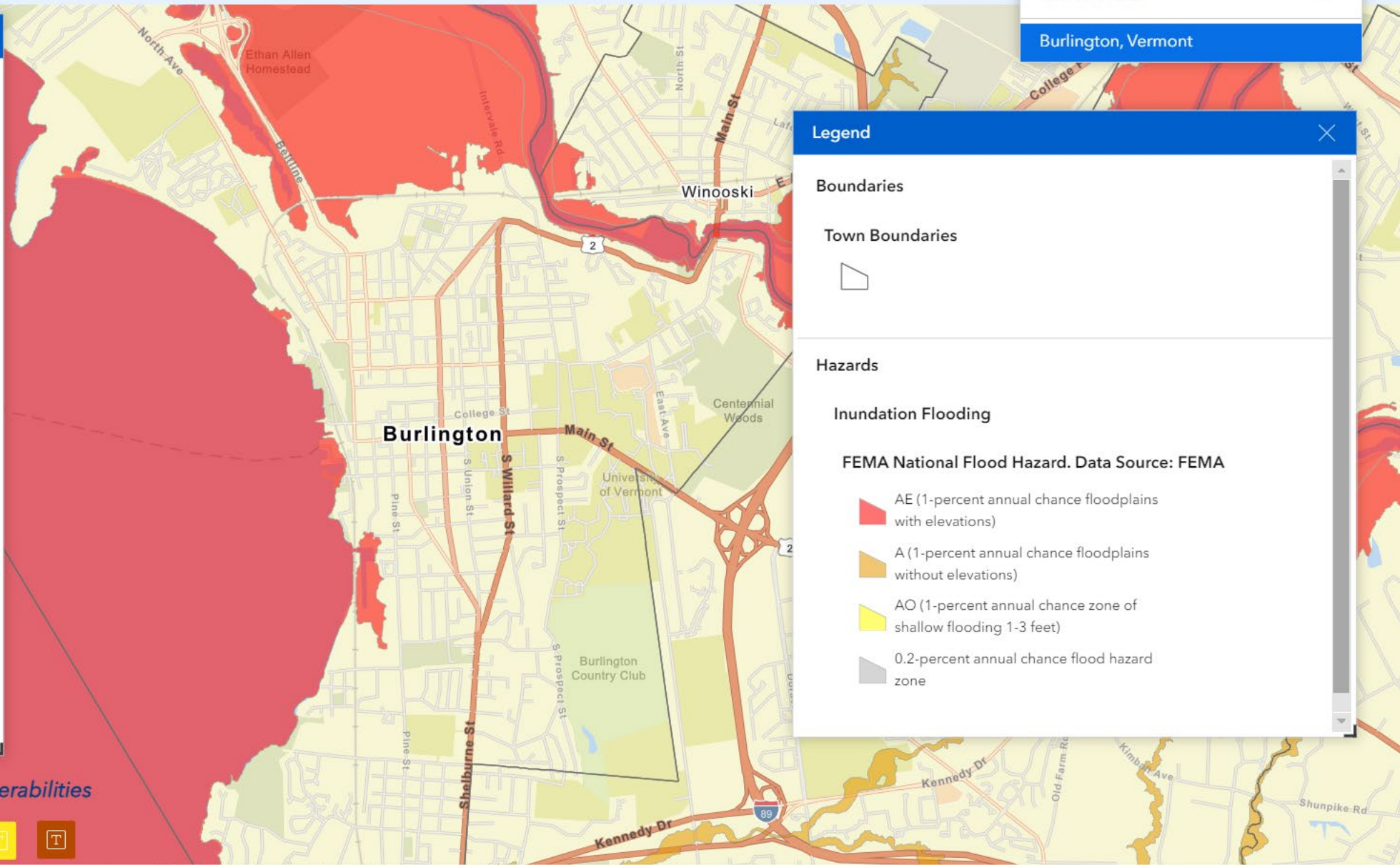
- ▶  Boundaries
- ▼  Hazards
  - Drought
  - Extreme Precipitation Projections (Days with precipitation greater than 2 inches). Data Source: UC San Diego
  - Fluvial Erosion - River Corridors. Data Source: VT DEC
  - Hail
  - Ice Storms
  - Invasive Species
  - ▼  Inundation Flooding
    - FEMA National Flood Hazard. Data Source: FEMA
    - Lake Champlain Basin Flood. Data Source: VT Center for GIS.
    - Landslides

