MOVE SKAGIT
TRANSPORTATION RESILIENCE IMPROVEMENT PLAN

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Approved by the Skagit Council of Governments Transportation Policy Board on [DATE]

Approved by the Federal Highway Administration (FHWA) on [DATE]

CREDITS

This report was prepared for the Skagit Council of Governments (SCOG) by WSP. This project was led by Sarah Ruether from SCOG and this report was prepared by individuals from WSP including Andrina Dominguez, Spiridon (Spiro) Pappas, Armin Golkhandan, Miaomiao Li, and Sabiha Tabassum in close collaboration with Resource Systems Group, Inc. and M Meyer Consulting, Inc.

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Table of Contents

Table of Figures

Table of Tables

MOVE SKAGIT
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Executive Summary

Natural hazards are leading to observable changes in Washington State's environment. Skagit County and the surrounding areas have experienced devastating flooding and high winds leading to community evacuations and widespread damage in the region. The region's transportation system has been affected; the region's communities, businesses, and other organizations have been disrupted; and many of the region's ecological systems have been impacted. Hazards often disproportionately affect historically underserved communities who already face significant challenges. These events also pose increasing safety concerns for travelers who use a variety of transportation modes to move in the region.

To better prepare the region for these types of hazards, the Skagit Council of Governments (SCOG) developed the Transportation Resilience Improvement Plan (TRIP). The TRIP is a foundational initiative to safeguard the Skagit County's transportation network against the growing threats posed by natural hazards. Developed as a core component of the Regional Transportation Plan (RTP) update and supported by the Federal Highway Administration's Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT) Discretionary Program, the TRIP establishes a strategic framework for identifying vulnerabilities, prioritizing investments, and guiding long-term planning to ensure the reliability and safety of the region's transportation infrastructure.

Central to the TRIP is a risk-based vulnerability assessment, which evaluates 638 miles of roadway and 266 bridges for exposure to coastal and fluvial flooding, landslides, seismic events, liquefaction, severe storms, drought, extreme temperatures, wildfire, and dam or levee breaches.

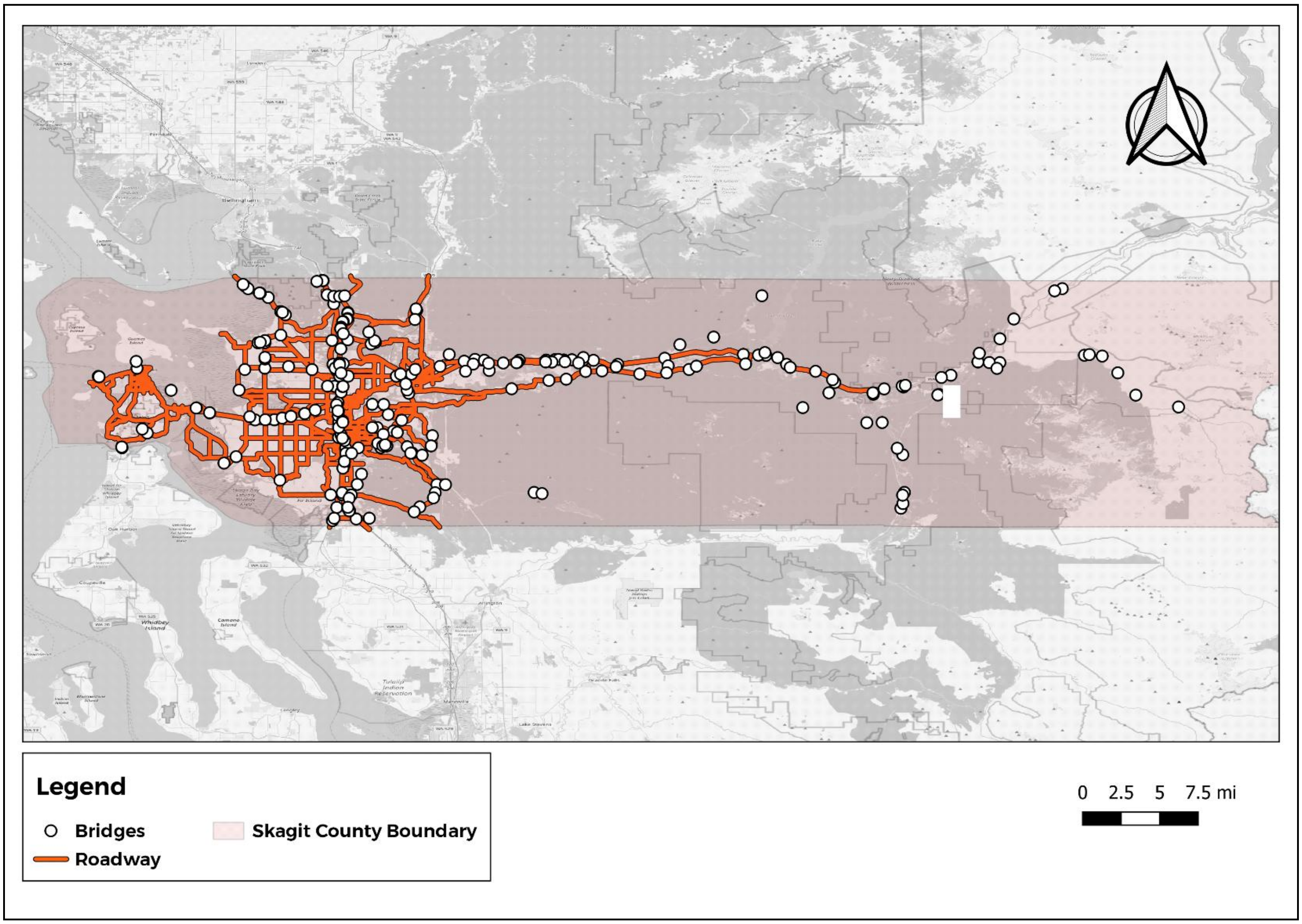

Figure 1. Transportation Assets Included in the Risk-Based Vulnerability Assessment

By integrating asset data with advanced hazard projections and lifecycle risk modeling, the plan quantifies both direct and indirect losses, enabling data-driven prioritization of resilience projects aimed at reducing the risks associated with future hazard events. The assessment indicates that landslides, levee breaches, and flooding represent the most significant risks, with major corridors such as Chuckanut Drive, Interstate 5 (I-5), and State Route 20 (SR-20) identified as particularly vulnerable to disruption.

The TRIP stakeholder engagement process included collaboration with member jurisdictions, Skagit Transit, emergency services, the Skagit Dike and Drainage Irrigation Consortium, the Port of Skagit, the Swinomish Indian Tribal Community, the Skagit Climate Science Consortium, Padilla Bay, WSDOT, the University of Washington Climate Impacts Group, and the broader community. This process, which relied on workshops, discussion groups, and online engagement platforms, captured local knowledge and identified community priorities. Public feedback highlighted the importance of addressing evacuation challenges and the needs of isolated communities. Findings from the engagement process informed every step of the TRIP development process, from the types of hazards assessed to the criteria used in the assessment.

The TRIP is not a standalone document, but rather a part of Move Skagit, the multimodal planning process connecting three concurrent planning processes including the Regional Transportation Plan update, Regional Safety Action Plan and this TRIP. The Regional Safety Action Plan and the Transportation Resilience Improvement Plan inform the Regional Transportation Plan in key areas related to roadway safety and resilience.

Figure 2. Move Skagit is the multimodal planning process connecting three concurrent planning processes including the Regional Transportation Plan update, Regional Safety Action Plan and Transportation Resilience Improvement Plan.

Further, the TRIP is designed to be fully incorporated into the RTP. It serves as a guiding framework for future transportation investments and policy decisions. Integrating TRIP into the RTP ensures that resilience considerations are embedded in all aspects of regional transportation planning. This alignment enables SCOG and its member agencies to address climate risks systematically, leverage federal and state funding opportunities, and coordinate across jurisdictions to protect regional infrastructure and maintain mobility for all residents. By establishing clear criteria for project evaluation, using performance monitoring, and reporting on likely outcomes of resilience-oriented investment, the TRIP supports continuous improvement and adaptive management, positioning Skagit County as a leader in transportation resilience.

Introduction

The Skagit Council of Governments (SCOG) prepared the Transportation Resilience Improvement Plan (TRIP) as part of its Regional Transportation Plan (RTP) update with funding from the Federal Highway Administration's (FHWA) Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Discretionary Program. The TRIP provides a strategic framework for enhancing the resilience of Skagit County's multimodal transportation system relating to current and future climate-related hazards. It will be used for both short-term and long-range planning activities and in support of investments to enhance the resilience of the surface transportation system. The results of the risk-based vulnerability assessment, conducted as part of the TRIP development process, identified transportation system and asset vulnerabilities in the regional transportation network and assessed how potential future climate-related hazards could impact these assets. The TRIP recommends strategies and candidate projects to mitigate or reduce the impacts of potential future climate-related hazards.

The scope of the TRIP includes:

- Evaluating exposure of roadways and bridges owned and operated by SCOG's member jurisdictions to the following potential natural hazards in Skagit County:
    - Coastal flooding
    - Fluvial flooding
    - Landslides
    - Seismic events
    - Liquefaction
    - Severe storm
    - Drought
    - Extreme Temperatures
    - Wildfire
    - Dam/Levee Breach

- Conducting a regional vulnerability assessment to understand how these hazards may impact the regional transportation network.
- Identifying resilience strategies and potential projects that reduce the risks to transportation assets.
- Recommending resilience strategies and a framework for evaluating projects that supports member agencies developing their own resilience projects.

Regulator and Policy Context

FEDERAL CONTEXT

As part of the Bipartisan Infrastructure Law, the PROTECT Program supports planning and capital investments that strengthen system resilience to natural hazards. As a PROTECT-funded planning activity, the TRIP follows FHWA guidance on the characteristics of the vulnerability assessment and the types of resilience strategies considered, with emphasis on roadway and bridge assets.

STATE CONTEXT

The Washington State Department of Transportation (WSDOT) is currently developing a statewide TRIP. SCOG relied on existing WSDOT resources as inputs into SCOG'S TRIP development process, which included statewide transportation system data and hazard information in order to ensure consistency with the statewide TRIP.

REGIONAL AND LOCAL ALIGNMENT

The TRIP supports and complements the SCOG RTP and the Regional Safety Action Plan update. The TRIP also aligns with and provides guidance for updates to local comprehensive plans, hazard mitigation plans, and tribal transportation plans, as well as supporting more general emergency management planning.

Stakeholder Engagement

Resilience of the roadway transportation system is a joint responsibility. A resilient transportation system benefits the entire traveling community. Community engagement plays a vital role in the development of the TRIP by ensuring that the voices, concerns, and perspectives of residents and stakeholders are actively integrated into the planning process. Through a combination of public meetings, focus groups, online platforms, and direct outreach, engagement efforts gathered diverse insights from those who use the transportation systems firsthand. These contributions help planners identify not only natural hazards of concern in the region, but also the unique challenges faced by specific communities within the region. Engagement for the TRIP was coordinated with other regional planning efforts, specifically – the RTP and Regional Safety Action Plan. Effective engagement fosters collaboration between agencies, tribal governments, and community organizations to enable any plan, and especially one targeted to improve the regional roadway network's resilience. Feedback from the community not only helped shape the identification of natural hazards of concern, but also guided the assessment and prioritization of interventions, helping ensure that TRIP is both comprehensive and responsive to the realities of Skagit County's communities. Aligning engagement for the TRIP with the Regional Safety Action Plan and the RTP helped clarify transportation strategies that address various community objectives and present a unified regional perspective on the transportation system.

MOVE SKAGIT PUBLIC ENGAGEMENT

The Move Skagit program hosted five virtual and in-person discussion groups and conducted nine tabling events where public feedback regarding the TRIP, RTP, and Regional Safety Action Plan was collected. These public community events are two-way information sharing opportunities for SCOG and can be catalysts for community engagement. Move Skagit was present at the following community events:

- Cascade Days, Concrete, August 15, 2025;
- Mount Vernon Block Party, Mount Vernon, August 16, 2025;
- Senior Day in the Park, Burlington, August 21, 2025;
- La Conner Swinomish Library, La Conner, August 28, 2025;
- Burlington Library, Burlington, September 9, 2025;
- Upper Skagit Library, Concrete, September 11, 2025;
- Anacortes Senior Activity Center, September 10, 2025;
- Anacortes Library, Anacortes, September 16, 2025; and
- Mount Vernon Senior Center, Mount Vernon, September 18, 2025.

Public participation in the TRIP was conducted through SCOG's Move Skagit online engagement platform, which includes a project website, newsletters, and an interactive map. These tools provided project updates and opportunities for community members to review hazard information, identify areas of concern, and learn how climate resilience is being incorporated into transportation planning.

Comments provided that relate to the TRIP included:

- City-added compacted gravel on side streets has eliminated drainage, causing stormwater pooling and algae growth.
- Americans with Disabilities Act (ADA) accessibility is compromised on 10th St. due to hazards and overgrown vegetation.
- Raised sidewalks need to be installed and proper drainage restored.
- Homeowners should be required to trim vegetation.
- Unofficial Kulshan Trail entrances indicate high levels of demand, but some entrances are hazardous due to erosion.
- Bluff erosion is increasing annually representing a potential threat to road safety.
- Flooding, sea level rise, and storms are growing concerns.
- Erosion needs to be monitored and integrated into climate resilience strategies.

