Known for excellence.
Built on trust.

ULSTER COUNTY TRANSPORTATION RESILIENCY PROJECT VULNERABILITY ASSESSMENT MEMORANDUM

November 2022
File No. 18.0175293.00

ULSTER COUNTY TRANSPORTATION COUNCIL

PREPARED FOR:
Ulster County Transportation Council
244 Fair Street
Kingston, NY 12401

GZA GeoEnvironmental of New York
104 West 29th Street, 10th Floor | New York, NY 10001
212-594-8140

31 Offices Nationwide
www.gza.com

Known for excellence.
Built on trust.

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION MANAGEMENT

GZA GeoEnvironmental of New York
104 West 29th Street
10th Floor
New York, NY 10001
T: 212.594.8140
F: 212.279.8180
www.gza.com

November 18, 2022
File No. 18.0175293.00

Mr. Dennis Doyle, Director
Ulster County Planning Department
244 Fair Street
Kingston, New York 12401

Re: Vulnerability Assessment Memorandum
Critical Transportation Infrastructure Vulnerability Assessment
Ulster County, New York

Dear Mr. Doyle:

In accordance with GZA's current contract with the County of Ulster dated August 18, 2021, for the above referenced project solicited under the RFP-UC21-015 Critical Transportation Infrastructure Vulnerability Assessment and its contract terms, we are pleased to present this report containing the Vulnerability Assessment Memorandum. This document is subject to the limitations outlined in **Appendix A**.

Please contact Sam Bell, the Project Manager for GZA, at (781) 223-7091 or by email at samuel.bell@gza.com with any questions.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

Samuel J. Bell, CFM
Sr. Project Manager/Climate Resiliency Planner

Chad W. Cox P.E.(MA)
Consultant Reviewer/Sr. Principal

David M. Leone, CFM, P.E.
Associate Principal

Attachment: Vulnerability Assessment Memorandum

Cc: Suseel Indrakanti, Cambridge Systematics

J:\175200's\18.0175293.00 Ulster County Vulnerability Assessment\Report\Vulnerability Assessment\Vulnerability Assessment \Memorandum\18.175293.00_UCTC Resiliency Project – Vulnerability Assessment Memorandum – November 2022.docx

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

UCTC Critical Infrastructure Vulnerability Assessment

Vulnerability Assessment Memorandum –

1.0 Introduction and Purpose

The UCTC initiated this study to address the vulnerability of critical surface transportation infrastructure elements to hazards. Vulnerability in the context of the UCTC Vulnerability Assessment project is defined as the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change or extreme weather events. In the transportation context, it is a function of transportation asset's **exposure** (the likelihood of an asset to be subjected to climate stressors), **sensitivity** (how an asset responds to or is affected by exposure to climate stressors) and **adaptive capacity** (how easily/quickly a disrupted asset can be restored or resume normal operations).