## Legend

- Boundaries**
  - Town Boundaries
- Hazards**
  - Inundation Flooding**

FEMA National Flood Hazard. Data Source: FEMA

    - AE (1-percent annual chance floodplains with elevations)
    - A (1-percent annual chance floodplains without elevations)
    - AO (1-percent annual chance zone of shallow flooding 1-3 feet)
    - 0.2-percent annual chance flood hazard zone



Additional Vulnerabilities





# Vermont Municipal Vulnerability Index

Find address or place

## Map Layers

- Fluvial Erosion - River Corridors. Data Source: VT DEC
- Hail
- Ice Storms
- Invasive Species
- Inundation Flooding
  - FEMA National Flood Hazard. Data Source: FEMA
- Increase transparency
- Decrease transparency
- Details
- Export
- Lake Champlain Basin Flood. Data Source: VT Center for GIS.
- Landslides
- Snow Storms
- High Temperature

## Additional Vulnerabilities



## Legend

### Boundaries

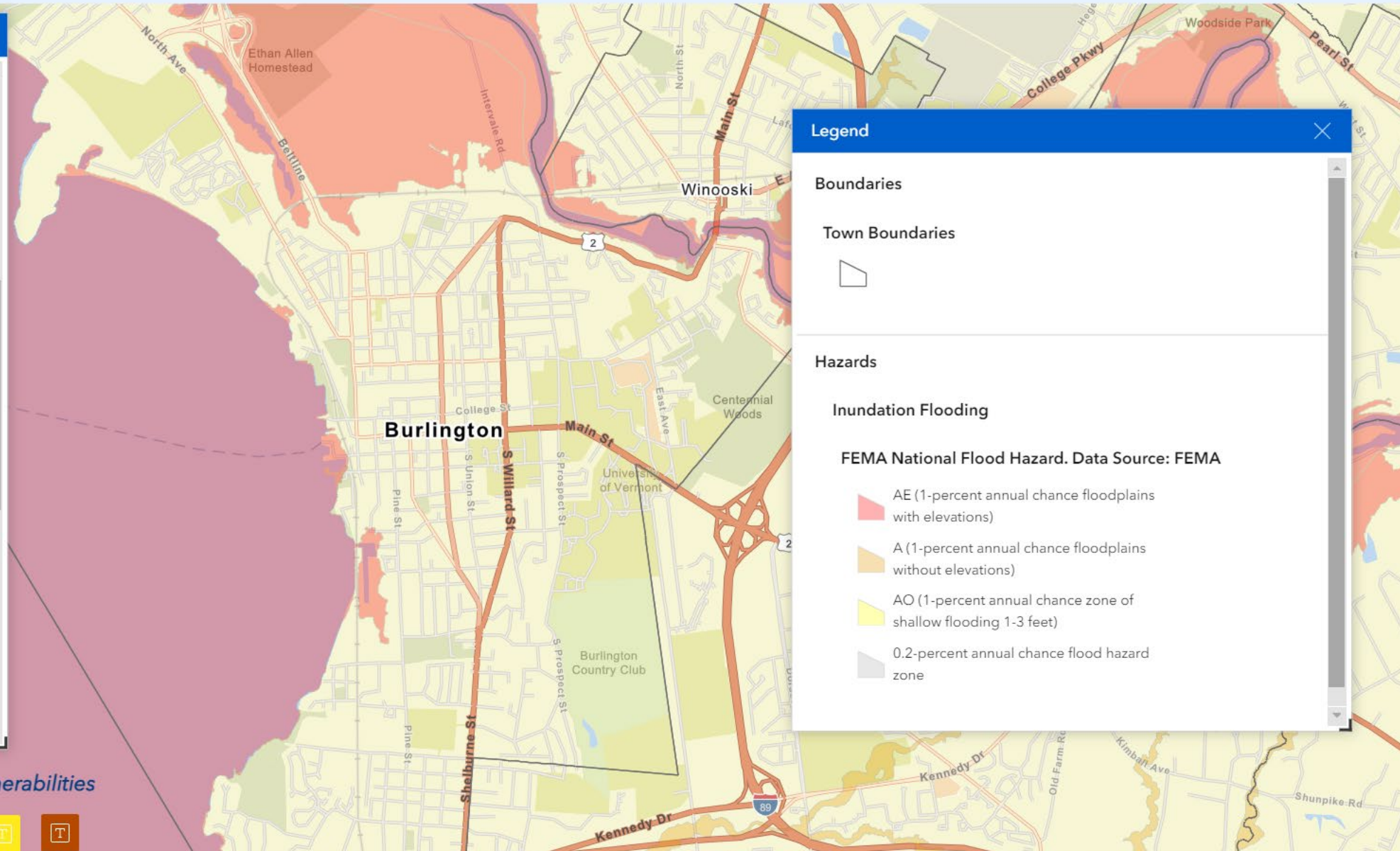
### Town Boundaries

### Hazards

### Inundation Flooding

### FEMA National Flood Hazard. Data Source: FEMA

- AE (1-percent annual chance floodplains with elevations)
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- 0.2-percent annual chance flood hazard zone