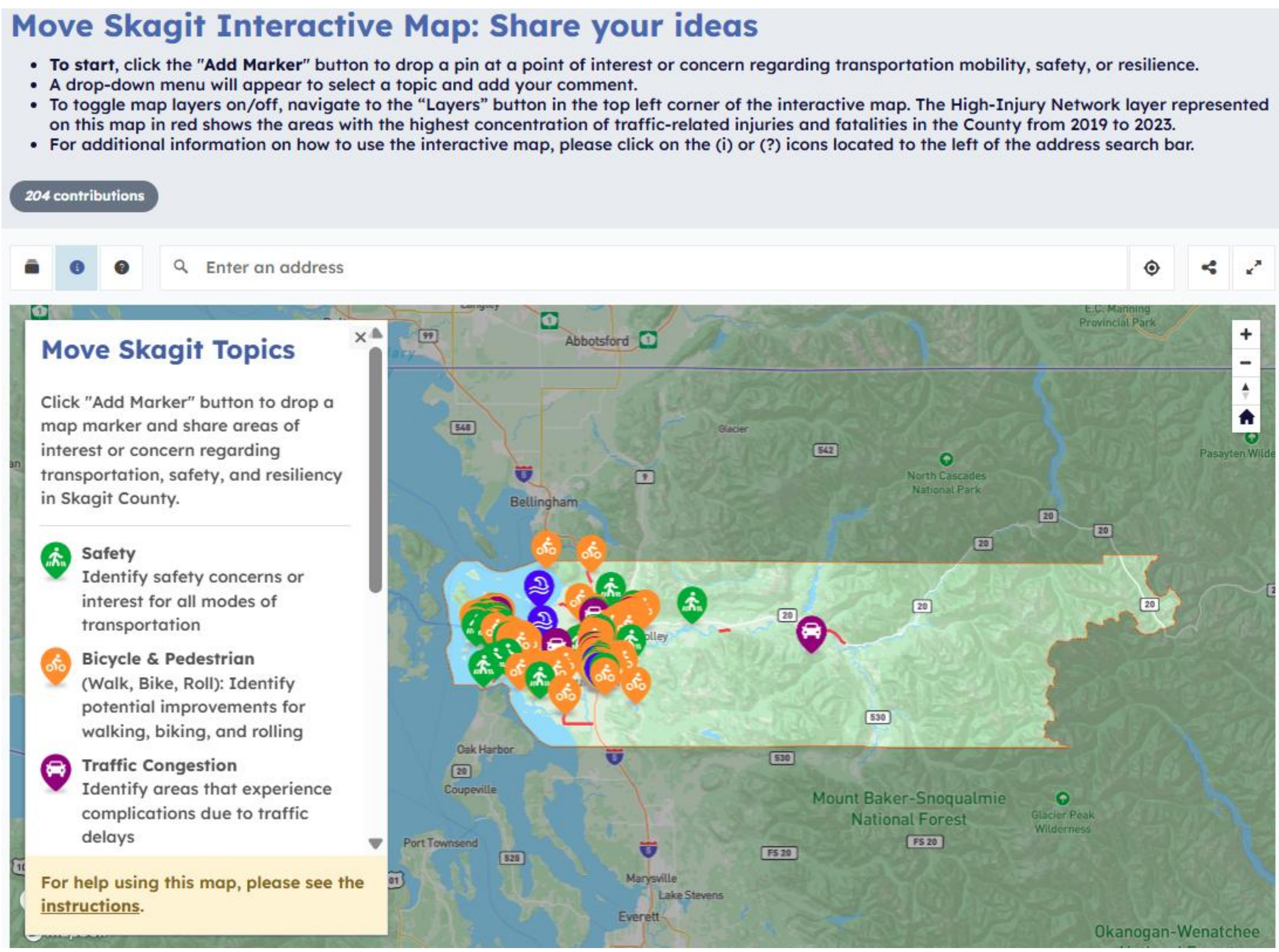

Figure 3. Social Pinpoint interactive web map, where the public was invited to place comments related to safety, transportation congestion, modal needs and resilience.

LOCAL AGENCY AND ORGANIZATION ENGAGEMENT

In addition to the Move Skagit public outreach efforts, SCOG hosted two discussion group meetings for the TRIP with member jurisdictions during the vulnerability assessment process. Member jurisdictions include:

- City of Anacortes
- Skagit County
- City of Burlington
- Skagit PUD
- City of Mount Vernon
- Skagit Transit
- City of Sedro Woolley
- Town of Concrete
- Port of Anacortes
- Town of Hamilton
- Port of Skagit
- Town of La Conner
- Swinomish Indian Tribal Community
- Town of Lyman
- Samish Indian Nation

The primary goals of these meetings were to, 1) discuss the methodology and gather information on transportation assets and climate hazards in the region, and 2) review the results of the vulnerability assessment and collect additional feedback on the prioritization process and the results. Other regional and state stakeholders invited to participate included WSDOT, the Skagit Climate Science Consortium, the Skagit Dike and Drainage Irrigation Consortium, the Swinomish Indian Tribal Community, Padilla Bay, and the University of Washington Climate Impacts Group.

A workshop was held in partnership with the Regional Safety Action Plan team and with emergency services and emergency management departments to collect information on transportation assets and current climate-related issues. Additionally, a discussion group was held with the SCOG Technical Advisory Committee (TAC) for the RTP, Regional Safety Action Plan, and TRIP to discuss key transportation needs and priorities for the region.

Feedback provided during the discussion groups and workshop included the following:

Hazard Data and Analysis

- Treat dam and levee failures as separate hazards.
- Consider Mt. Baker Lahar as a hazard.
- Add liquefaction as a key seismic hazard.
- Review data from the 2021 heat dome; humidity/wet bulb events may need to be considered.
- Conduct multi-frequency analysis (50-, 100-year events) for the vulnerability assessment to better prioritize investments.
- Assign probabilities to each of the six levee breach scenarios.

Transportation Network and Users

- Consider evacuation challenges during the 2021 floods that highlight the need for alternative routes and emergency supply movement.

- Note transportation access inequities and aging population trends. Suggested data resources included Skagit County public health data.
- Consider isolation and evacuation concerns, especially for overburdened communities and critical facilities.
- Assess freight mobility impacts and supply chain considerations.
- Align the TRIP with regional and state transportation plans.
- Rebuild the stormwater system and the corresponding roads to address stormwater concerns in the flatlands and around the Skagit River.
- Consider the elderly, rural communities, and people with medical transportation needs, perhaps the most significant transportation challenges in the county.

Locations of Concern

- Flag bluff erosion along Bayview Edison Road as a concern.
- Examine Samish Island's isolation if the main connecting road floods.
- Consider South Skagit Highway as an option for local emergency services and businesses if SR 20 is blocked; this involves crossing the Skagit River twice.

Implementation Considerations

- Include mitigation projects given they are critical for grant eligibility and funding prioritization.
- Explore additional prioritization lenses beyond monetization including equity, isolation, and community vulnerability.
- Ensure there are benefits for localities, not just the regional transportation network.
- Consider emergency services access from outside of the county ensuring access for aid into Skagit County from the south or north.

MEMBER AGENCY RESOURCES DEVELOPMENT

Additional outreach occurred with SCOG member agencies to ensure that proposed tools and outputs were practical, actionable, and aligned with local agency needs. Engagement occurred through virtual meetings with representatives from SCOG, Skagit County, and member cities including Sedro-Woolley and Mount Vernon. Input from member cities was also provided outside of these meetings from individuals who could not attend.

The project team presented the purpose of the TRIP, structure, and timeline. Agencies were guided through the regional risk assessment approach, including hazard screening, asset vulnerability, and loss estimation. Agencies engaged in detailed discussions on the risk results, particularly the interpretation of high-ranking roadway and bridge segments, the use of regional datasets, and how jurisdiction-specific context can influence perceived risk and prioritization. This feedback reinforced the importance of supplementing regional analysis with local knowledge and clearly communicating assumptions, limitations, and intended use of the results.

Member agencies also provided input on the suite of tools and resources being developed in parallel with the TRIP, including jurisdiction-specific results, GIS map layers, benefit-cost analysis (BCA) examples, a solutions toolkit, and guidance on how to leverage the results of the TRIP. Member agencies emphasized the need for resources that integrate seamlessly into existing capital planning, hazard mitigation, and grant application workflows, and that supported adding resilience elements to planned projects (rather than creating standalone resilience projects). Discussions highlighted the importance of tailoring solution examples to what cities and counties can realistically implement and identifying funding sources compatible with transportation projects. This outreach was instrumental in refining the guidance, selecting BCA examples, and advancing the TRIP to public review and adoption.

Key takeaways from this broad engagement included:

- Regional risk results are most valuable when paired with jurisdiction-specific context, clearly stated assumptions, and transparent explanations of data limitations.
- Member agencies want tools that help enhance existing projects with resilience features, rather than requiring separate, resilience-only projects.
- Practical and locally-grounded BCA examples are critical, particularly those that clearly address cost–benefit alignment across local, regional, and state interests.
- The solutions toolkit should reflect strategies that are feasible at the city and county level and support local prioritization and decision-making.
- Clear linkage of TRIP recommendations to funding eligibility and grant competitiveness is a strong motivator for agency use and adoption.

PUBLIC COMMENT PERIOD

Section to be updated following public comment period.

The draft TRIP was released for public comment on April 15, 2026. SCOG received XX comments from the community and partner agencies. A summary of all comments received is included in Appendix A.

Incorporating Resilience into the Regional Transportation Plan

During development of the TRIP project list, the team worked with the RTP team to integrate planning-level studies, and coordination with the RTP continues as the TRIP is updated over time. The TRIP identifies and prioritizes projects that reduce damage, mitigate disruptions, and protect transportation infrastructure from natural hazards. Projects identified through the TRIP are integrated into the RTP, which guides long-term investment and planning for a safer, more reliable transportation system. By aligning TRIP recommendations with the RTP, SCOG and its member agencies systematically address vulnerabilities to natural hazards, prioritize investments, and foster adaptive management practices that help safeguard the region.

The TRIP establishes a strategic framework for identifying and prioritizing projects that enhance transportation system resilience. Integration of the TRIP into the RTP enables:

- **Systematic Risk Reduction**: The TRIP's risk-based vulnerability assessment informs the RTP's long-term investment strategies, ensuring that resilience considerations are central to project selection and resource allocation.
- **Coordinated Action**: By embedding TRIP findings into the RTP, SCOG and its member agencies can leverage federal and state funding opportunities, coordinate across jurisdictions, and align local, regional, and tribal transportation resilience priorities.
- **Continuous Improvement**: The TRIP provides a foundation for ongoing adaptation, allowing the RTP to evolve in response to emerging hazards, new data, and stakeholder feedback.



Resilience in Goals

Resilience is explicitly reflected in the RTP's goals that include the region's ability to withstand and recover from climate-related hazards. Goal 8 of the RTP focuses on transportation resilience, defined as fostering a reliable and resilient transportation system that maintains essential mobility and access during disruptions and supports long-term sustainability and recovery.

Resilience in Policies

Under Goal 8, the RTP includes resilience through a suite of policies that guide planning, design, and implementation:

- 8.1: **Integration of Natural Hazard Data**: Incorporate comprehensive natural hazard data (including flooding, landslides, seismic, liquefaction, severe storms, and levee breaches) into project prioritization and planning processes, to enable data-driven decision-making.
- 8.2: **Resilient Design Standards**: Provide member jurisdictions guidance to integrate resilience considerations into roadway and bridge design standards, capital planning, and maintenance programs, where feasible.
- 8.3: **Project Development Support**: Facilitate the inclusion of resilience elements in transportation projects, providing technical assistance and a framework for evaluating resilience benefits.
- 8.4: **Cooperative Planning**: Foster interagency collaboration to address network connectivity, shared hazard exposures, and operational interdependencies, ensuring that resilience strategies are coordinated and comprehensive.
- 8.5: **Resilience Performance Measures**: Develop and adopt resilience performance measures into the RTP, identifying the appropriate data resources needed for future reporting. Examples of resilience performance measures could include, but would not be limited to:
  - Monitor and report reductions in service disruptions attributable to climate-related hazards
  - Track improvements in emergency response and evacuation times
  - Document the completion and effectiveness of prioritized resilience projects
  - Regularly update vulnerability assessments and hazard data to reflect new information

Resilience is an ongoing process that requires adaptive management and regular review. The TRIP is a living document that serves as a tool for member agencies to support continuous integration of resilience into transportation planning, design, and engineering decision-making. As new data, emerging risks, and insights from project implementation and stakeholder engagement become available, the TRIP may be updated accordingly. This adaptive approach enables the region to remain proactive in addressing climate challenges, apply best practices, and maintain alignment with evolving state and federal guidance.

Assessing the Transportation System's Vulnerability and Risk

Assessment Overview

A risk-based vulnerability assessment with a long-term planning period was conducted in the initial stages of the TRIP development process. The assessment reflects a systemic approach to surface transportation system resilience and is consistent with and complementary of State and local mitigation plans. The risk-based nature of the assessment evaluates the exposure and vulnerability of the transportation network, including roadways and bridges, to a comprehensive range of current and potential future weather events and natural disasters. The studied hazards were selected based on their relevance to the region, historical occurrences, and potential to disrupt the transportation network and in particular network connectivity. By integrating asset data with hazard information, the risk-based vulnerability assessment identified areas where transportation assets are most at risk and enables an understanding of vulnerabilities across the transportation network. This information also supports the prioritization of resilience improvements and informs strategies to protect the transportation network against future hazard events.