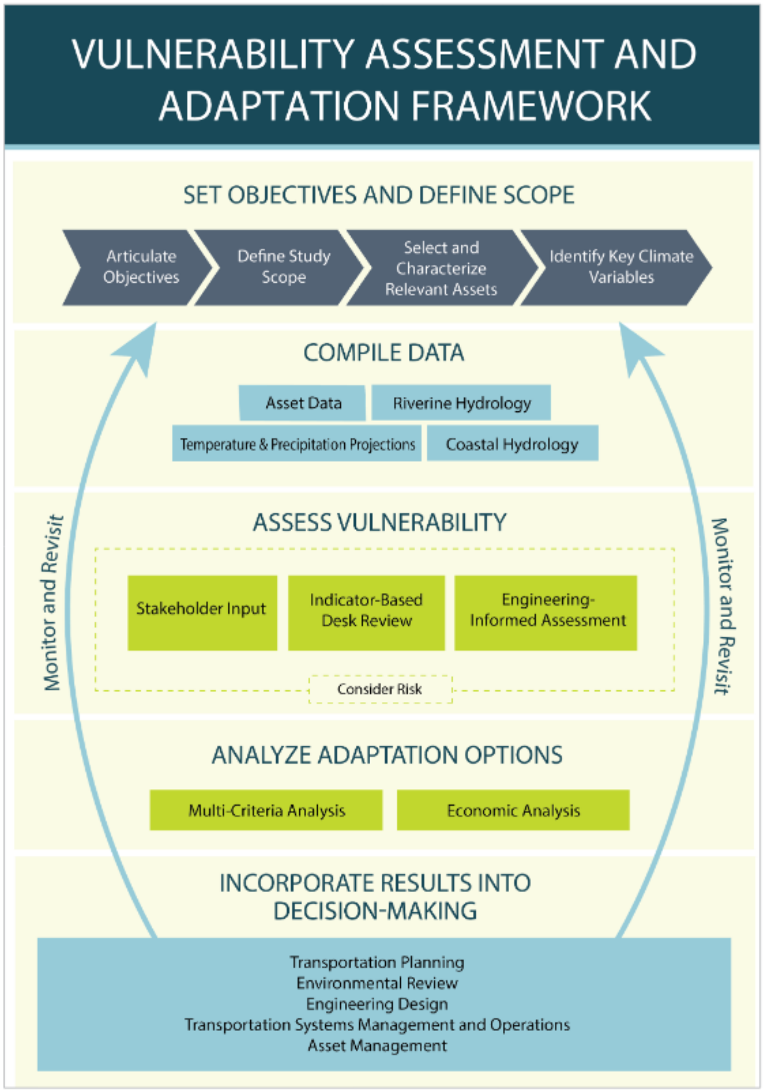
This vulnerability assessment specifically focuses on assessing the vulnerabilities of regional transportation infrastructure elements--roads and bridges, based on the inventory and hazard assessments that were performed prior to this task. The results provide a needs-based priority listing of vulnerable and critical facilities in the study area to flooding and extreme temperature, which were prioritized as the key hazards for the region. This information will support UCTC's decisions about addressing vulnerabilities and improve the regional resilience of the transportation system.

2.0 Approach

The project team used the Federal Highway Administration's (FHWA) Vulnerability Assessment and Adaptation Framework (VAAF) which helps transportation agencies and their partners assess the vulnerability of transportation infrastructure and systems to extreme weather and climate effects. The advantages of using an assessment methodology compatible with FHWA's framework include adoption of a tested and refined methodology developed over a range of regional and state DOT projects across the US, consistency with federal guidance, and scope for availability of technical and other resources as may be needed for future UCTC endeavors.

This framework includes the primary steps involved in conducting a vulnerability assessment as shown in **Figure 1** below. FHWA's Vulnerability Assessment Scoring Tool (VAST) was used to assess climate stressor impacts on roads and bridges across Ulster County. This memorandum outlines the main takeaways from the analysis including directions from UCTC on approach and methodological decisions, and the team's assumptions and reviews to support vulnerability outcomes. Theses assessments provide a comprehensive, high-level indication of roads and bridges that are anticipated to be vulnerable to future climate events based on their current/predicted asset conditions and exposure to climate stressors.

Figure 1. FHWA's Vulnerability Assessment and Adaptation Framework (3rd Edition)