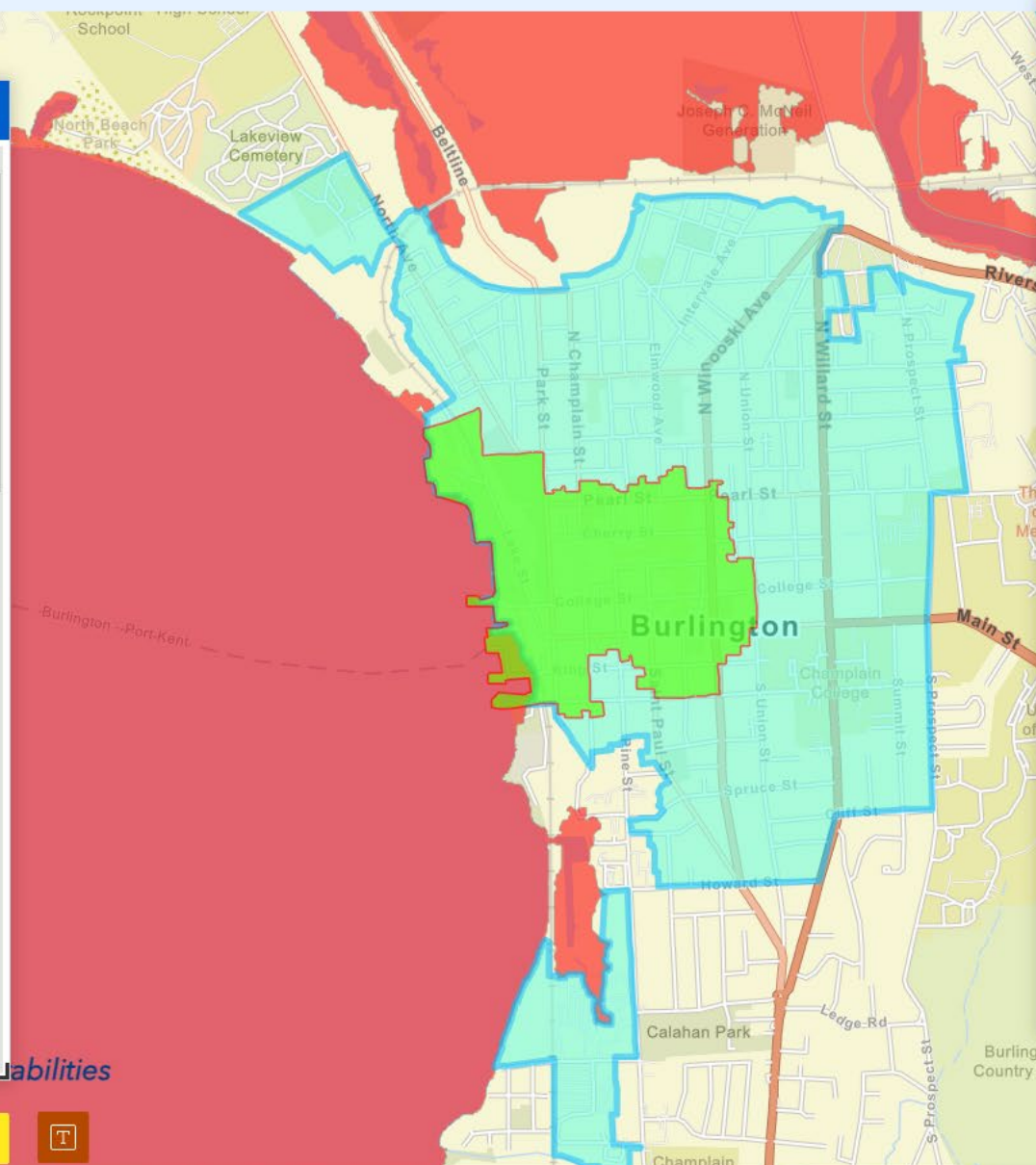


# Vermont Municipal Vulnerability Index

Find address or place

## Map Layers

- ▶ Built & Physical Environment Domain
- ▼ Community Domain
  - Designated Growth Center
  - Downtown District Boundaries
  - Municipal Financial Capacity
  - Municipal Staff Capacity
  - Neighborhood Development Area
  - New Town Center Boundaries
  - Plan + Regulation Status
  - State Register of Historic Districts
  - Village Boundaries
  - Emergency Relief & Assistance Funds
- ▶ Social Domain