The vulnerability and risk assessment is critical to evaluating the potential loss of roadway and bridges in the transportation system to hazards like fluvial and coastal flooding, severe storms, drought, extreme temperature, wildfire, landslide, seismic events, liquefaction, and dam/levee breaches. Analyses were conducted quantitatively or qualitatively based on data availability. The analyses included identifying which assets are exposed to each hazard, the likelihood of damage under current and projected conditions, and the potential direct damage cost to assets and indirect consequences of damage to operations. The assessment produced risk profiles for each asset. This assessment helps identify potential projects, which projects should receive priority, and what type of support is necessary to reduce the risk to the regional transportation system.

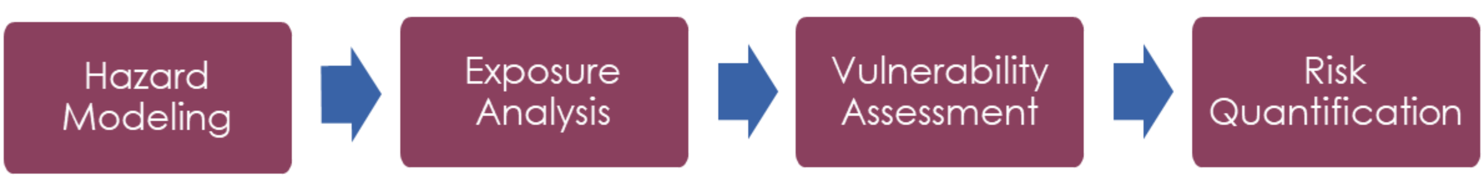

Figure 4. Quantitative Risk Assessment Approach

This section identifies the transportation assets and hazards included in the TRIP risk-based vulnerability assessment, describes the vulnerability and risk assessment methodology, and presents the results of the assessment. These findings are intended to inform long-term planning, prioritization, and resilience investment decisions. These findings are not intended to prescribe or assume a jurisdiction's immediate maintenance needs. Maintenance priorities are best determined by individual agencies based on local conditions, asset ownership, operational requirements, and available resources. These findings are intended to complement existing asset management, maintenance, and capital planning processes.

Step 1. Identify Transportation Assets

The risk assessment focuses on critical components of the regional transportation network, specifically roadways and bridges, which serve as essential links for the movement of people, goods, and emergency services in the region. The continued and reliable functioning of these assets is vital to the transportation network and to the communities it serves.

In total, 638 miles of roadway and 266 bridges were evaluated (see Figure 5. Transportation Assets). Roadway assets included local roads, county roads, state and interstate highways, and major arterials. The dataset was extracted from the SCOG Online GIS Portal. Within the dataset, the road name, length, and posted speed of each road segment are included.

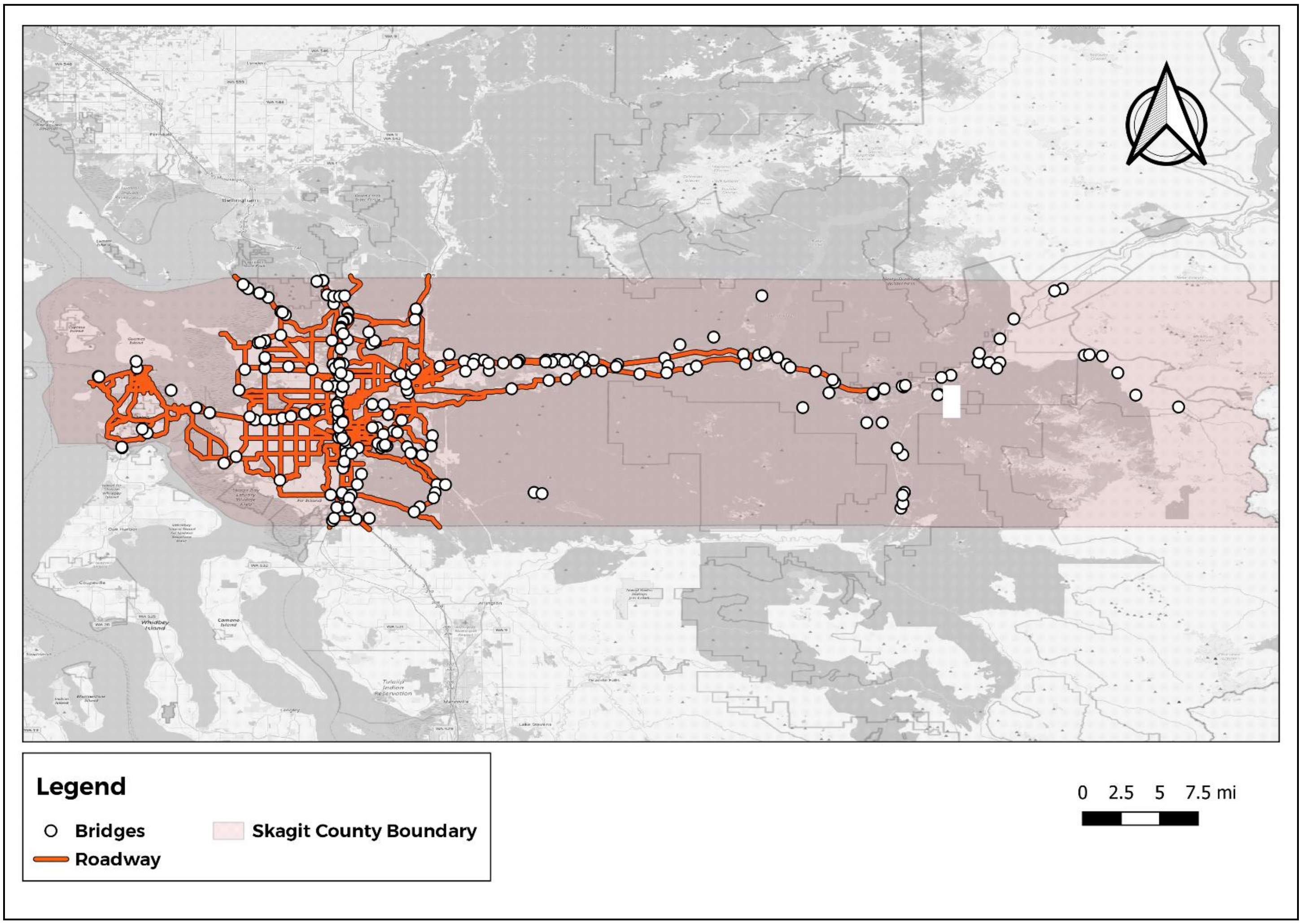

Figure 5. Transportation Assets

Bridges include bridge structures within the regional transportation network. The source of the bridge dataset is the [WSDOT All Bridge And Tunnel Inventory](), which includes the bridge name and geometric properties.

Step 2. Identify Relevant Hazards

The hazards considered include fluvial flooding, coastal flooding, severe storm, drought, wildfire, landslides, seismic, liquefaction, and dam/levee breach. Each hazard presents unique risks to the assets included in this assessment. Hazards were selected based on their potential to affect transportation infrastructure, their relevance to regional climate trends, and the availability of reliable data sources. Climate-related hazards were evaluated using historical observations and downscaled projections from the University of Washington Climate Impacts Group[1] under the high-emissions Representative Concentration Pathway (RCP) 8.5, which represents a future with continued high greenhouse gas emissions through the end of the century. The assessment focuses on mid- and late-century time horizons to capture both near- and long-term changes in hazard exposure.

FLUVIAL FLOODING

Fluvial flooding occurs when rivers or streams overflow their banks due to heavy or prolonged rainfall. In the SCOG region, this hazard reflects flooding associated with major river systems such as the Skagit River and local tributaries. The analysis used FEMA floodplain data[2] to identify the extent of potential inundation for 100- and 500-year floods.

COASTAL FLOODING

Coastal flooding occurs when elevated tides, storm surge, and sea level rise sea level rise inundate low-lying coastal areas. This hazard combines sea level rise projections from

[1] Washington County Climate Projections
[2] Flood Data Viewers and Geospatial Data | FEMA.gov

Washington Climate Impacts Group with flood modeling data from the Swinomish Indian Tribal Community[3] to evaluate 100-year flood depths under current and future sea level rise conditions. The analysis considers present, mid-century, and late-century scenarios to capture changes in inundation potential driven by rising sea levels.

SEVERE STORM

Severe storms include extreme precipitation events that can produce localized flooding, debris flows, and/or infrastructure damage. This hazard is characterized by using the average annual number of days with more than one, two, or three inches of precipitation, representing potential increases in the frequency of heavy rainfall events that can contribute to flooding. This hazard was analyzed using Washington Climate Impacts Group projections under the Representative Concentration Pathways (RCP) 8.5, a high greenhouse gas emissions scenario in the absence of policies to combat climate change, leading to continued and sustained growth in atmospheric greenhouse gas concentration, often described as the "worst case" climate scenario.[4]

DROUGHT

Drought represents periods when water availability is reduced due to limited precipitation or diminished snowpack. Two indicators were used in this assessment:

(a) Precipitation drought: the likelihood that total summer precipitation (June–August) will be below 75% of the historical normal.
(b) Snowpack drought: the likelihood that April 1st snowpack will fall below 75% of the historical average.

Prolonged dry conditions can dry out and shrink the soils beneath pavements (especially clay soils), reducing support and leading to cracking, rutting, and early degradation of asphalt.

Data came from Washington Climate Impacts Group for the RCP 8.5 scenario.

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[3] Home Page | Swinomish Indian Tribal Community, WA
[4] IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In press.

EXTREME TEMPERATURE

Extreme temperature refers to periods of unusually high heat that can stress infrastructure and public health. This hazard is characterized by two indicators:

(a) Extreme heat days: the average number of days per year with maximum temperature above 100°F over a 30-year period.
(b) 90°F maximum humidex days: average number of days in a year with a maximum humidex greater than 90°F in a 30-year period. The humidex is a measure of experienced heat conditions and takes into consideration both temperature and humidity.

Increases in these indicators represent heightened risks to transportation systems and heat-related health risks for transportation system users. The assessment is based on Washington Climate Impacts Group projections for the RCP 8.5 scenario.

WILDFIRE

Wildfire hazards capture conditions conducive to ignition and spread of large destructive fires across the region. An increased likelihood of climate and fuel conditions conducive to wildfire indicates a greater potential for wildfire-based damage to transportation infrastructure. Projections from Washington Climate Impacts Group are based on fire process model simulations under the RCP 8.5 scenario.

LANDSLIDES

Landslide hazards describe areas where slope instability, soil saturation, and precipitation combine to trigger downslope movement of earth materials. This hazard is represented through landslide susceptibility modeling, integrating slope relief and precipitation factors. Data were used from the U.S. Geological Survey's Landslide Inventory and Susceptibility Dataset.[5]

[5] Belair, G.M., Jones, J.M., Martinez, S.N., Mirus, B.B., and Wood, N.J., 2024, Slope-Relief Threshold Landslide Susceptibility Models for the United States and Puerto Rico: U.S. Geological Survey data release, https://doi.org/10.5066/P13KAGU3

SEISMIC

The seismic hazard represents the potential for ground shaking during an earthquake. The analysis relies on the U.S. Geological Survey's National Seismic Hazard Model,[6] which provides ground motion parameters such as peak ground acceleration. This data set captures the most current understanding of seismic activity across Washington State.

LIQUEFACTION

Liquefaction occurs when saturated soil temporarily loses strength during strong ground shaking, resulting in ground failure that could damage transportation assets. This hazard indicates the potential for liquefaction, considering factors such as soil characteristics, depth of the water table, and the intensity of seismic activity. The National Earthquake Reduction Program (NEHRP) site class dataset available through Washington Geologic Information Portal[7] provides a general guide to areas where earthquake shaking will be the strongest and where the potential damage to buildings and other structures may be elevated because of soil effects. Peak ground acceleration at areas with high and moderate-to-high liquefaction susceptibility was considered using the U.S. Geological Survey's National Seismic Hazard Model.

DAM/LEVEE FAILURE

The dam and levee breach hazard represents the potential flooding caused by failure, overtopping, or localized breach of flood protection infrastructure within the Skagit River watershed. Data for this analysis were provided by Swinomish Indian Tribal Community as preliminary results from flood modeling of the Skagit River system. Two primary scenarios were evaluated:

(a) With Levee condition: represents the 100-year riverine flood under current conditions.

(b) Levee Breach condition: combines six individual breach simulations based on weak points identified in the 2013 Skagit General Investigation study. The Levee Breach scenario reflects the maximum flood depth across all individual breach locations, allowing an identification of assets exposed only under breach conditions or experiencing increased flood depth due to levee failure.

[6] Petersen, M.D. et al., 2023, Data Release for the 2023 U.S. 50-State National Seismic Hazard Model - Overview: U.S. Geological Survey data release, https://doi.org/10.5066/P9GNPCOD
[7] Washington Geologic Information Portal

In addition to the hazards described above, volcanic hazard data from the U.S. Geological Survey was also reviewed, which provides simplified hazard polygons for Washington's five stratovolcanoes—Mount Adams, Mount Baker, Glacier Peak, Mount Rainier, and Mount St. Helens, available through Washington Geologic Information Portal. This dataset identifies potential volcanic phenomena such as lahars, debris avalanches, surges, and regional lava flows. Because the entire project area lies within a single volcanic hazard zone, lahar, a detailed assessment of volcanic activity was not conducted.