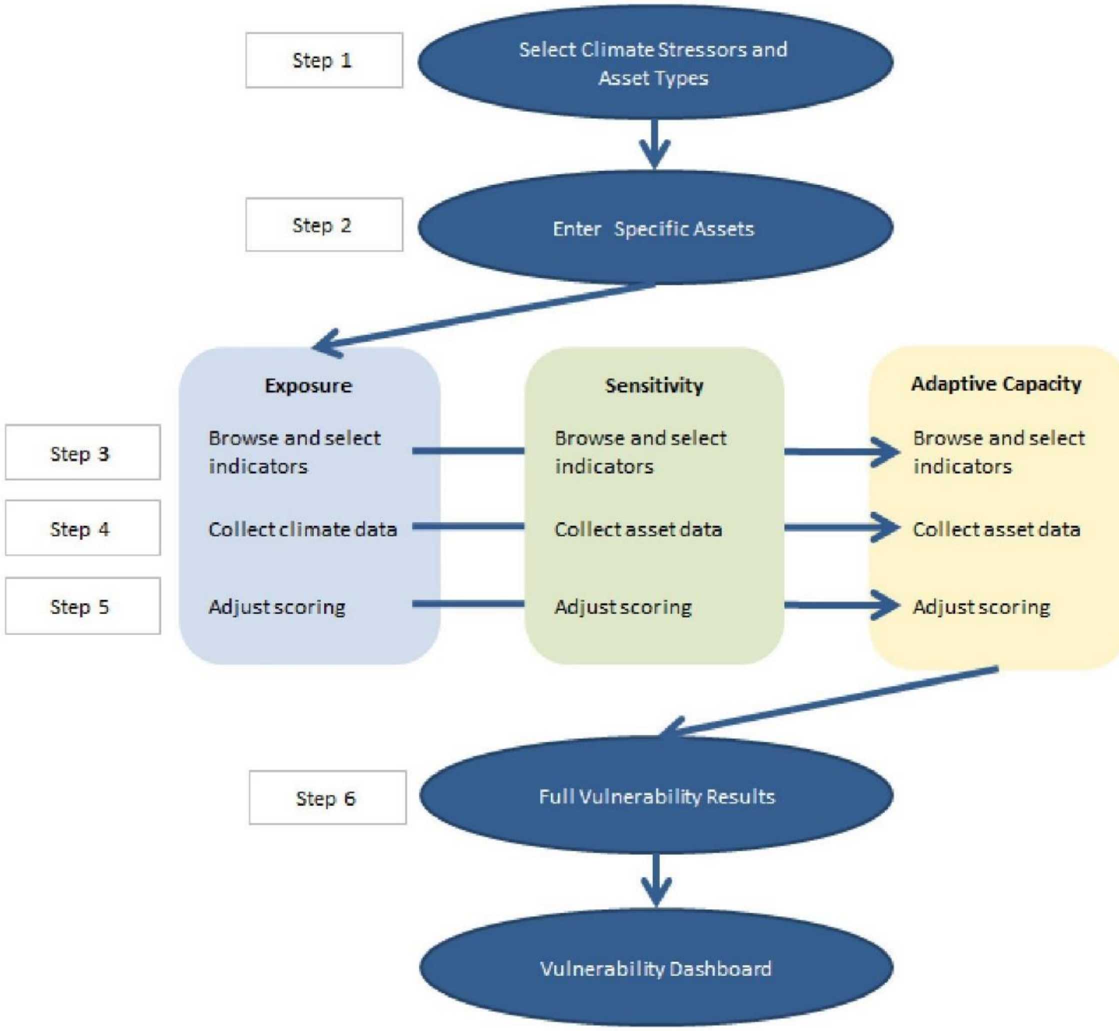


3.0 FHWA' s VAST Tool and Run Set-ups

USDOT developed VAST as an indicator-based, Microsoft-Excel desktop application that enables users to produce a set of vulnerability scores for multiple types of transportation assets (such as airports, bridges, and roadways) and climate stressors (such as temperature, inland flooding, and sea-level rise) that can be compared across two scenarios. The project team used VAST to undertake the indicator-based vulnerability assessment of Ulster County's roads and bridges for extreme temperature and flooding.

The process to run VAST includes a series of steps such as identifying unique climate stressors and assets, selecting indicators, datasets, and adjusting scoring methodology to produce vulnerability results as shown in **Figure 2** and detailed below.

Figure 1. Vulnerability Assessment Scoring Tool approach diagram



Climate Stressors and Asset Types

The project team worked with UCTC's project management team to select the climate stressors and asset types included and prioritized for the vulnerability assessment. The project team coordinated with UCTC to assess and select transportation asset data based on availability and suitability for application. The priority tier of transportation assets included for the assessment included roadways and bridges.