- ▶ Economic & Job Domain



## Legend

- Community Domain
  - Downtown District Boundaries
  - Neighborhood Development Area
- Hazards
  - Inundation Flooding
    - FEMA National Flood Hazard. Data Source: FEMA
      - AE (1-percent annual chance floodplains with elevations)
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      - AO (1-percent annual chance zone of shallow flooding 1-3 feet)
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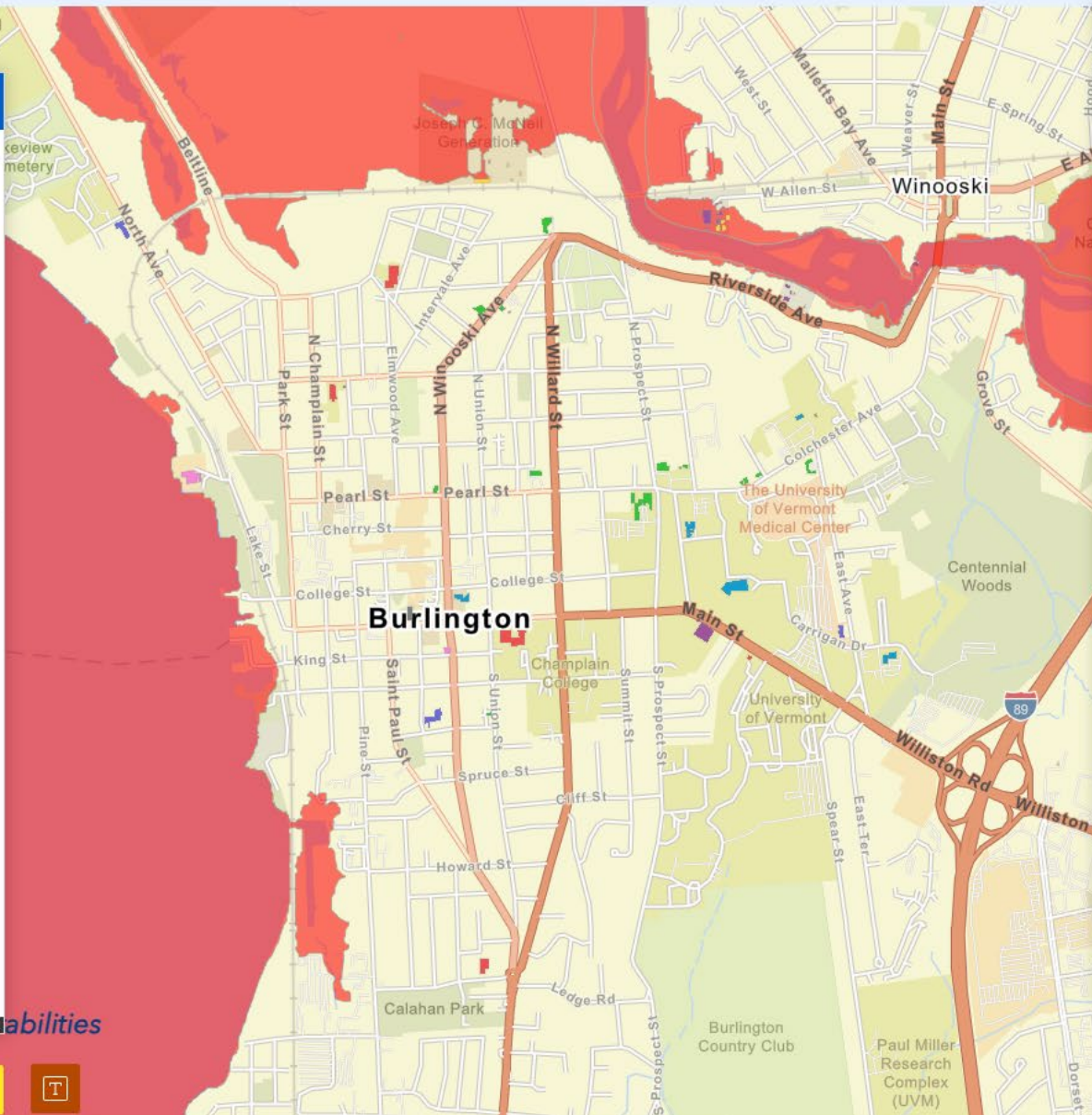
# Vermont Municipal Vulnerability Index