Table 1. Summary of Hazards

Hazard	Key Metric/Indicator	Time Horizon	Scenario	Data Source
Fluvial Flooding	Flood extent (100- and 500-year)	Current	–	FEMA Flood Hazard Area
Coastal Flooding	Flood depth (100-year event)	Current; 2040s; 2080s	RCP 8.5	University of Washington Climate Impacts Group (Sea Level Rise Projections); Swinomish Indian Tribal Community Flood Modeling
Severe Storm	Annual days >1", >2", >3" precipitation	Historical; 2050; 2080	RCP 8.5	University of Washington Climate Impacts Group
Drought	Precipitation Drought (summer precipitation <75% of normal); Snowpack Drought (April 1 snowpack <75% of normal)	Historical; 2050; 2080	RCP 8.5	University of Washington Climate Impacts Group
Extreme Temperature	Hot Days (>100°F); Maximum Humidex Days (>90°F)	Historical; 2050; 2080	RCP 8.5	University of Washington Climate Impacts Group
Wildfire	Wildfire probability	Historical; 2050; 2080	RCP 8.5	University of Washington Climate Impacts Group
Landslides	Landslide susceptibility	Current	–	U.S. Geological Survey (USGS) Landslide Inventory and Susceptibility Dataset
Seismic	Peak Ground Acceleration (PGA-975)	Current	–	U.S. Geological Survey (USGS) National Seismic Hazard Model
Liquefaction	Liquefaction susceptibility (high and moderate-to-high zones) and Peak Ground Acceleration (PGA-975)	Current	–	National Earthquake Reduction Program (NEHRP); USGS National Seismic Hazard Model
Dam/Levee Breach	Flood depth under levee breach and with-levee scenarios	Current	–	Swinomish Indian Tribal Community (Preliminary Skagit River Flood Modeling)

Step 3. Conduct an Exposure Assessment

To accurately evaluate the exposure of transportation infrastructure to various hazards, a geospatial analysis was conducted by overlaying the hazard data, representing the geographic extent and/or intensity of a specific hazard, with the asset data that contains the location-specific characteristics of transportation assets.

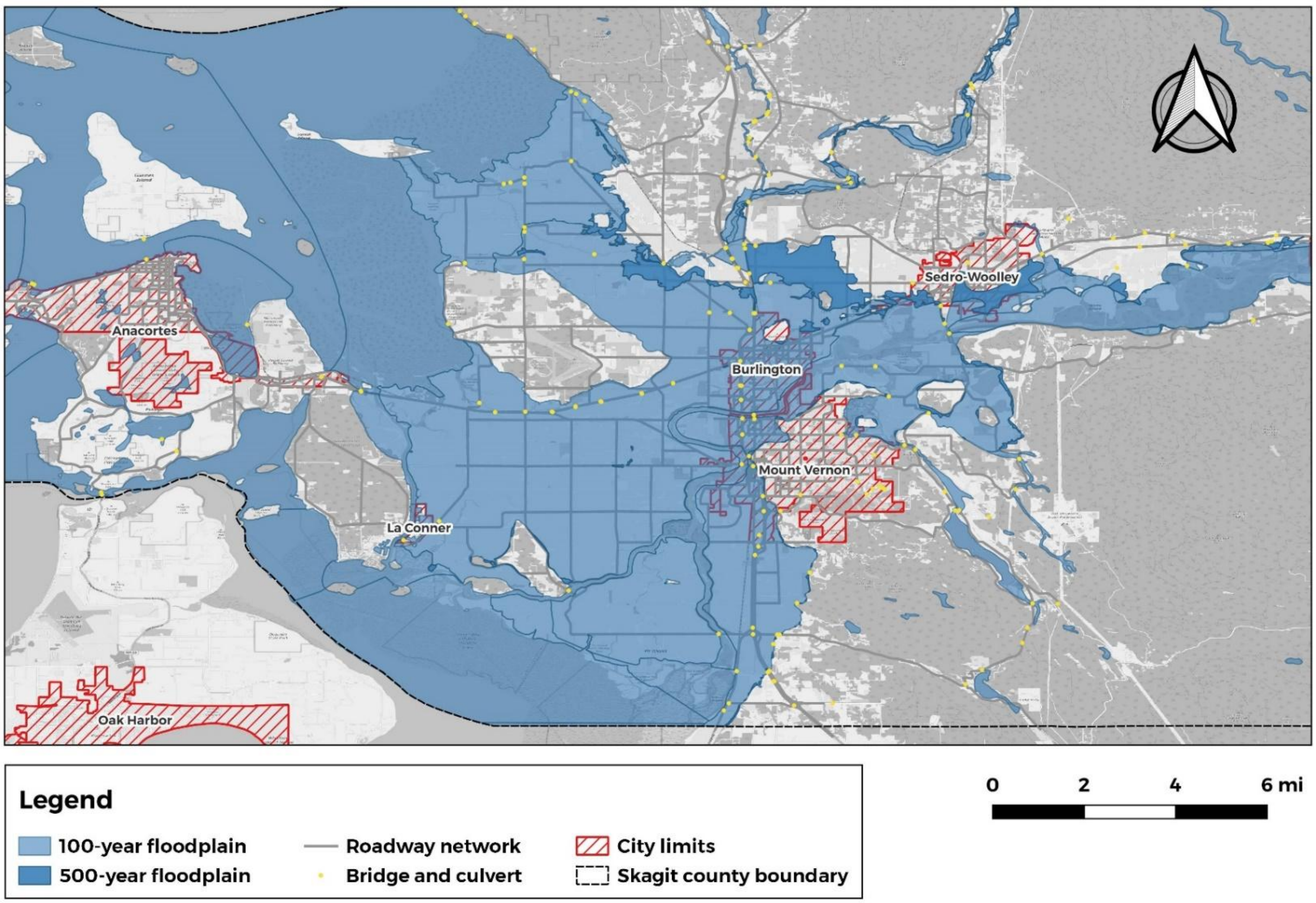

Figure 6. An exposure analysis identifies which assets are located in hazard areas

Table 2 summarizes the results of the exposure assessment, including the exposed length or number of transportation assets affected by each hazard for different scenarios.

Table 2. Exposure Assessment Summary

Hazards	Exposed Roadway (Percent of Roadway)	Exposed Bridge (Percent of Bridges)
Coastal flooding	– Current: 1.53 miles (0.24%) – 2040: 1.83 miles (0.29%) – 2080: 3.49 miles (0.55%)	– Current: 21 bridges(7.89%) – 2040: 23 bridges (8.65%) – 2080: 27 bridges(10.15%)
Fluvial flooding	– 100-year floodplain: 238.59 miles (37.43%) – 500-year floodplain: 269.79 miles (42.33%)	– 100-year floodplain: 137 bridges (51.50%) – 500-year floodplain: 153 bridges (57.52%)
Dam/Levee breach	137.97 miles (21.65%)	69 bridges (25.94%)
Landslides	414.36 miles exposed (64.99%) – Low to moderate risks: 365.2 miles (57.36%) – Moderate to high risks: 49.16 miles (7.71%)	175 bridges exposed (65.79%) – Low to moderate risks: 123 bridges (46.24%) – Moderate to high risks: 52 bridges (19.55%)
Liquefaction	– Moderate to high: 403.15 miles (63.47%) – Low to moderate: 232.07 miles (36.53%)	– Moderate to high: 150 bridges (56.39%) – Low to moderate: 87 bridges (32.71%)
Wildfire	Weighted Average Wildfire Probability: – Historical: 0.12% – 2050s: 3.37% – 2080s: 2.69%	Average Wildfire Probability: – Historical: 0.17% – 2050s: 3.19% – 2080s: 3.88%

Hazards	Exposed Roadway (Percent of Roadway)	Exposed Bridge (Percent of Bridges)
Extreme temperature	Weighted Average Exposure: – Annual days exceed 100°F o Historical: 0.03 days o 2050: 0.22 days o 2080: 0.22 days – Annual days exceed 90°F o Historical: 2.08 days o 2050: 25.21 days o 2080: 53.85 days	Average Exposure: – Annual days exceed 100°F o Historical: 0 days o 2050: 0.14 days o 2080: 0.84 days – Annual days exceed 90°F o Historical: 4.18 days o 2050: 28.72 days o 2080: 55.68 days
Severe storm	Weighted Average Exposure: – Annual days exceed 3 inches o Historical: 0.09 days o 2050: 0.12 days o 2080: 0.21 days – Annual days exceed 2 inches o Historical: 0.66 days o 2050: 0.87 days o 2080: 1.26 days – Annual days exceed 1 inch o Historical: 5.64 days o 2050: 7.34 days o 2080: 8.87 days	Average Exposure: – Annual days exceed 3 inches o Historical: 0.31 days o 2050: 0.43 days o 2080: 0.61 days – Annual days exceed 2 inches o Historical: 1.66 days o 2050: 2.11 days o 2080: 2.61 days – Annual days exceed 1 inch o Historical: 9.89 days o 2050: 11.77 days o 2080: 13.40 days

Hazards	Exposed Roadway (Percent of Roadway)	Exposed Bridge (Percent of Bridges)
Drought	Weighted Average Exposure: – Precipitation drought probability: o Historical: 0.25 o 2050: 0.26 o 2080: 0.39 – Snowpack drought probability: o Historical: 0.07 o 2050: 0.07 o 2080: 0.07	Average Exposure: – Precipitation drought probability: o Historical: 0.25 o 2050: 0.26 o 2080: 0.39 – Snowpack drought probability: o Historical: 0.15 o 2050: 0.17 o 2080: 0.19

Step 4. Assess Transportation Asset Vulnerability

Vulnerability refers to the degree to which an asset is affected or damaged by a hazard, which reflects how sensitive the asset is to the impact of that hazard. The assessment of vulnerability can be approached from both quantitative and qualitative perspectives depending on the availability of relevant data.

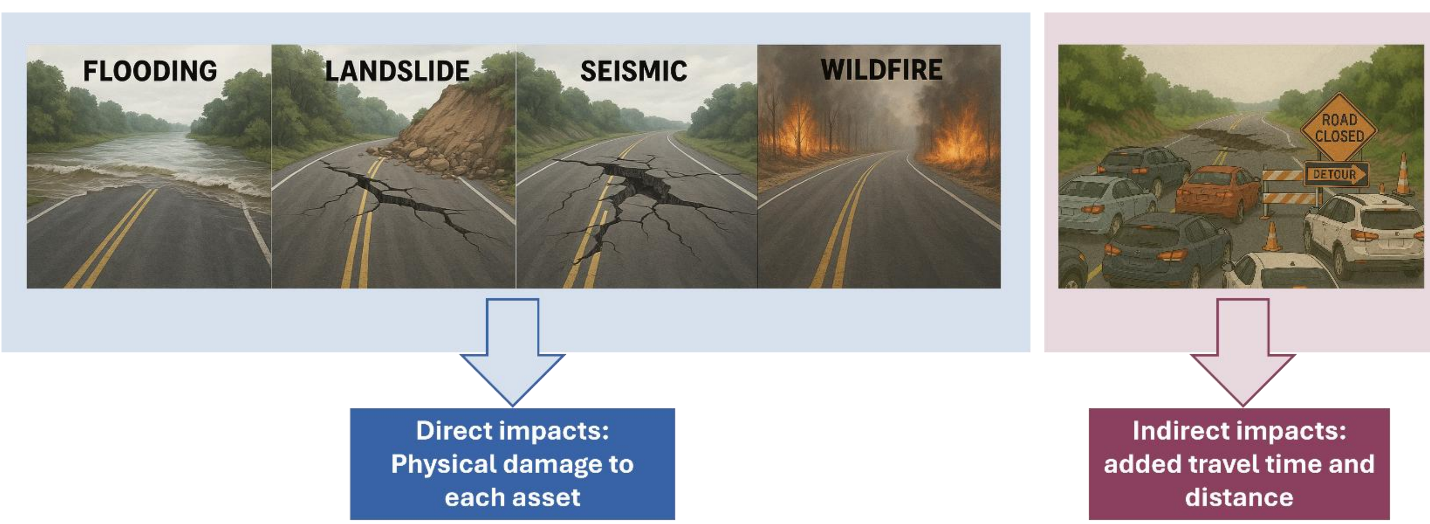

Figure 7. A vulnerability assessment measures the degree to which an asset is affected or damaged by a hazard

QUANTITATIVE VULNERABILITY ANALYSIS

In quantitative analysis, vulnerability is typically represented through a vulnerability curve or function. This curve illustrates the damage ratio experienced by an asset at varying levels of hazard intensity, such as the depth of flooding. If a vulnerability curve is not available, a fragility curve can be used as an alternative method to quantify the impact of hazards. The fragility curve displays the probability of exceeding different damage states for an asset given a specific hazard intensity. This probability can be translated into the expected asset damage.

Table 3 lists the applied vulnerability functions or assumptions with their references.

Table 3. Quantitative Vulnerability Analysis

Asset	Hazards	Hazard intensity measure	Vulnerability	Reference
Roadway	Coastal flooding Dam/Levee breach	Flooding depth	Depth-Damage Function	Huizinga, J., de Moel, H., and Szewczyk, W.: Global flood depth-damage functions: Methodology and the Database with Guidelines, Joint Research Centre (JRC), 108 pp., https://doi.org/10.2760/16510, 2017.
	Fluvial flooding	Flooding extent	When the asset is exposed to fluvial flooding, the exposed portion will have 50% damage	For fluvial flooding, infrastructure inundation depth varies widely depending on floodplain geometry, topography, and hydraulic stage. A representative damage ratio (50%) is applied to provide a conservative vulnerability assumption.
	Landslides	Landslide susceptibility	Landslide impact categorization according to landslide susceptibility	Mirus, Benjamin B., et al. "Parsimonious high-resolution landslide susceptibility modeling at continental scales." AGU Advances 5.5 (2024): e2024AV001214.
	Earthquake	Peak Ground Acceleration (PGA)	Earthquake fragility function	Argyroudis, S. and Kaynia, A. M.: Fragility Functions of Highway and Railway Infrastructure, in: SYNER-G: Typology Definition and Fragility Functions for Physical Elements at Seismic Risk., vol. 27, edited by: Pitilakis, K., Crowley, H., and Kaynia, A. M., Springer, Dordrecht, 299–326, 2014.