Earlier, the hazards judged to pose the most significant risks to the County's transportation assets, extreme heat (annual number of days > 90°F) and flooding were selected. For extreme temperature the ClimAid report for New York State was used as reference to derive change in annual number of days > 90°F as the threshold for the temperature stressor.[1] This stressor

[1] Responding to Climate Change in New York State (ClimAID), Climate Risks, Chapter 1, https://www.nyserda.ny.gov/About/Publications/Research%20and%20Development%20Technical%20

evaluated the change in number of days above 90°F, comparing RCP 4.5 as the lowest considered emissions scenario in 2030 and RCP 8.5 as the most extreme emissions scenario in 2050.

Flooding risk was considered as the other climate stressor, and data for flooding exposure was obtained from FEMA as 100-year floodplain and 500–year floodplain data from FEMA's flood hazard layer. Due to the limitations of floodplain data, only a two-dimensional GIS analysis was conducted for the flood exposure, which did not consider the inundation depth of the flood data to asset data.

Roadway and bridge asset types were identified as higher tier assets for inclusion in the vulnerability assessment based on the Asset Data Collection Plan that was generated prior to conducting the vulnerability assessment in VAST. Indicators that were collected from the GIS data attribute tables were used in the vulnerability assessment.

Indicator Selection

Selection of indicators and supporting datasets across chosen transportation assets and climate stressors are needed to support the vulnerability assessment. An inventory of potential indicators and supporting data for each stressor-climate pair were identified and refined using three criteria:

- Data availability (related to dataset availability and robustness),
- VAST Requirements (related to data readiness to load into VAST), and
- Balancing operational and scope components of running VAST.

Selection of these indicators has been done in coordination and direction from the UCTC project management staff. The indicators that were considered for the vulnerability assessment are shown in **Table 1**.

Table 1. Adaptive Capacity and Sensitivity Indicators

Stressor	Vulnerability Components	Roads	Bridges
Extreme Heat (Annual Number of days > 90F)	Sensitivity	• Truck Traffic • Pavement Condition	• Condition Rating • Bridge Length
	Adaptive Capacity	• Functional Class • Evacuation Route	• Detour Length • Deck Area
Flooding (Location relative to floodplains)	Sensitivity	• Pavement Condition	• Scour Rating • Bridge Age
	Adaptive Capacity	• Functional Class • Evacuation Route	• Detour Length • Deck Area

Reports/Environmental%20Research%20and%20Development%20Technical%20Reports/Response%20to%20Climate%20Change%20in%20New%20York

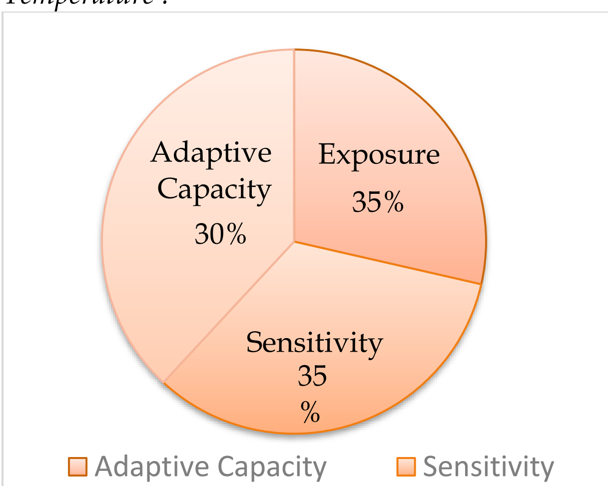
After indicators and datasets are identified, a scoring approach is needed to convert indicator data into relative vulnerability scores. The VAST application produces scoring on a scale of 1-4, which was adopted in this study.

