**PATHWAY 2: Proactively and strategically invest to enhance resilience in transportation, communications, water/wastewater, and energy infrastructure statewide.**

The strategies and actions supporting this pathway will improve the resilience of the State’s transportation, energy, and water infrastructure systems to climate change threats. All three sectors are considered critical infrastructure, which is defined in the Vermont Infrastructure Protection and Resilience Plan as “…public and private sector systems and assets, whether physical or virtual, that are so vital their incapacity or destruction would have a debilitating effect on the security, economy, public health or safety, environment, or any combination of these matters across any Federal, State, regional, territorial or local jurisdictions.” General information on the three sectors is provided below. Additional work is required to develop actions specific to communications, which will require engaging with the private sector owners of those services and related infrastructure systems.

Electric Distribution

The electrical grid in Vermont includes Transmission, Sub-Transmission, and Distribution facilities that transmit and distribute energy into, out of, and throughout Vermont, both from larger generation resources and local distributed generation resources. Vermont’s electric grid has become a bi-directional conduit for electrical energy that serves residential, commercial, and industrial customers throughout the state.

Vermont has 17 electric distribution utilities (one investor-owned, two cooperatives, and 14 municipal electric utilities), with each having an exclusive service territory serving in total over 648,000 Vermont residents throughout the state. All Vermont distribution utilities own electric distribution facilities, and some own transmission facilities. Vermont also has a statewide transmission operator, the Vermont Electric Power Company (VELCO). Vermont electric utilities are fully regulated vertically integrated, meaning they can own and operate generation facilities.

Vermont’s grid serves the electric needs of its citizens, in that it is the “highway” for electricity to flow from generators to load to meet demand every hour of the year. The grid has and will continue to become more critical in terms of both safety in a less forgiving climate as well as a key ingredient of decarbonization as we transition our thermal and transportation sectors off fossil fuels, primarily to fuel-switching to electricity.

Vermont’s grid has become increasingly susceptible to climate-change induced severe weather, mainly due to the rural nature of our landscape and our unique geography locally in the northeastern U.S. Threats to the grid include more frequent, stronger storms, high winds, ice, and heavy, wet snowstorms along with more frequent flooding from a large increase in extreme precipitation events. As Vermonters come to rely increasingly on electricity for heating and transportation, doubling down on grid resilience to keep pace with a changing climate will be essential.

Transportation

Vermont’s transportation system includes 14,174 miles of public roadways of which 2,700 miles are maintained and operated by the Vermont Agency of Transportation. The balance of the highway system is managed by Vermont’s 251 municipalities. Non-highway infrastructure and services include seven regional public transit operators providing nearly 5-million rides annually, 578 miles of active rail lines, 305 miles of which are owned by the state, and 16 public airports, 10 of which are owned by the state. The Agency of Transportation oversees 140 miles of rail-banked rail-trails and municipalities provide and maintain many more miles of sidewalks, shared-use paths and other pedestrian and bicycle facilities.

The transportation system is critical to the state’s economy and quality of life and is essential for emergency response. It provides access to jobs and mobility for the movement of goods and services that are essential to Vermont businesses, brings tourists and other visitors to the state, provides access for residents’ daily activities, and delivers food and other products that Vermonters need for everyday living.

The transportation related actions listed below emphasize resilience to damage from flooding and fluvial erosion, climate change threats which are identified by the 2018 Vermont State Hazard Mitigation Plan as the highest-ranking hazard in the state. The transportation system is also challenged by other incremental climate change threats such as more frequent freeze and thaw cycles, increasing mixed precipitation events, and greater variations between high and low temperatures which reduce service life and affect on-going maintenance and operational activities like snow removal.

Water

Four fundamental forms of water infrastructure must be supported to provide for a climate resilient society. These are “gray,” “green,” “natural,” and “human.” Gray, or traditional infrastructure consists of drinking and wastewater treatment and collection/distribution systems and their related appurtenances. Green infrastructure consists of engineered systems in developed lands that endeavor to mimic natural hydrology functions, by attenuating and treating ever-increasing stormwater flows, by using engineered wetlands to treat wastewater, and/or by using reclaimed water for landscape irrigation. Green stormwater infrastructure improves groundwater recharge, reduces flood scour, and limits sediment and nutrient pollution that kills fish in streams and rivers and produces harmful algal blooms in lakes and ponds. Green infrastructure also includes distributed or decentralized water supply and wastewater treatment infrastructure which can mitigate disruption of services by isolating climate-induced impacts. Natural infrastructure consists of existing or restored natural systems managed to provide for water storage and natural water purification, while promoting carbon storage. Human infrastructure is critical to the development, management, operation, and maintenance of all forms of water infrastructure, and must not be ignored as a key component of climate resilience.