Asset	Hazards	Hazard intensity measure	Vulnerability	Reference
Roadway	Liquefaction	Liquefaction susceptibility (high and moderate-to-high zones) and Peak Ground Acceleration (PGA-975)	When PGA-975 exceeds 0.44g, and the liquefaction susceptibility (moderate to high zones)	National Earthquake Reduction Program (NEHRP); USGS National Seismic Hazard Model
	Severe storm	Daily precipitation depth	Additional repair ratio due to precipitation	Intense precipitation can increase pavement saturation and material degradation, resulting in maintenance and repair needs. Because no deterministic function exists linking daily precipitation to a precise damage percentage, a scenario-based additional repair ratio is assumed when daily precipitation exceeds selected thresholds.
Bridges	Coastal Flooding	Scour depth	Bridge scour damage	Tafur, Anibal, et al. "Climate-resilient railway networks: a resource-aware framework." *Communications Engineering* 4.1 (2025): 157.

QUALITATIVE VULNERABILITY ANALYSIS

When quantitative data is limited or unavailable, vulnerability can be described qualitatively. This approach involves characterizing the susceptibility of assets to hazards using descriptive measures, providing insight into the potential impacts without relying on numerical data. **Error! Reference source not found.** shows the parameters of the qualitative analysis.

Table 4. Qualitative Vulnerability Analysis

Hazards	Hazard intensity measure	Impacts on structural performance	Impacts on asset users
Extreme temperature	Extreme Heat Days (>100°F); Maximum Humidex Days (>90°F)	– For flexible pavement, accelerated asphalt rutting and bleeding under high pavement temperatures, which leads to loss of structural capacity	– Unsafe driving conditions due to pavement deformation

Hazards	Hazard intensity measure	Impacts on structural performance	Impacts on asset users
		– For the rigid pavement, thermal expansion causes pavement blowup or joint distress – For bridges, thermal expansion leads to joint locking, seal deterioration, and heat-induced material fatigue	– Health risks for drivers and passengers due to high temperatures
Drought	Precipitation Drought (summer precipitation <75% of normal); Snowpack Drought (April 1 snowpack <75% of normal)	– Typically, minimal direct impact on roadway and bridge structural components – Effects are primarily limited to soil-structure interface – Impacts are generally low and location-dependent	– Higher wildfire susceptibility along the corridor
Wildfire	Wildfire probability	– Roadway: o For flexible pavement, heat damage to asphalt surfaces will lead to softening ,rutting, and stripping o Material degradation and accelerated aging and reduced lifespan o Roadside facilities damaged or melted o Heavy post-fire equipment loading can cause structural damage o Erosion and slope instability o Drainage blockage – Bridges: o Damage to timber bridges or components o Loss of protective coating on steel members o Heat damage to bearing sand expansion joints	– Road closures due to fire danger or smoke conditions – Reduced visibility causing collisions

Step 5. Evaluate Financial Impact

To evaluate the impacts of various hazards on transportation assets, direct and indirect losses are applied as monetized impacts, which contribute to the overall consequences experienced by asset owners and users.

DIRECT LOSSES

Direct losses are the immediate physical damage sustained by transportation infrastructure due to a hazard-related impact. These include the cost of repairing or replacing damaged roads and bridges. For example, after a flood or a seismic event, sections of a road may require reconstruction or a bridge might need significant structural repairs.

Direct losses are calculated by a damage ratio and exposed asset values. The damage ratios are determined by vulnerability analysis, and the exposed asset values are calculated by the unit price and exposed length or size. The assumption of the unit price for the roadway is from the HAZUS Inventory Technical Manual (see Table 5).

Table 5. Unit price for roadway (source: HAZUS Inventory Technical Manual)

Road types	Replacement cost $/mile ($2025)
Major road with four lanes	$13,521,219
Urban streets with two lanes	$6,760, 610

The unit price for bridges is based on the HAZUS Inventory Technical Manual by categorizing bridges into corresponding classes, as shown in Table 6.

Table 6. Unit price for bridges (source: HAZUS Inventory Technical Manual)

Bridge Class	Bridge Description	Replacement cost $/Square Foot ($2025)
HWB1	Major Bridge - Length > 150 meters (Conventional Design)	$770
HWB2	Major Bridge - Length > 150 meters (Seismic Design)	$705
HWB3	Single Span – (Not HWB1 or HWB2) (Conventional Design)	$513
HWB4	Single Span – (Not HWB1 or HWB2) (Seismic Design)	$610
HWB5	Concrete, Multi-Column Bent, Simple Support (Conventional Design), Non-California (Non-CA)	$482
HWB6	Concrete, Multi-Column Bent, Simple Support (Conventional Design), California (CA)	$482
HWB7	Concrete, Multi-Column Bent, Simple Support (Seismic Design)	$610
HWB8	Continuous Concrete, Single Column, Box Girder (Conventional Design)	$385
HWB9	Continuous Concrete, Single Column, Box Girder (Seismic Design)	$513
HWB10	Continuous Concrete, (Not HWB8 or HWB9) (Conventional Design)	$353

Bridge Class	Bridge Description	Replacement cost $/Square Foot ($2025)
HWB11	Continuous Concrete, (Not HWB8 or HWB9) (Seismic Design)	$385
HWB12	Steel, Multi-Column Bent, Simple Support (Conventional Design), Non-California (Non-CA)	$705
HWB13	Steel, Multi-Column Bent, Simple Support (Conventional Design), California (CA)	$705
HWB14	Steel, Multi-Column Bent, Simple Support (Seismic Design)	$898
HWB15	Continuous Steel (Conventional Design)	$705
HWB16	Continuous Steel (Seismic Design)	$898
HWB17	PS Concrete Multi-Column Bent, Simple Support (Conventional Design), Non-California	$482
HWB18	PS Concrete, Multi-Column Bent, Simple Support (Conventional Design), California (CA)	$482
HWB19	PS Concrete, Multi-Column Bent, Simple Support (Seismic Design)	$610
HWB20	PS Concrete, Single Column, Box Girder (Conventional Design)	$482
HWB21	PS Concrete, Single Column, Box Girder (Seismic Design)	$610
HWB22	Continuous Concrete, (Not HWB20/HWB21) (Conventional Design)	$449
HWB23	Continuous Concrete, (Not HWB20/HWB21) (Seismic Design)	$513
HWB24	Same definition as HWB12 except the bridge length is less than 20 meters	$705
HWB25	Same definition as HWB13 except the bridge length is less than 20 meters	$770
HWB26	Same definition as HWB15 except the bridge length is less than 20 meters and Non-CA	$962
HWB27	Same definition as HWB15 except the bridge length is less than 20 meters and in CA	$962
HWB28	All other bridges that are not classified (including wooden bridges)	$385

By utilizing the unit price and asset geometry attributes, the value of an asset can be estimated. When integrated with the damage ratio, this allows for the calculation of direct losses in the event of a hazard.

INDIRECT LOSSES

Indirect losses refer to the secondary effects that arise as a result of the asset being damaged or out of service. These can include increased travel times, additional vehicle operation, congestion, noise, additional safety costs, and additional pavement damage. In this analysis, changes in Vehicle Miles Traveled (ΔVMT) and Vehicle Hours Traveled (ΔVHT) are used as quantitative measures for indirect losses. ΔVMT captures the additional distance vehicles travel due to detours or route changes, while ΔVHT reflects the increased travel time resulting from detours. Monetizing these impacts uses unit values listed in Table 7.

Table 7. Indirect losses unit price (source: US DOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs)

Variable	Unit	Value (2025$)
Vehicle Operating Costs per Mile - Autos	2025$/mile	$0.474

Variable	Unit	Value (2025$)
Congestion Costs per Mile - Autos	2025$/mile	$0.134
Noise Costs per Mile - Autos	2025$/mile	$0.002
Safety Costs per Mile - Autos	2025$/mile	$0.015
Average Vehicle Occupancy - Auto	people/auto	1.67
Value of Time - Auto	2025$/hour	$20.188
Auto Average Pavement Cost	2025$/mile	$0.003

Calculating total indirect losses for transportation asset users and the broader community during disruptions is achieved by multiplying the changes in vehicle miles traveled (ΔVMT) and vehicle hours traveled (ΔVHT) by their respective unit costs.

Step 6. Analyze Long-Term System Risk

In addition to asset-level damage and quantified losses, disruptions to critical transportation corridors in Skagit County can result in system-level isolation with significant implications for mobility, emergency response, and community access. Several corridors function as primary or sole connections for large geographic areas where closures can impact regional connectivity. SR 20 represents a key vulnerability in this regard. If SR 20 becomes inoperable, much of eastern Skagit County may become isolated from the remainder of the regional transportation network. Similarly, disruptions to SR 20 affecting access to Fidalgo Island can result in limited or no viable alternative routes. These examples highlight how conditions can constrain evacuation, emergency response, and access to essential services, particularly for rural and isolated communities. While this TRIP focuses on screening-level risk assessment, the results highlight the importance of future, targeted studies focused on evacuation routes, operational performance during emergencies, and network redundancy to reduce reliance on single access corridors and improve overall system resilience.

Assessing the risks to transportation assets involves analyzing the annual hazard probabilities and their associated impacts. By multiplying the annual hazard probability by the total estimated impact for each asset (direct and indirect losses), annual losses can be quantified. Furthermore, through lifecycle analysis, cumulative losses over a 30-year period can be projected, providing a long-term perspective on asset risks. Table 8 shows the parameters used for lifecycle analysis.

Table 8. Lifecycle analysis parameters

Variable	Unit	Value
Base year of analysis	year	2025

Variable	Unit	Value
Construction time	years	2
Project Opening Year	year	2026
Analysis Period	years	30
End year of analysis	year	2055
Discount rate	percent	3.1%[8]

Figure 8 provides an overview of roadway segments evaluated across Skagit County and highlights those identified among the top 20 based on estimated losses. Figure 9 shows a more detailed view of the locations of the top 20 segments. Table 9 presents the losses associated with the top 20 assets facing the highest risks from all hazards.