Vulnerability Assessment Results

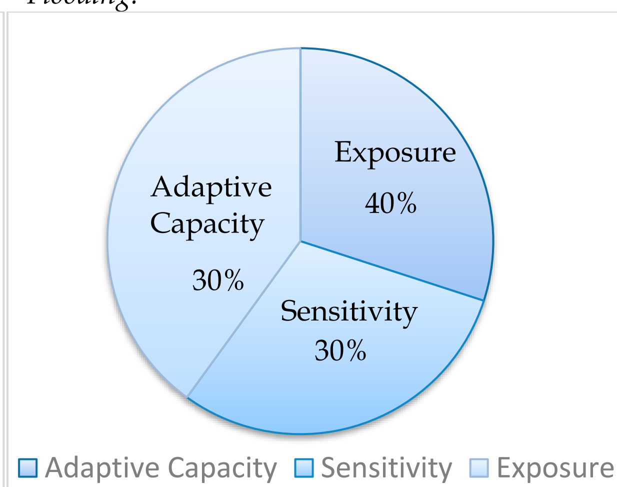
After indicators, datasets, and scoring methodologies are selected, the project team ran the VAST tool and generated the vulnerability assessment results for each asset and climate pair. Vulnerability was calculated based on weights of exposure, sensitivity, and adaptive capacity that were selected in consultation with UCTC staff for both stressors given their unique impact and occurrence in recent past. The weighting considerations for UCTC in the VAST tool for temperature and flooding stressors can be seen in **Figure 3** below. For extreme temperature, exposure and sensitivity were given the same weight of 35% and adaptive capacity was 30%. Based on consultation with the UCTC staff, a higher weight for exposure was considered for flooding as compared to extreme temperature, as based on local knowledge, observed, and perceived incidence of exposure to flooding in Ulster County.

Figure 3. VAST weighting considerations for Temperature and Flooding

Temperature :



Flooding:



4.0 Vulnerability Assessment Results and Key Takeaways

The project team classified vulnerability into VAST-generated scores of Low (≥1), Medium(≥2 and <3), High(≥ 3), for roads and bridges. The VAST runs are generated separately for extreme temperature and flooding, and so an asset has one vulnerability score for extreme temperature and one for flooding. Therefore, a composite vulnerability score was developed to assess the overall vulnerability of regional transportation assets to more than one stressor. For this, the average of both the vulnerability scores was calculated weighting both flooding and extreme temperature vulnerability equally. **Table 2** provides a summary of the VAST composite scores across both climate stressors and assets for both the 2030 and 2050 scenarios. In the near-term, the share of roadway assets that are highly vulnerable are low, while the bridge assets have a significantly higher share that are highly vulnerable. As the projections for the mid-century are incorporated, the roadway assets that are highly vulnerable more than double in centerline-mileage in 2050 (12%) from those in 2030 (5%).

For bridges, the vulnerability is summarized by deck area in square feet. In 2030, a significant share of the overall bridge deck area is classified as being highly vulnerable (37%), which increases to 55% in the year 2050, with over one million square feet of bridge deck area classified as highly vulnerable.

Table 2. Composite Vulnerability 2030 and 2050

	Composite Vulnerability 2030			Composite Vulnerability 2050		
Asset Type	Low vulnerability (%)	Medium vulnerability (%)	High vulnerability (%)	Low vulnerability (%)	Medium vulnerability (%)	High vulnerability (%)
Roads (miles)	660 (28%)	1567 (67%)	113 (5%)	122 (5%)	1940 (83%)	278 (12%)
Bridges (Deck Area sqft)	2,220 (0.12%)	1,187,533 (62%)	712,267 (37%)	0 (0%)	865,158 (45%)	1,036,862 (55%)

Combining Vulnerability and Criticality for Prioritization

As UCTC intends to improve regional resilience, it will need decision support to prioritize strengthening assets with the highest need and importance. A combined measure of composite vulnerability and criticality provides a needs-based priority order of facilities that are both important and vulnerable. **Figure 4** represents a matrix that shows a vulnerability-criticality matrix that can be used for prioritizing transportation assets based on the two indicators.

Figure 4. Composite Analysis: Vulnerability and Criticality

Vulnerability		Low Criticality	Moderate Criticality	High Criticality
	High	High Vulnerability, Low Criticality	High Vulnerability, Moderate Criticality	High Vulnerability, High Criticality
	Moderate	Moderate Vulnerability, Low Criticality	Moderate Vulnerability, Moderate Criticality	Moderate Vulnerability, High Criticality
	Low	Low Vulnerability, Low Criticality	Low Vulnerability, Moderate Criticality	Low Vulnerability, High Criticality
		Low	**Moderate**	**High**
		Criticality		

Composite vulnerability and criticality was calculated by equally weighting them for each roadway and bridge asset. **Table 3** provides the composite criticality and vulnerability scores for roads and bridges for 2030 and 2050 scenarios. The total mileage of roadway segments classified as highly vulnerable and critical increases from 8% in 2030 to 12% in 2050.