Water infrastructure is regulated at the state level, and State agencies such as the Department of Environmental Conservation also provide significant financing and technical assistance resources. Municipalities and private entities are largely responsible for the operation, maintenance, and improvement of grey and green infrastructure, while non-profits typically administer the acquisition and restoration of natural infrastructure. Most natural and municipal infrastructure are publicly funded and financed with state, federal, or ratepayer dollars. The human capital necessary to support resilient water infrastructure cuts across the public, private, and non-profit sectors, and collectively should be considered a small but growing economic sector in its own right in Vermont.

All forms of water infrastructure are threatened by climate impacts, particularly flooding, and also drought. During Irene, many municipal drinking and wastewater systems were disrupted or even lost due to the floods. While some of this infrastructure was restored, many systems, especially wastewater and stormwater systems, remain necessarily located in flood prone areas. In most municipalities served by public water systems and wastewater treatment facilities, the cost and complexity of moving water from source, to tap, to toilet, then treatment is minimized by the fact that water is typically pumped to a high location, then gravity-fed downhill from tanks and standpipes to treatment. During flooding, upland drinking water reservoirs may experience undue water loading threatening the integrity of their dams, while wastewater treatment facilities or water supply wells located in floodplains may be adversely affected by inundation or erosion. During drought, drinking water supply systems are not able to keep pace with demand, necessitating reliance on lesser-quality sources, or even hauling of water by truck. One alarming manifestation of drought on public water supply is the diminishment of sufficient volumes of water to support fire suppression; a significant threat to towns.

**Strategies**

1. **Create a policy, planning and organizational foundation to support effective investments in infrastructure resilience.**

A common theme for transportation, energy and water infrastructure is a need to better understand the threats and vulnerabilities caused by climate change, and how to use that information to guide decision-making and investments that improve resilience in an equitable and cost-efficient manner. State agencies would be the designated lead for almost all of these actions and most could be implemented within two years with adequate funding and dedication of staff resources. Although state agencies would lead most of these actions, they would have to be carried forward in collaboration with other stakeholders. Because these actions are laying the foundation for decision making, they provide an opportunity to incorporate equity from the start.

All Infrastructure Sectors

* Develop a vulnerability index methodology and tool for broad use by stakeholders to identify priority areas for investment. The index will account for the vulnerability communication, energy, transportation and water infrastructure in addition to socioeconomic and equity factors that affect community resilience.
* Update or adopt as appropriate infrastructure design standards to reflect impacts from a changing climate, such as more frequent extreme weather as well as an increasing range of high and low temperatures, freeze/thaw cycles, and mixed precipitation (harden, incorporate redundancies, maximize life span, reduce annual maintenance and operational costs. etc.)

Electric Distribution

* Seek federal stimulus (ARPA), infrastructure bill, and other non-ratepayer funding to defray costs of utility resilience upgrades that exceed benefits to ratepayers, such as:
	+ Ubiquitous communications networks that enable full utilization and participation of distributed energy resources in an interactive grid.
	+ Resiliency Zones: batteries installed at or near critical facilities, potentially paired with solar (and/or small wind) and with a microgrid /islanding where possible, to allow them to continue to operate in the event of extended disruptions to electric service.
	+ Strategic upgrades to substations, distribution, and transmission capacity across the Vermont grid needed to enable the state’s renewable and electrification goals, after first exploring feasibility of any lower-cost options, e.g. flexible load management, curtailment, and storage.
	+ Emerging non-wires technologies that address major challenges system resilience (e.g. long-duration outages).
* Create a framework for identifying and evaluating climate resilience threats and impacts to energy systems serving rural communities.

Transportation

* Complete the flood vulnerability assessment of all bridges, culverts and road segments on the state and town highway systems, identify and prioritize needed investments. This action includes completing the statewide expansion of the [Transportation Resilience Planning Tool](https://vtrans.vermont.gov/planning/transportation-resilience).
* Complete a flood vulnerability assessment of state-owned rail infrastructure to identify and prioritize needed improvements
* Incorporate GHG reduction goals and CAP strategies, and actions related to resilience in the VTrans transportation planning and project development process.