[8] Discount Rates for Benefit-Cost Analysis

Figure 8. Overview of Roadway Segments Evaluated

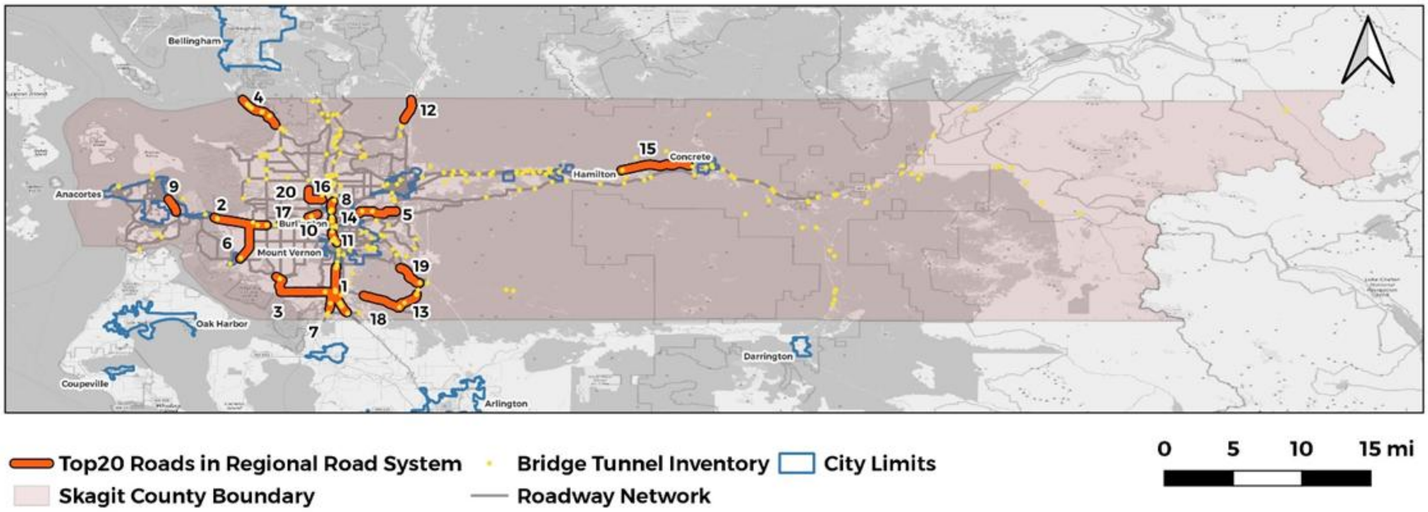

Figure 9. Zoomed-in view of the Top 20 Segments

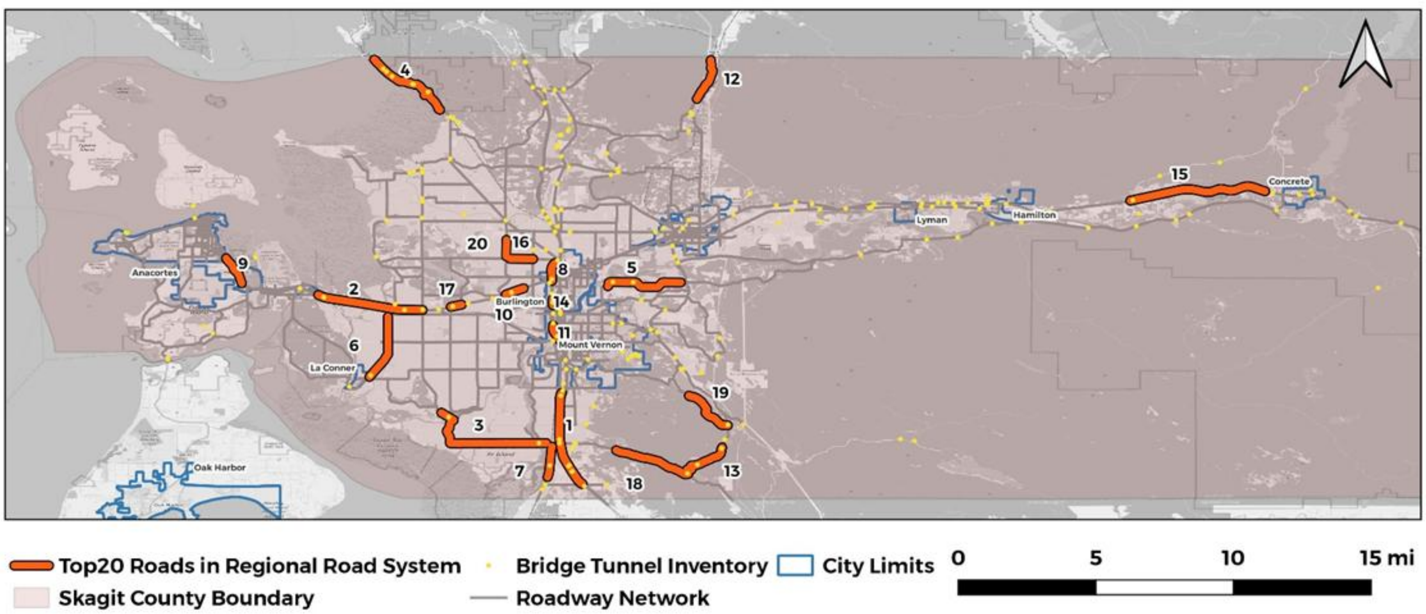

Table 9. Top 20 highest risk assets with losses

No.	Road Segment	Coastal Flooding	Fluvial Flooding	Levee Breach	Landslides	Seismic	Liquefaction	Severe Storm	Total Losses
1	I-5	$220,329	$3,959,742	$808,113,465	$5,300,059	$1,103,118	$1,064,240	$6,275	**$819,767,229**
2	State Route 20	$21,755,681	$1,635,549	$301,655,217	$1,635,099	$463,736	$509,600	$11,932	**$327,666,814**
3	Fir Island Road	$8,969,597	$1,205,373	$262,769,731	$4,223,795	$257,386	$340,601	$1,409	**$277,767,893**
4	Chuck-anut Drive	$63,958	$33,075	$0	$239,546,967	$73,486	$0	$4,347	**$239,721,832**
5	Francis Road	$225,646	$772,116	$200,759,768	$609,346	$93,860	$0	$4,340	**$202,465,076**
6	La Conner Whitney Road	$196,778	$866,548	$183,531,876	$0	$90,928	$231,261	$4,273	**$184,921,664**
7	Pioneer Highway	$1,263,562	$420,078	$102,875,826	$711,251	$64,595	$111,971	$0	**$105,447,283**
8	I 5	$0	$737,768	$99,851,016	$1,116,222	$105,397	$0	$0	**$101,810,402**
9	State Route 20 Spur	$0	$0	$0	$101,171,150	$119,756	$0	$0	**$101,290,906**
10	State Route 20	$0	$370,617	$96,314,009	$0	$53,192	$0	$0	**$96,737,818**
11	I 5	$0	$472,228	$81,509,363	$13,099,929	$116,320	$0	$0	**$95,197,841**
12	State Route 9	$0	$0	$0	$81,254,448	$69,982	$2,037	$11,016	**$81,337,483**
13	State Route 9	$0	$0	$0	$69,687,465	$72,156	$0	$1,538	**$69,761,159**
14	I 5	$0	$256,943	$65,208,697	$733,527	$18,753	$0	$3,649	**$66,221,569**
15	North Cascades Highway	$21,500	$207,028	$38,840,284	$23,326,703	$184,037	$0	$2,907	**$62,582,460**
16	Josh Wilson Road	$0	$210,079	$54,586,766	$0	$30,028	$0	$4,374	**$54,831,247**

No.	Road Segment	Coastal Flooding	Fluvial Flooding	Levee Breach	Landslides	Seismic	Liquefacti-on	Severe Storm	Total Losses
17	State Route 20 East-bound	$0	$205,939	$51,755,563	$0	$30,771	$54,892	$0	**$52,047,165**
18	State Route 534	$0	$0	$0	$48,023,470	$109,785	$0	$0	**$48,133,255**
19	West Big Lake Boulevard	$0	$9,854	$0	$46,993,885	$164,103	$0	$4,129	**$47,171,971**
20	Avon Allen Road	$0	$224,754	$45,341,339	$0	$16,351	$0	$1,029	**$45,583,473**

In summary, landslides, levee breaches, and coastal/fluvial flooding account for most losses in road segments. These hazards can lead to significant damage, causing roads to become impassable and disrupting transportation networks. As shown in Table 9, considering quantified losses across all hazards, a segment of *Chuckanut Drive* is the most vulnerable road segment, spanning 4.183 miles and containing six bridges. Located within Larrabee State Park, this segment faces a high risk of severe landslides. The majority of Chuckanut Drive falls within areas where landslide susceptibility is significant. In addition to landslides, this segment is at high risk from seismic events and coastal flooding. Table 9 also shows that many of the highest-ranked vulnerable assets experience substantial losses from levee breach scenarios. This underscores how catastrophic an event would be for the transportation network in this area and indeed for the entire community.

Regionally Significant Transportation Resilience Project Locations

The top 20 assets facing the highest risks from all hazards were further reviewed as candidate project sites for future mitigation of potential climate-related hazard impacts. The following sections summarize key characteristics and natural hazard exposure for roadway segments identified as having the highest potential losses within the Skagit County regional roadway system. These candidate project site descriptions provide an “at-a-glance” reference to support regional conversations about transportation risk, resilience needs, and potential areas for further evaluation. Each roadway segment description includes:

- Segment length and location
- Roadway functional classification

- Exposure to select natural hazards based on available data and modeling

The information presented is designed to complement, not replace, more detailed technical analyses. The candidate project site descriptions are not intended to establish project scopes, rank projects for funding, or prescribe specific mitigation actions. Instead, the intent is to:

- Provide a clear and consistent snapshot of hazard exposure across the highest risk roadway segments.
- Support a comparative review and discussion among member agencies.
- Inform screening-level prioritization, planning, and coordination efforts.
- Help identify locations that may warrant more detailed study, project development, or integration into future planning and funding efforts.

These candidate project site descriptions should not be used as the sole basis for investment decisions, design standards, emergency response planning, or damage assessments at any specific location. Percentages, depths, and hazard metrics represent modeled or mapped conditions at a regional screening level. Local conditions, design features, and future changes may not be fully reflected. The information presented is based on available datasets and regional-scale models. Actual local hazard impacts and damages may differ from those shown.

I-5 (No. 1)

LENGTH

- 5.11 miles

START AND END LOCATION

- Start: South of Mount Vernon Road
- End: North of Starbird Road

HAZARD INFORMATION

Coastal Flooding

- 2020: 0.1% of the road segment is exposed to the maximum flood depth of 1.64 ft, 16.7% of the bridges are exposed to the maximum flood depth of 1.10 ft
- 2040: 0.1% of the road segment is exposed to the maximum flood depth of 1.66 ft, 16.7% of the bridges are exposed to the maximum flood depth of 1.12 ft
- 2080: 0.1% of the road segment is exposed to the maximum flood depth of 2.03 ft, 16.7% of the bridges are exposed to the maximum flood depth of 1.49 ft

Dam/Levee Breach

- Exposed maximum inundation depth: 17.8 ft

Fluvial Flooding

- 77% of segment is located in the 100-year and 79% of segment is located in 500-year flood plain

Landslides

- Highest landslide susceptibility: 6.61 out of 81 (the higher value represents higher landslide risks)

Seismic

- The road segment is exposed to peak ground acceleration (PGA-975) of 0.45g to 0.46g

Liquefaction

- 8% of the road segment is exposed to very low liquefaction susceptibility
- 15% of the road segment is exposed to low to moderate liquefaction susceptibility
- 45% of the road segment is exposed to moderate to high liquefaction susceptibility
- 32% of the road segment is exposed to high liquefaction susceptibility

ROADWAY CLASSIFICATION

- Interstate

SR 20 (No. 2)

LENGTH

- 3.90 miles

START AND END LOCATION

- Start: South Marchs Point Road
- End: Best Road

HAZARD INFORMATION

Coastal Flooding

- 2020: 3.3% of the road segment is exposed to the maximum flood depth of 36.93 ft, 33.3% of the bridges are exposed to the maximum flood depth of 5.65 ft
- 2040: 3.3% of the road segment is exposed to the maximum flood depth of 37.39 ft, 33.3% of the bridges are exposed to the maximum flood depth of 5.67 ft
- 2080: 0.001% of the road segment is exposed to the maximum flood depth of 38.14 ft, 33.3% of the bridges are exposed to the maximum flood depth of 5.67 ft

Dam/Levee Breach

- Exposed maximum inundation depth: 10.3 ft

Fluvial Flooding

- 83% of the road segment is located in the 100-year and 500-year flood plain

Landslides

- Highest landslide susceptibility: 9.55 out of 81 (the higher value represents higher landslide risks)

Seismic

- The road segment is exposed to peak ground acceleration (PGA-975) of 0.46g to 0.47g

Liquefaction

- 46% of the road segment is exposed to moderate to high liquefaction susceptibility
- 54% of the road segment is exposed to high liquefaction susceptibility

ROADWAY CLASSIFICATION

- Freeway

Fir Island Road and Best Road (No. 3)

LENGTH

- 7.59 miles

START AND END LOCATION

- Start: Dike Road
- End: Summers Drive

HAZARD INFORMATION

Coastal Flooding

- 2020: 0.9% of the road segment is exposed to the maximum flood depth of 33.12 ft, none of the bridges are exposed to coastal flooding
- 2040: 2.1% of the road segment is exposed to the maximum flood depth of 33.61ft, 50% of the bridges are exposed to the maximum flood depth of 0.37 ft
- 2080: 2.3% of the road segment is exposed to the maximum flood depth of 34.41 ft, 50% of the bridges are exposed to the maximum flood depth of 3.02 ft

Dam/Levee Breach

- Exposed maximum inundation depth: 20.99 ft

Fluvial Flooding

- 89% of the road segment is located in the 100-year and 500-year flood plain

Landslides

- Highest landslide susceptibility: 29.84 out of 81 (the higher value represents higher landslide risks)

Seismic

- The road segment is exposed to peak ground acceleration (PGA-975) of 0.46 g to 0.48g

Liquefaction

- 35% of the road segment is not exposed to liquefaction susceptibility
- 1% of the road segment is exposed to very low liquefaction susceptibility
- 61% of the road segment is exposed to low to moderate liquefaction susceptibility
- 2% of the road segment is exposed to moderate to high liquefaction susceptibility

ROADWAY CLASSIFICATION

- Major Collector

Chuckanut Drive (No. 4)

LENGTH

- 4.18 miles

START AND END LOCATION (ESTIMATED USING MILEPOST LOCATOR MAP)

- Start: Milepost 9.65
- End: Milepost 13.94

HAZARD INFORMATION

Coastal Flooding

- 2020: 33.3% of the bridges are exposed to the maximum flood depth of 8.37 ft
- 2040: 33.3% of the bridges are exposed to the maximum flood depth of 8.37 ft
- 2080: 33.3% of the bridges are exposed to the maximum flood depth of 8.37 ft

Fluvial Flooding

- 3% of the road segment is located in the 100-year and 500-year flood plain

Landslides

- Highest landslide susceptibility: 70.92 out of 81 (the higher value represents higher landslide risks)

Seismic

- The entire road segment is exposed to peak ground acceleration (PGA-975) of 0.43g

ROADWAY CLASSIFICATION:

- Major Collector

Francis Road (No. 5)

LENGTH

- 3.07 miles

START AND END LOCATION

- Start: Thillberg Road
- End: Near the roundabout of State Route 9 and Francis Road

HAZARD INFORMATION

Coastal Flooding

- 2020: 0.5% of the road segment is exposed to the maximum flood depth of 1.88 ft

- 2040: 0.5% of the road segment is exposed to the maximum flood depth of 1.89 ft
- 2080: 0.5% of the road segment is exposed to the maximum flood depth of 1.92 ft

Dam/Levee Breach

- Exposed maximum inundation depth: 49.4 ft

Fluvial Flooding

- The entire segment is located in the 100-year and 500-year flood plain

Landslides

- Highest landslide susceptibility: 4.02 out of 81 (the higher value represents higher landslide risks)

Seismic

- The road segment is exposed to peak ground acceleration (PGA-975) of 0.41g to 0.43g

ROADWAY CLASSIFICATION

- Major Collector

La Conner Whitney Road (No. 6)

LENGTH

- 3.44 miles

START AND END LOCATION

- Start: 14142 La Conner Whitney Road
- End: Near the roundabout of La Conner Whitney Road, Chilberg Road, and Morris Street

HAZARD INFORMATION

Coastal Flooding

- 2020: 0.2% of the road segment is exposed to the maximum flood depth of 2.74 ft
- 2040: 0.2% of the road segment is exposed to the maximum flood depth of 3.66ft
- 2080: 0.3% of the road segment is exposed to the maximum flood depth of 7.58 ft