For bridges, the vulnerability is represented by deck area in square feet and the criticality score is assigned as the higher of the connecting roadway segments. . There was a 14% increase in the deck area that was classified as highly vulnerable and critical between 2030 and 2050.

Table 3. Composite Vulnerability and Criticality 2030 and 2050

	Composite Vulnerability and Criticality 2030			Composite Vulnerability and Criticality 2050		
Asset Type	Low vulnerability (%)	Medium vulnerability (%)	High vulnerability (%)	Low vulnerability (%)	Medium vulnerability (%)	High vulnerability (%)
Roads (miles)	76 (3%)	2,078 (89%)	186 (8%)	0.35 (0%)	2062 (88%)	277 (12%)
Bridges (Deck Area sqft)	2,220 (0.12%)	1,199,840 (63%)	701,720 (37%)	0 (0%)	934,584 (49%)	967,436 (51%)

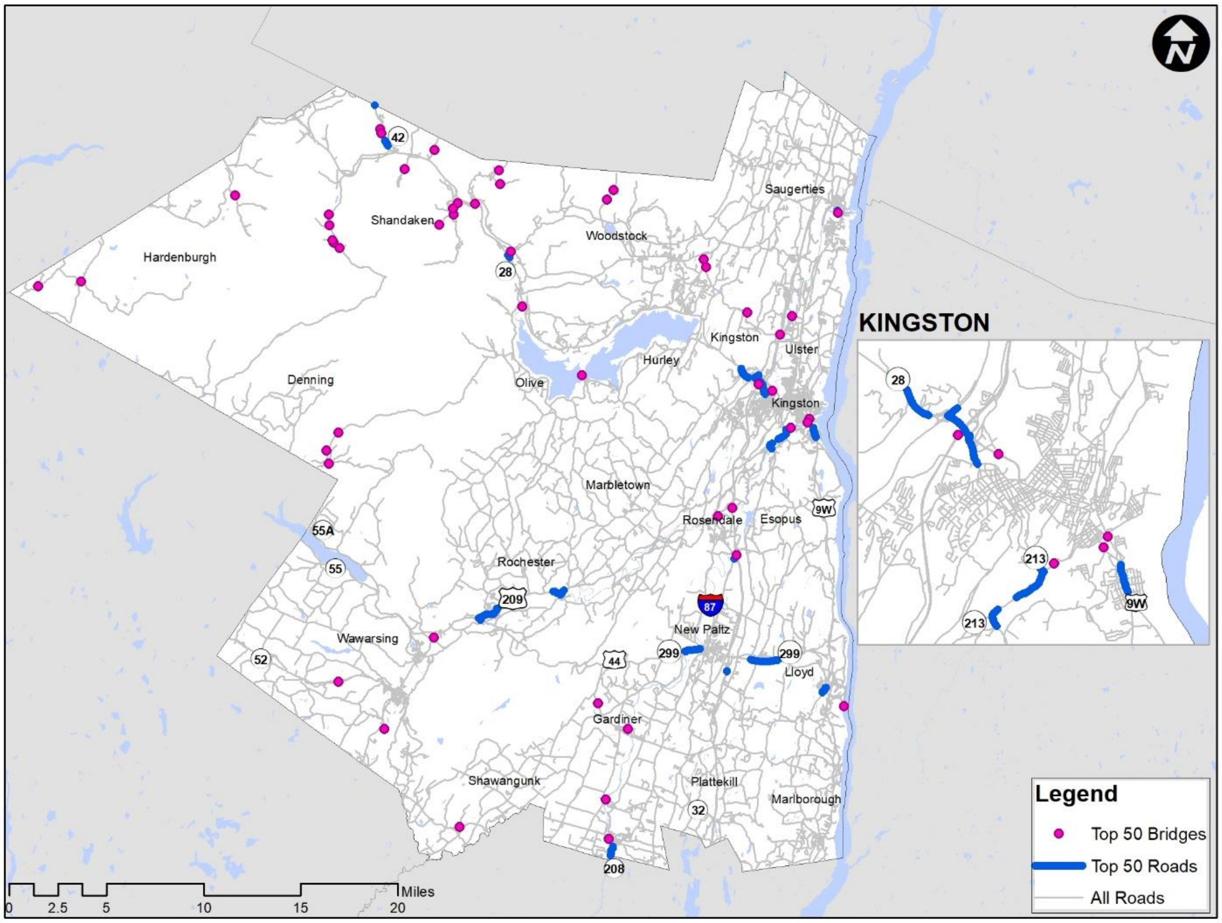
Distribution of Top 50 Highly Vulnerable Assets