Water

* Increase funding for floodplain restoration, including buy-out programs
* Increase investment to municipalities to support reductions in inflow and infiltration into wastewater collection systems.
* Examine the climate impacts of sludge and biosolids to determine if regional facilities can reduce utility costs and climate impacts. Support investment in strategically placed facilities for sludge and septage processing (much is currently trucked to Montpelier/Chittenden Co.)
* Increase investment to municipalities to support reductions in inflow and infiltration into wastewater collection systems.
* Increase efforts and funding towards pollution prevention programs at wastewater facilities.
* Understand source water vulnerabilities and invest in planning efforts to assist communities, especially those that are vulnerable for their long-term water supply needs. Revamp funding programs for source protection programs, increase funding for programs (include existing and new water sources) and conservation easements
* Increase the number of public water systems and publicly owned wastewater treatment works implementing an asset management program. Expanding programs, funding opportunities, and incentives to develop and implement these programs.
* Continue investments in traditional and green infrastructure to intercept, sink and treat stormwater.
* Encourage adoption of low impact development regulations for municipal zoning, including Xeriscaping and increased density outside of flood prone areas.

 **2. Public, private, and nonprofit entities should be prepared to respond and recover quickly to disruptions caused by severe weather and other climate change threats.**

Since it is not possible to eliminate all vulnerabilities in transportation, energy and water infrastructure, the ability to respond quickly to major disruptions caused by climate change, such as flooding events, will always be a critical component to providing resilient infrastructure. There is only one high priority action included below due to the extensive experience of Vermont Emergency Management and all the other state agencies, regional planning commissions, municipalities, utilities, and others have in responding to and recovering from disasters.

All Infrastructure Sectors

* Strategically integrate planning and preparedness across disciplines and geographies addressing the interdependencies of energy, communications, and other systems.

**3. Increase the resilience of critical infrastructure to severe weather and other climate change threats by reducing vulnerabilities of specific facilities.**

Implementation of the actions below would result in projects that improve the resilience of specific transportation, utility, or water infrastructure. Most of these actions could begin within a couple of years with sufficient funding and staff resources, would be on-going and would result in a steady pace of improvements over time.

All Infrastructure Sectors

* Identify mission critical facilities in collaboration with local and regional planners, utilities and transportation providers to identify actions, procedures, or investments to mitigate the impact of extreme weather events to services provided by these facilities Examples of mission-critical facilities include designated emergency shelters, first responder facilities, hospitals and other medical facilities, key infrastructure such as water/wastewater pumping and treatment and sewer, key communications infrastructure such as fiber nodes, government offices, fuel suppliers, transportation hubs, supermarkets and other facilities municipalities identify as critical to serving communities during extreme weather events.

Electric Distribution

* Replace aging electric and communication infrastructure with the most appropriate resilient alternative when cost effective. For example, during normal replacement schedules for aging and unreliable lines, evaluate and where cost effective and feasible, improve resilience by relocating lines underground or through other options.

Transportation

* Create a transportation flood resilience funding program to meet the requirements and related funding that are anticipated to be part of the 2021 reauthorization of the federal transportation act.

Water

* Expand public investment, particularly hazard mitigation funding to flood-proof or relocate drinking water and wastewater treatment infrastructure at significant risk of flooding, when flood damaged, or during end-of-life refurbishment.
* Work with Vermont villages and property owners to relocate septic systems and public or private drinking water wells that are at risk due to floods
* Develop programs to achieve net zero energy drinking water and wastewater treatment facilities Including microhydro, solar energy, heat exchange, building envelope; AND operational and technological efficiencies
* Improve road drainage around lakes / ponds to reduce stormwater runoff and erosion, especially on municipal roads

**4. Increase the resilience of critical infrastructure to severe weather and other climate change threats by improving system efficiency, reliability and redundancies.**

While the actions in Strategy 3 focus on specific facilities, this strategy includes actions that seek to make systemwide improvement in resilience. Actions that lay the groundwork for systemwide improvements could happen within a couple of years leading to incremental improvements as specific initiatives are implemented.

All Infrastructure Sectors

* Evaluate the risks and opportunities created by potential climate change in-migration to VT's critical infrastructure.
* Implement the recommendations from an AOT study evaluating road usage charges such as a flat fee, mileage-based fee and per kilowatt hour fee to replace the decline in state motor fuel taxes resulting from vehicle electrification.

Communications and Transportation Infrastructure

* Expand broadband to support remote work and tele-services to reduce the impact of travel disruptions.

Electric Distribution

* Deploy foundational informational and operational technology statewide to enable and optimize storage and other distributed energy resources (e.g., GridLogic, Virtual Peaker, other emerging distributed energy resource management systems, in particular those that are open-source to various technologies and vendors)

Transportation Infrastructure

* Update the 1995 Vermont State Highway Design Standards to create context sensitive, multi-modal projects that support smart growth per the Act 167 (2014) Sec 26 Report - VT State Standards Work Plan.
* Increase infrastructure investment needed to for walking, biking and transit; support planning for regional bike corridors to improve safety and transportation options between community centers. Identify and eliminate barriers to development, including inequities resulting from match, maintenance and other requirements.