Dam/Levee Breach

- Exposed maximum inundation depth: 11.3 ft

Fluvial Flooding

- The entire segment is located in the 100-year and 500-year flood plain

Seismic

- The road segment is exposed to peak ground acceleration (PGA-975) of 0.47g to 0.48g

Liquefaction

- The entire road segment is exposed to moderate to high liquefaction susceptibility

ROADWAY CLASSIFICATION

- Major Collector

Pioneer Highway (No. 7)

LENGTH

- 1.67 miles

START AND END LOCATION

- Start: Near the roundabout of Pioneer Highway, Main Street, Fir Island Road, and Conway Frontage Road
- End: 0.45 miles north of Milltown Road

HAZARD INFORMATION

Coastal Flooding

- 2020: 0.9% of the road segment is exposed to the maximum flood depth of 7.36 ft,100% of the bridges are exposed to the maximum flood depth of 10.29 ft
- 2040: 0.9% of the road segment is exposed to the maximum flood depth of 7.63ft, 100% of the bridges are exposed to the maximum flood depth of 10.71 ft
- 2080: 0.03% of the road segment is exposed to the maximum flood depth of 8.22 ft, 100% of the bridges are exposed to the maximum flood depth of 11.15 ft

Dam/Levee Breach

- Exposed maximum inundation depth: 17.9 ft

Fluvial Flooding

- The entire segment is located in the 100-year and 500-year flood plain

Landslides

- Highest landslide susceptibility: 5.28 out of 81 (the higher value represents higher landslide risks)

Seismic

- The entire road segment is exposed to peak ground acceleration (PGA-975) of 0.46g

Liquefaction

- 98% of the road segment is exposed to moderate to high liquefaction susceptibility
- 2% of the road segment is exposed to high liquefaction susceptibility

ROADWAY CLASSIFICATION

- Major Collector

I-5 (No. 8)

LENGTH

- 0.96 miles

START AND END LOCATION (ESTIMATED USING MILEPOST LOCATOR MAP)

- Start: South of State Highway 11
- End: Milepost 230.06

HAZARD INFORMATION

Dam/Levee Breach

- Exposed maximum inundation depth: 34.4 ft

Fluvial Flooding

- The entire segment is located in the 100-year and 500-year flood plain

Landslides

- Highest landslide susceptibility: 5.03 out of 81 (the higher value represents higher landslide risks)

Seismic

- The road segment is exposed to peak ground acceleration (PGA-975) of 0.43g to 0.44g

ROADWAY CLASSIFICATION

- Interstate

SR 20 – Spur (No. 9)

LENGTH

- 1.50 miles

START AND END LOCATION

- Start: Milepost 48.2
- End: Milepost 49.7

HAZARD INFORMATION

Landslides

- Landslide susceptibility: 52.34 out of 81 (the higher value represents higher landslide risks)

Seismic

- The entire road segment is exposed to peak ground acceleration (PGA-975) of 0.48g

ROADWAY CLASSIFICATION

- Freeway

SR 20 (No. 10)

LENGTH

- 0.74 miles

START AND END LOCATION (ESTIMATED USING MILEPOST LOCATOR MAP)

- Start: Milepost 57.78
- End: Milepost 58.52

HAZARD INFORMATION

Dam/Levee Breach

- Exposed maximum inundation depth: 25.6 ft

Fluvial Flooding

- The entire segment is located in the 100-year and 500-year flood plain

Seismic

- The entire road segment is exposed to peak ground acceleration (PGA-975) of 0.44g

ROADWAY CLASSIFICATION

- Principal Arterial

I-5 (No. 11)

LENGTH

- 1.07 miles

START AND END LOCATION

- Start: South of West College Way
- End: North of Broad Street

HAZARD INFORMATION

Dam/Levee Breach

- Exposed maximum inundation depth: 40.1 ft

Fluvial Flooding

- 54% of the road segment is located in the 100-year and 74% of the road segment is located in the 500-year flood plain

Landslides

- Highest landslide susceptibility: 18.58 out of 81 (the higher value represents higher landslide risks)

Seismic

- The entire road segment is exposed to peak ground acceleration (PGA-975) of 0.44g

ROADWAY CLASSIFICATION

- Interstate

SR 9 (No. 12)

LENGTH

- 2.25 miles

START AND END LOCATION (ESTIMATED USING MILEPOST LOCATOR MAP)

- Start: Milepost 67.78
- End: Milepost 65.53

HAZARD INFORMATION

Landslides

- Highest landslide susceptibility: 55.90 out of 81 (the higher value represents higher landslide risks)

Seismic

- The entire road segment is exposed to peak ground acceleration (PGA-975) of 0.39g

Liquefaction

- 20% of the road segment is exposed to low to moderate liquefaction susceptibility
- 80% of the road segment is exposed to moderate to high liquefaction susceptibility

ROADWAY CLASSIFICATION

- Major Collector

SR 9 (No. 13)

LENGTH

- 2.04 miles

START AND END LOCATION (ESTIMATED USING MILEPOST LOCATOR MAP)

- Start: Milepost 40.4
- End: Milepost 42.44

HAZARD INFORMATION

Landslides

- Highest landslide susceptibility: 52.96 out of 81 (the higher value represents higher landslide risks)

Seismic

- The entire road segment is exposed to peak ground acceleration (PGA-975) of 0.43g

ROADWAY CLASSIFICATION

- Major Collector

I-5 (No. 14)

LENGTH

- 0.34 miles

START AND END LOCATION (ESTIMATED USING MILEPOST LOCATOR MAP)

- Start: Milepost 228.71
- End: Milepost 229.11

HAZARD INFORMATION

Dam/Levee Breach

- Exposed maximum inundation depth: 35.1 ft

Fluvial Flooding

- The entire segment is located in the 100-year and 500-year flood plain

Landslides

- Highest landslide susceptibility: 9.09 out of 81 (the higher value represents higher landslide risks)

Seismic

- The entire road segment is exposed to peak ground acceleration (PGA-975) of 0.44g

ROADWAY CLASSIFICATION

- Interstate

North Cascades Highway (No. 15)

LENGTH

- 5.15 miles

START AND END LOCATION

- Start: Baker Lake Road
- End: Grassmere Road

HAZARD INFORMATION

Coastal Flooding

- 2080: 100% of the bridges are exposed to the maximum flood depth of 1.49 ft

Dam/Levee Breach

- Exposed maximum inundation depth: 169.4 ft

Fluvial Flooding

- 13% of the road segment is located in the 100-year and 30% of the road segment is located in the 500-year flood plain

Landslides

- Highest landslide susceptibility: 18.69 out of 81 (the higher value represents higher landslide risks)

Seismic

- The road segment is exposed to peak ground acceleration (PGA-975) of 0.31g to 0.33g

ROADWAY CLASSIFICATION

- Minor Arterial

SUPPLEMENTAL NOTE: SOUTH SKAGIT HIGHWAY

- South Skagit Highway functions as a parallel roadway to North Cascades Highway and faces similar hazard impacts. If SR 20 or North Cascades Highway is impacted during a hazard event, South Skagit Highway becomes vitally important to transportation redundancy. South Skagit Highway has been identified as a detour for traffic rerouting from SR 20 during hazard events. South Skagit Highway should be considered for comparable resilience improvements with North Cascades Highway.

Josh Wilson Road (No. 16)

LENGTH

- 0.84 miles

START AND END LOCATION

- Start: East of Avon Allen Road
- End: Pulver Road

HAZARD INFORMATION

Dam/Levee Breach

- Exposed maximum inundation depth: 25.0 ft

Fluvial Flooding

- The entire segment is located in the 100-year and 500-year flood plain

Seismic

- The road segment is exposed to peak ground acceleration (PGA-975) of 0.43g to 0.44g

ROADWAY CLASSIFICATION

- Minor Arterial

SR 20 (No. 17)

LENGTH

- 0.41 miles

START AND END LOCATION

- Start: Higgins Airport Way
- End: Bradshaw Road

HAZARD INFORMATION

Dam/Levee Breach

- Exposed maximum inundation depth: 17.3 ft

Fluvial Flooding

- The entire segment is located in the 100-year and 500-year flood plain

Seismic

- The road segment is exposed to peak ground acceleration (PGA-975) of 0.45g to 0.46g

Liquefaction

- The entire road segment is exposed to high liquefaction susceptibility

ROADWAY CLASSIFICATION

- Principal Arterial

SR 534 (No. 18)

LENGTH

- 2.99 miles

START AND END LOCATION

- Start: Estate Drive
- End: SR 9

HAZARD INFORMATION

Landslides

- Highest landslide susceptibility: 33.14 out of 81 (the higher value represents higher landslide risks)

Seismic

- The road segment is exposed to peak ground acceleration (PGA-975) of 0.44g to 0.45g

ROADWAY CLASSIFICATION

- Major Collector

West Big Lake Boulevard (No. 19)

LENGTH

- 2.37 miles

START AND END LOCATION

- Start: West Lakeview Lane
- End: SR 9

HAZARD INFORMATION

Fluvial Flooding

- 2% of the road segment is located in the 100-year and 500-year flood plain

Landslides

- Highest landslide susceptibility: 40.94 out of 81 (the higher value represents higher landslide risks)

Seismic

- The road segment is exposed to peak ground acceleration (PGA-975) of 0.42g to 0.43g

ROADWAY CLASSIFICATION

- Minor Collector

Avon Allen Road (No. 20)

LENGTH

- 0.89 miles

START AND END LOCATION

- Start: Benson Road
- End: North of Josh Wilson Road

HAZARD INFORMATION

Dam/Levee Breach

- Exposed maximum inundation depth: 24.1 ft

Fluvial Flooding

- The entire segment is located in the 100-year and 500-year flood plain

Seismic

- The entire road segment is exposed to peak ground acceleration (PGA-975) of 0.44g

ROADWAY CLASSIFICATION

- Major Collector

Illustrative Regionally Significant Transportation Projects from the RTP

Several of the identified top 20 at-risk candidate project sites were incorporated into the RTP as illustrative regionally significant transportation projects. While the top 20 at-risk candidate project sites look at individual road segments, the RTP resilience-related illustrative regionally significant transportation projects combine several of these at-risk segments into corridor-level projects, listed in

Table 10.

Table 10. Illustrative Resilience Regionally Significant Transportation Projects From the RTP

ID	Agency	Project Name	Project Description	Type	Cost[9]	Time Frame	Expected Completion Year
216	WSDOT /SCOG	Chuckanut Drive Corridor Resilience Study	Conduct a corridor-level resilience planning study along the identified vulnerable segment of Chuckanut Drive (including 6 bridges in this segment to assess hazard exposure, quantify the risk, and develop planning-level adaptation strategies.	Study	$	Short	2027
217	WSDOT /SCOG	State Route 20 (Burlington to Anacortes Segment) Resilience Study	Conduct a corridor-level resilience planning study along the identified vulnerable segments along State Route 20. For those segments, screen planning level resilience strategies to inform future investment decisions.	Study	$	Short	2028

[9] Cost: $ = up to $1 million; $$ = $1 to $10 million; $$$ = $10 to $100 million; $$$$ = over $100 million.

ID	Agency	Project Name	Project Description	Type	Cost[9]	Time Frame	Expected Completion Year
218	WSDOT /SCOG	I5 and Pioneer Highway Resilience Study	Conduct a corridor-level resilience planning study for the vulnerable segments along I-5 and the parallel Pioneer Highway Corridor to assess transportation network redundancy under hazard scenarios and screen planning-level resilience strategies to support system reliability and emergency response.	Study	$	Short	2028
219	WSDOT /SCOG	Skagit County Evacuation and Transportation Network Redundancy Study	Conduct a countywide, system-level resilience study to evaluate evacuation route performance and transportation network redundancy under hazard scenarios, identifying critical links and failure points, and informing planning-level resilience investment priorities.	Study	$	Short	2029

Resilience Improvement Strategies

While the list of Regionally Significant Transportation Resilience Project Locations identifies the hazards of concerns, the solutions to address those potential impacts are likely multi-pronged. While the PROTECT Program emphasizes infrastructure improvements, there are often additional operational or policy-level interventions that can provide overall process improvements that ultimately foster effective resilient infrastructure improvements.

Infrastructure Improvement Strategies

Enhancing the physical resilience of Skagit County's transportation network is foundational to the TRIP. Infrastructure improvements should be designed to address the most significant climate-related hazards identified in the vulnerability assessment. These infrastructure improvements should be prioritized based on asset exposure to hazards, the vulnerability of the asset, the risks posed by the hazards, and the potential to reduce long-term maintenance costs and service disruptions. Table 11. Infrastructure Strategy Examples provides examples of infrastructure strategies that could be considered.