Given the number of transportation assets included in the vulnerability assessment, the project team worked with UCTC to highlight the top 50 vulnerable roads and bridges for UCTC staff and the project technical advisory committee (TAC) review, while including the entire datasets with the study area-wide lists in the form of shapefiles. The top 50 roadway and bridge assets are also shown in **Figure 5**. These assets were distributed across Ulster County, in both urban and rural areas. One other observation is that though the vulnerability assessment is done at a roadway segment or bridge (asset) level, it is acknowledged that UCTC will develop "projects" that bring efficiencies of bundling or consolidation if they are grouped together geographically or if it makes sense to improve the facilities if they exist along a corridor.

The project team has identified clusters of assets that was classified as highly vulnerable in the Kingston area along NY28, US9W and NY213. In the northwest part of Ulster County, the more rural region, there were segments of NY42 and NY28 that fell under the top 50 vulnerable roads. In the southern part of Ulster County there was a cluster of roads that were highly vulnerable in New Paltz, along NY299 and US 44. US209 in the southeast part of Ulster County had a few segments in Rochester that were highly vulnerable.

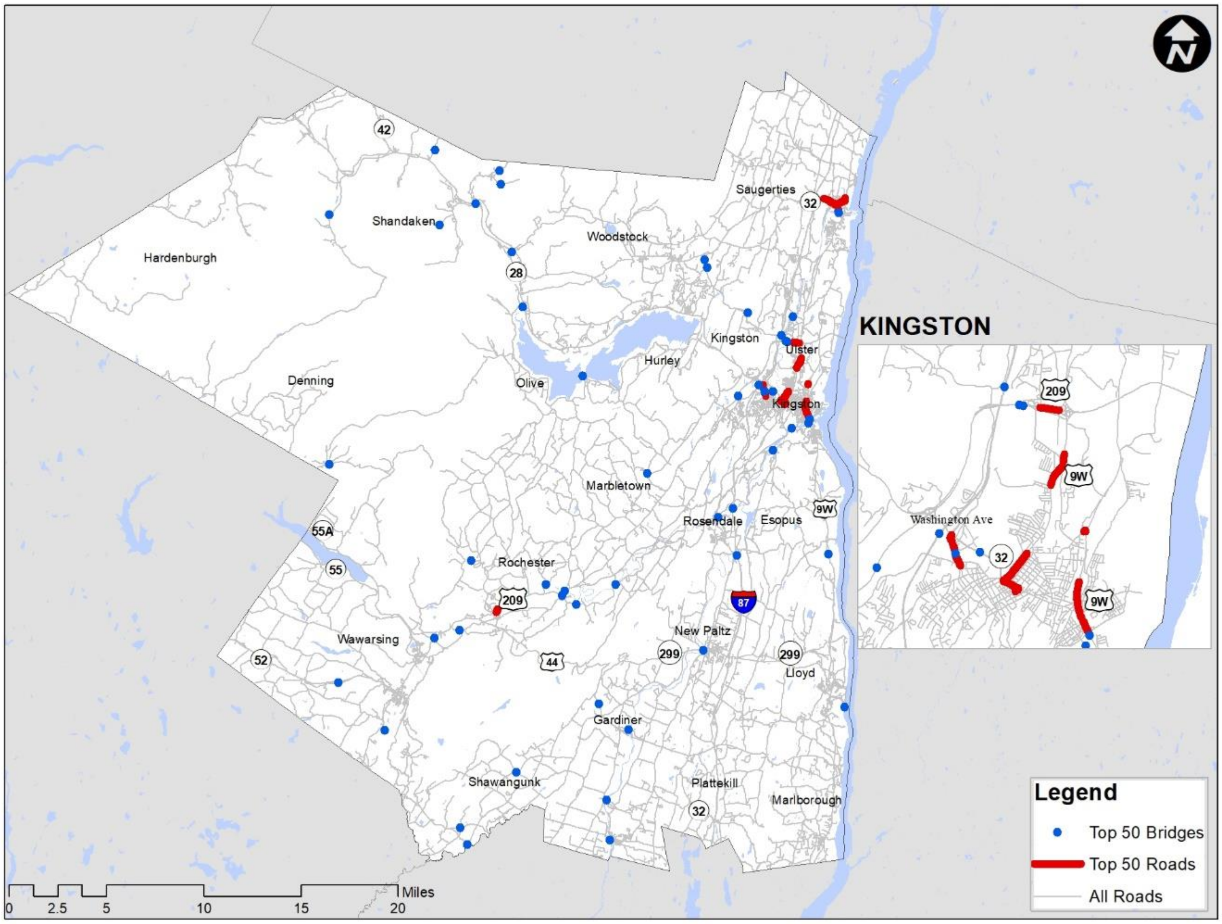
The top 50 bridges that were classified as highly vulnerable distributed across the county with slight clustering in the northwest part of Ulster County. A series of bridges classified as highly vulnerable were located on the Oliverea Road in the Big Indian Wilderness.