Find address or place



## Map Layers

- ▼ Built & Physical Environment Domain ...
- 👁 Critical Assets ...
- 👁 Emergency Services ...
- 👁 Mobile Homes ...
- 👁 Other Site Types ...
- 👁 Residential Dwellings ...
- ▶ 👁 Housing Age ...
- ▶ 👁 Community Domain ...
- ▶ 👁 Social Domain ...
- ▶ 👁 Economic & Job Domain ...
- ▶ 👁 Infrastructure Domain ...
- ▶ 👁 Natural Environment Domain ...
- ▶ 👁 Other Vermont Vulnerability Projects ...
- ▶ 🗺 Boundaries ...



## Legend

### Built & Physical Environment Domain

#### Critical Assets

- SCHOOL K / 12
- LIBRARY
- HEALTH CLINIC
- TOWN GARAGE
- WASTEWATER TREATMENT PLANT
- COMMUNICATION TOWER
- SUBSTATION
- TOWN OFFICE
- UTILITY
- NURSING HOME / LONG TERM CARE
- HYDROELECTRIC FACILITY
- CITY / TOWN HALL
- PUBLIC WATER SUPPLY WELL

#### Hazards

##### Inundation Flooding



# Vermont Municipal Vulnerability Index

Find address or place



## Map Layers

- ▼ Built & Physical Environment Domain ...
- 👁 Critical Assets ...
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- 👁 Residential Dwellings ...
- ▶️ 👁 Housing Age ...
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- ▶️ 👁 Social Domain ...
- ▶️ 👁 Economic & Job Domain ...
- ▶️ 👁 Infrastructure Domain ...
- ▶️ 👁 Natural Environment Domain ...
- ▶️ 👁 Other Vermont Vulnerability Projects ...
- ▶️ 👁 Boundaries ...

Abilities

1 of 2

### Critical Assets

Zoom to

Type of Site	WASTEWATER TREATMENT PLANT
Address	250 W ALLEN ST
Town	WINOOSKI
County	CHITTENDEN
Source Origin	E911
Update Date	3/4/2022, 5:33 AM

## Legend

### Built & Physical Environment Domain

#### Critical Assets

- SCHOOL K / 12
- LIBRARY
- HEALTH CLINIC
- TOWN GARAGE
- WASTEWATER TREATMENT PLANT
- COMMUNICATION TOWER
- SUBSTATION
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- HYDROELECTRIC FACILITY
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- PUBLIC WATER SUPPLY WELL