Figure 5. Top 50 Highly Vulnerable Roads and Bridges for 2030



The top 50 Vulnerable roads and bridges for 2050 are shown in **Figure 6**. In Kingston, two of the roads that were highly vulnerable in the year 2030, Washington Ave and US9W, continued to be highly vulnerable in 2050 as well. US209 and NY32 were the additional roadway segments in Kingston that fell in the top 50 assets that were considered highly vulnerable for 2050. Overall, the highly vulnerable roadway segments in 2050 were clustered around Kingston and were not as spread out as those in 2030. The top 50 bridges that were highly vulnerable in 2030 remained fairly distributed across the county, with a higher concentration in the Kingston area.

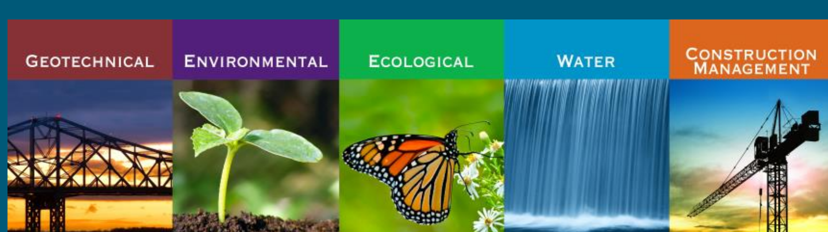
Figure 6. Top 50 Highly Vulnerable Roads and Bridges for 2050



5.0 Conclusions and Next Steps

This vulnerability assessment of the two high priority natural hazards in the UCTC region, extreme temperatures and flooding, are a critical first step in the understanding of which transportation assets require improvements to enhance the transportation system's regional resiliency. The incorporation of key planning factors and emphasis areas like access to critical destinations and incorporation of equity provide UCTC with a comprehensive framework that aligns with the agency's long term planning goals. This will help UCTC identify projects and improvements that will improve transportation system resiliency and enable the regional transportation assets to adapt, withstand, and recover from the impacts of extreme temperatures and flooding. The project team will develop brief white papers that provide recommendations for using the results of the vulnerability assessment into UCTC's functions and business processes including project screening, prioritization, design, and maintenance guidance to enhance regional resilience of the transportation system in supporting the overall sustainability and quality of life of the people in Ulster County.

APPENDIX A - LIMITATIONS



GZA GeoEnvironmental, Inc.