### Hazards

#### Inundation Flooding





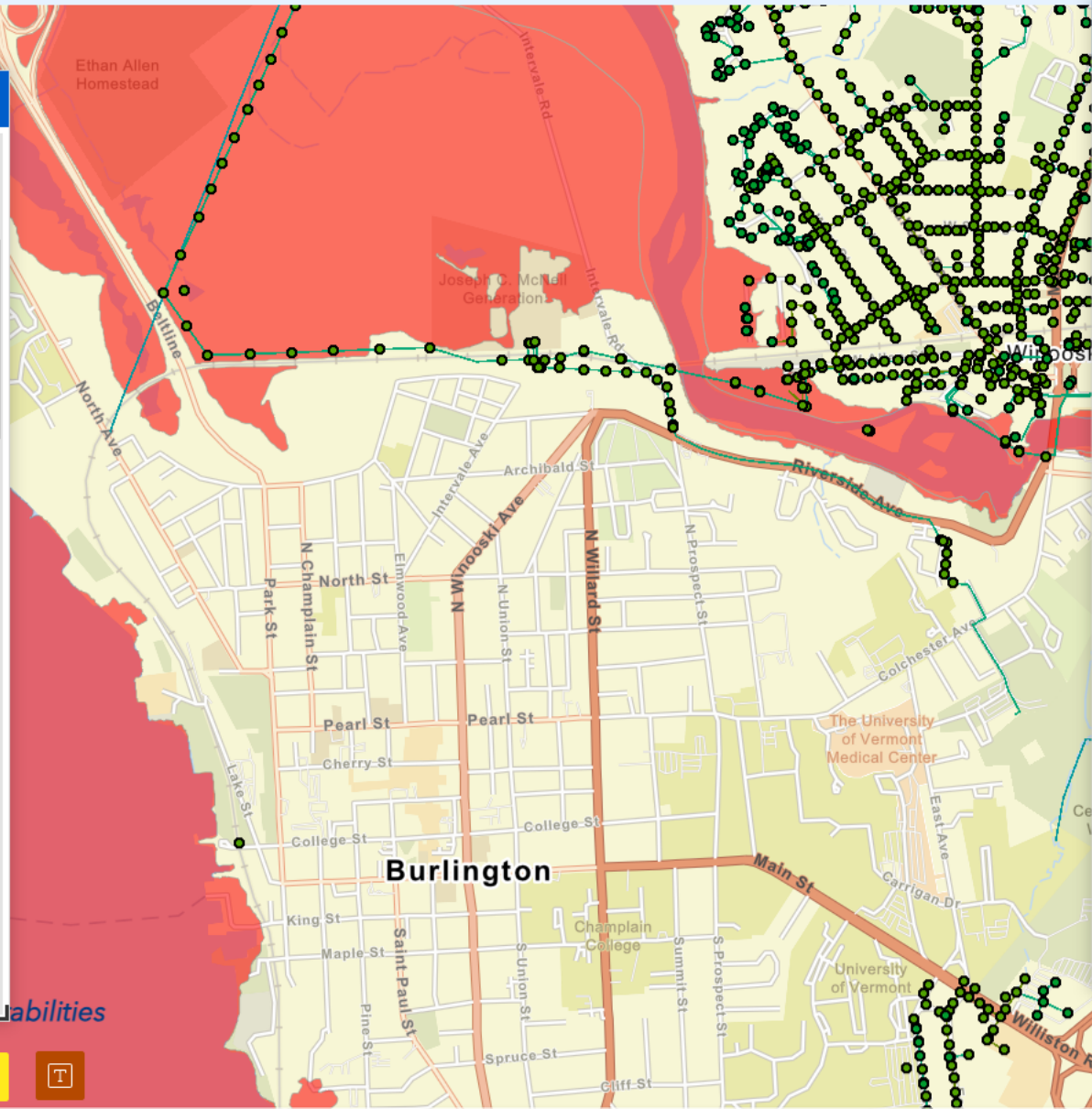
# Vermont Municipal Vulnerability Index

Burlington, VT, USA

Search result

## Map Layers

- Infrastructure Domain
  - Airports
  - Roads
  - Bridges
  - Culverts
  - Drinking Water Infrastructure
  - Electric Substations
- Impervious Surfaces (Vermont Open Geodata Portal)
- Power Lines (Green Mountain Power Lines)
  - VT Green Mountain Power Underground Structure Data
  - VT VEC Poles - Points
  - VT Telecommunication Facilities
  - VT Electric Transmission Line Corridors - substation points



## Legend

- Infrastructure Domain
  - Power Lines (Green Mountain Power Lines)
    - VT Green Mountain Power Underground Structure Data
    - VT VEC Poles - Points
    - VT Green Mountain Power Pole Data
    - VT 3-Phase-Power (Generalized) for Planning
    - VT Green Mountain Power Line Data
    - VT Electric Transmission Line Corridors - corridor lines
    - VT VEC Primary Overhead and Underground Distribution Lines

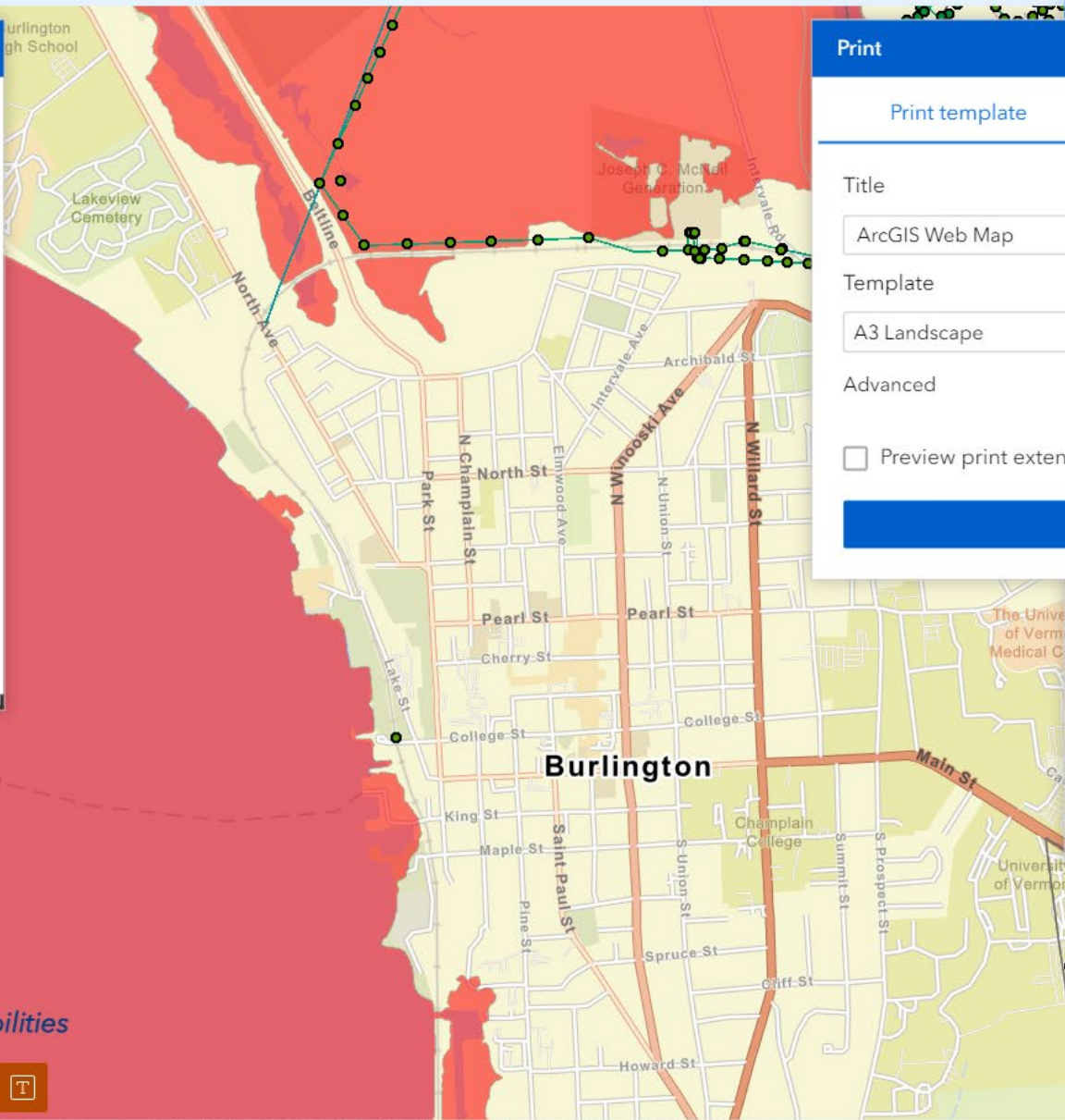


# Vermont Municipal Vulnerability Index

Find address or place

**Map Layers**

- Line Data
- VT Electric Transmission Line Corridors - corridor lines
- VT VEC Primary Overhead and Underground Distribution Lines
- VT Sewer Service Areas
- VT Telephone Exchange Boundaries
- Powerlines (VEC "spans" data)
- Power Lines (WEC Utility Lines)
- Power Plants and



**Print**

Print template | Print result

Title: ArcGIS Web Map

Template: A3 Landscape

Advanced

Preview print extents

**Print**

VT Green Mountain Power Line Data

VT Electric Transmission Line Corridors - corridor lines

## Additional Vulnerabilities



# Next Steps

- Currently developing (by mid-April):
  - MVI user guide
  - Final project report
- Tool training for regional planning commissions: April-May 2024
- MVI released for use: Anticipated mid-April 2024



Questions?