Table 11. Infrastructure Strategy Examples

Hazard	Example Strategy
Flooding (Coastal and Fluvial)	• Upgrade and modernize stormwater drainage systems, including upsizing culverts and storm drains based on updated rainfall projections. • Install or upgrade pump stations and backflow preventers to improve drainage performance during high river and tidal conditions. • Floodproof critical transportation infrastructure by reducing water intrusion and damage (e.g., sealing utility penetrations, armoring embankments against scour, using water-resistant materials, and protecting electrical or mechanical components). • Implement green infrastructure, estuary restoration, and floodplain reconnection projects that reduce flood risk while providing ecological co-benefits, such as wetland restoration, tidal storage enhancement, and setback levees where feasible. • Coordinate with regional flood management efforts, including the Skagit Diking and Drainage Special Purpose District's Flood Risk Management Guidance, to identify opportunities for multi-benefit restoration and, where appropriate, strategic property acquisition that supports flood risk reduction and habitat restoration.
Landslides	• Improve surface and subsurface drainage to reduce slope saturation • Install slope stabilization measures such as retaining walls, soil nail systems, and rockfall barriers in high-risk areas • Monitor high-risk slopes using geotechnical or remote sensing techniques to support early detection and proactive maintenance
Seismic and liquefaction	• Retrofit bridges and roadway structures to improve seismic performance, consistent with current standards and available funding programs • Strengthen foundations and abutments and implement ground improvement techniques in areas with high liquefaction susceptibility • Identify and prioritize lifeline corridors and plan for redundant routes to maintain network connectivity following seismic events
Severe Storms	• Upgrade roadside drainage, culverts, and stormwater inlets to better manage extreme precipitation events • Reinforce signage, signals, guardrails, and other roadside infrastructure to withstand high wind and storm conditions • Improve debris management and clearance strategies to reduce post-storm closures and speed recovery

The consideration of integrating green infrastructure into investment solutions is critical to any infrastructure strategy, which not only has resilience benefits but also recreational, social, and health-related benefits for communities. Examples of green infrastructure include stormwater wetlands, stormwater tree trenches, bioswales, porous pavers, and porous asphalt.[10] As the region looks to address the most pressing hazards, it will be critical to consider a range of solutions that leverage both the built and natural environment.

These measures are intended to reduce the frequency and severity of hazard event disruptions, safeguard essential routes, and protect investments in regional mobility. Ongoing monitoring and proactive management of resilience strategies, particularly along corridors flagged as high-risk, is essential to maintaining safe and reliable transportation links.

Operational Strategies

Operational strategies are integral to maintaining the functionality and safety of the transportation system during and after hazard events. Operational strategies support the safe and reliable functioning of the transportation system during hazard events and are particularly important for evacuation and emergency response. Recent events in Skagit County have demonstrated that roadway closures can quickly shift traffic to alternate routes that were not designed to accommodate high volumes or serve as primary evacuation corridors. These conditions can create safety and operational challenges, highlighting the need for coordinated evacuation route identification and redundancy planning.

A key component of operational resilience is the clear identification of evacuation routes and critical lifeline corridors, including an understanding of how these routes perform under emergency conditions. Some corridors may be formally designated, while others may

10 EPA Mitigate Flooding

function as informal or ad hoc evacuation or detour routes when primary facilities are unavailable. For example, the 2025 flood event illustrated how increased traffic volumes on routes such as Cook Road strained capacity and introduced safety concerns when other corridors were constrained.

Operational planning should build on evacuation route identification by focusing on how these corridors operate during emergencies. This includes traffic control and incident management, interagency coordination, and integration of operational needs into infrastructure planning and maintenance activities. Future efforts to evaluate evacuation routing, corridor redundancy, and emergency operations will help reduce reliance on single access routes, improve system performance during hazard events, and support safer and more effective evacuations.

Recommended operational strategies include:

- Adoption of enhanced monitoring systems and early warning systems to track flood levels, slope movement, and storm conditions along critical corridors.
- Pre-seasonal and pre-event maintenance and preparedness activities focused on drainage clearing, slope inspection, the identification of vulnerable assets before hazard seasons begin, and the readiness of traffic control devices.
- Refined detour and traffic management planning for evacuation and lifeline routes, coordinated with emergency management and law enforcement to ensure that alternative routes are available.
- Clear and timely communication to the public in the event of roadway closures, detours, and evacuation guidance during hazard events.

Strategies like these would enable timely detection of emerging threats and support rapid response efforts.

Policy, Governance, and Partnership Coordination Strategies

Policy and governance strategies should be designed to create a supportive environment for resilience investments, facilitate interagency coordination, and ensure that responsibilities are clearly defined and aligned with regional and local priorities. Building long-term resilience requires effective governance structures and strong partnerships across all levels of government and with the broader community. Examples of policy and governance strategies include:

- Systematic sharing of data on roadway and bridge vulnerabilities among member jurisdictions.
- Joint planning for corridors that cross multiple jurisdictions to ensure consistent resilience standards and to address shared hazard exposures.
- Strengthened coordination among agencies through joint exercises, shared protocols, and integrated communication platforms.

These types of collaborative approaches would ensure that resources are efficiently allocated and that response actions are unified and effective, enabling coordinated planning and informed decision-making.

Collaboration with tribal governments is a priority, especially for projects that impact network connectivity to tribal lands and that expedite emergency response. Partnerships with natural resource and flood control districts should be utilized to improve understanding of levee systems, enhance flood forecasting capabilities, and support integrated hazard mitigation efforts. Ongoing engagement with State and Federal agencies (including WSDOT and FHWA) will help identify technical assistance, statewide risk data, and funding opportunities.

Community Considerations

Community resilience is a central consideration to the TRIP's approach, recognizing that climate-related hazards disproportionately impact vulnerable populations and isolated communities. There are communities at risk of isolation during floods, landslides, or bridge closures, including tribal communities and rural residents who rely on single-access routes for mobility and emergency services. Resilience investments should be considered for prioritization where they address the needs of these populations and support robust and inclusive emergency response and evacuation planning.

Community stakeholders should also be engaged in the identification of risks and the co-creation of resilience strategies, drawing on local knowledge and lived experience to inform project design and implementation. Co-benefits such as safer travel conditions, reduced maintenance costs, and improved access for all users are potential key outcomes of resilience projects.

Project Prioritization

Effective prioritization of resilience projects and strategies is essential to maximizing the impact of investments and ensuring the long-term reliability of Skagit County's transportation network. The TRIP's prioritization framework is designed to guide member agencies and partners through a transparent, data-driven process that considers the following key factors:

- **Hazard Exposure**: Assessment of the degree to which a roadway or bridge segment is subjected to climate-related hazards, including flooding, landslides, seismic risk, liquefaction, and levee breach inundation. Projects addressing assets with high exposure are prioritized to reduce the likelihood and severity of disruptions.
- **Emergency Management**: Evaluate the importance of each asset for regional mobility, freight movement, emergency response, and access to tribal lands. Corridors and infrastructure serving isolated or vulnerable communities receive elevated consideration.
- **Vulnerability**: Determine the likelihood that hazard exposure will result in damage or service disruption, using both quantitative and qualitative risk assessments. Assets with high vulnerability are targeted for resilience improvements.
- **Community Isolation**: Identify projects that serve communities without reliable alternative routes, ensuring that investments address the needs of populations at risk of isolation during hazard events.
- **Cost and Feasibility**: Consider the technical and financial practicality of proposed resilience solutions, including estimated costs, implementation timelines, and potential funding sources. Projects that offer high impact and feasible implementation are prioritized.

Prioritization is not limited to physical infrastructure improvements. The TRIP encourages the development of operational, policy, and partnership strategies that complement capital investments, including:

- *Operational Strategies:* Enhanced monitoring systems, pre-seasonal maintenance, detour planning, and rapid response protocols to maintain functionality during hazard events.
- *Policy and Governance:* Adoption of resilient design standards, integration of hazard data into planning processes, and establishment of interagency coordination mechanisms.
- *Land Use and Preservation:* Development or application of programs like the Skagit County's Farmland Legacy Program that protect farmland and enhance ecological conditions, which could also support broader resilience and hazard mitigation objectives.
- *Community Engagement:* Ongoing stakeholder involvement in project identification, strategy co-creation, and evaluation to ensure that local knowledge and priorities inform decision-making.

Recognizing that risks, data, and community needs evolve over time, the TRIP's prioritization process is designed to be adaptive. Member agencies are encouraged to:

- Regularly update hazard exposure and vulnerability assessments as new information becomes available.
- Reassess project priorities in response to changing conditions, emerging risks, and lessons learned from completed projects.
- Maintain flexibility in strategy development to accommodate evolving technologies, funding opportunities, and stakeholder feedback.

Implementation Roadmap

Member Agency Resources

As noted earlier in the report, SCOG conducted additional outreach with member agencies to ensure that the tools and outputs developed through the TRIP were practical, actionable, and responsive to local agency needs. These discussions focused on interpretation of the risk assessment results, including how high-ranking roadway and bridge segments should be understood, how regional datasets can be applied locally, and how jurisdiction-specific context may influence perceptions of risk and prioritization. Member agencies also provided input on a suite of supporting resources developed in parallel with the TRIP including jurisdiction-specific results, GIS map layers, example BCA's, a solutions toolkit, and guidance on how to apply TRIP findings in local planning and project development.

JURISDICTION-SPECIFIC RISK ASSESSMENT RESULTS

To support local application of the regional risk assessment, SCOG developed jurisdiction-specific roadway and bridge risk results organized by member agency. This allows agencies to focus on assets within their own jurisdiction, ownership, or area of responsibility and to better understand how regional risk findings translate to local contexts. The jurisdiction-specific results are intended to support internal discussions, screening-level prioritization, and identification of locations that may warrant further site-specific evaluation.

GIS MAP LAYERS

GIS map layers were developed to provide spatial data for the risk assessment results and underlying hazard information. These layers will allow member agencies to visualize exposure and risk across their transportation networks, overlay results with local datasets, and integrate TRIP findings into existing GIS workflows. The GIS map layers are intended to support planning, coordination, and communication and are not intended to replace detailed engineering or site-specific analyses.

GUIDE TO APPLYING THE RISK ASSESSMENT RESULTS

A guide was prepared that includes information for how to leverage the risk assessment results to inform site-specific resilience planning. The guide describes how agencies can move from system-level screening to more detailed, project-level evaluation by incorporating local knowledge, additional data, and professional judgment. The guide is designed to be flexible and scalable, allowing agencies to apply it to projects at different stages of development and with varying levels of available information.

MEMBER AGENCY RESILIENCE GUIDANCE FORM

An accompanying guidance form was developed to help member agencies systematically evaluate how resilience considerations can be incorporated into existing or planned transportation projects. The form walks users through key steps including hazard screening, assessment of potential impacts, identification of applicable resilience strategies, consideration of performance and costs, and exploration of funding opportunities. The form is intended to support internal scoping and coordination discussions and does not commit an agency to a specific project, solution, or funding source.

BENEFIT-COST ANALYSIS EXAMPLES

Example BCAs were developed to demonstrate how agencies can evaluate the economic performance of resilience strategies using the TRIP risk assessment results. The examples illustrate how reductions in expected damages and service disruptions can be compared against implementation costs to support project prioritization and funding decisions. These BCAs are available to member agencies for illustrative purposes only and are not intended to represent final project evaluations.

SOLUTIONS TOOLKIT

The Solutions Toolkit provides a menu of example resilience strategies that may be applicable to transportation assets exposed to different hazards, including flooding, extreme temperatures, wildfire, severe storms, landslides, and seismic and liquefaction risks. The toolkit highlights implementation opportunities, potential outcomes, and examples from other jurisdictions to illustrate how resilience features can be integrated into transportation projects. The strategies presented are illustrative and are intended to inform consideration of options rather than prescribe specific solutions.

Project Evaluation

In addition to the member agency resources that have been developed, there are also several considerations for SCOG and the region as transportation resilience projects begin to take shape. The resilience project criteria presented below are designed to support SCOG and member agencies as they systematically evaluate how projects can address current and future climate-related hazards or risks. By incorporating resilience considerations into decision-making processes, these criteria can help ensure that projects help reduce vulnerabilities from natural hazards and promote strategic investments aimed at enhancing transportation system resilience. The following section lists a menu of proposed project criteria to be further evaluated and refined with project partners.

PROPOSED PROJECT CRITERIA CHECKLIST

- **Alignment with Regional and System Resilience Goals**
    - Aligns with Hazard Mitigation Plan.
    - Aligns with regional and/or local planning goals related to system resilience.
    - Aligns with the SCOG Transportation Resilience Improvement Plan (TRIP).
- **Planning-level Assessment of Exposure**
    - Addresses multiple hazard types present in the project area.
    - Addresses intensity and frequency of current and projected future conditions, where data is available.
    - Considers lessons learned from past disruptions and events.
- **Solutions Evaluation**

- Considers and incorporates adaptive design features where appropriate.
- Considers and incorporates nature-based solutions where appropriate.
- Provides environmental co-benefits such as emissions reduction and/or improved environmental quality.
- Identifies specific resilience benefits to the asset owner, asset users, and the broader community.

- **Regional Operational Resilience**
    - Addresses network cascading impacts—when a primary hazard event (trigger) is followed by a chain of consequences (e.g., an earthquake triggers a tsunami that leads to utility failures).[11]
    - Includes continuity-of-operations measures that maintain or rapidly restore safe travel, emergency response, and evacuation functionality during and after hazard events.
    - Demonstrates interagency coordination and assignment of responsibilities for managing evacuation routes, emergency access, traffic operations, and system recovery under emergency conditions.
    - Identifies and addresses interdependencies among agency responsibilities that influence evacuation performance, emergency response, and operational decision-making.
    - Improves the operational safety and reliability of designated evacuation routes and implements measures that avoid maladaptation or shifting risks.
    - Enhances system redundancy by reducing reliance on single corridors and ensuring continued network connectivity if primary routes are compromised.
- **Social and Community Resilience**
    - Resilience benefits are identified for different community groups, including vulnerable or underserved communities.
    - Strengthens community resilience and preparedness.
    - Engages community stakeholders in identifying risks and potential resilience strategies.
- **Economic and Institutional Resilience**
    - Demonstrates a business case for resilience investment.

[11] National Academies of Sciences, Engineering, and Medicine. 2022. Resilience for Compounding and Cascading Events. Washington, DC: The National Academies Press. https://doi.org/10.17226/2453.

- Specific resilience benefits to the asset owner, asset users, and the broader community have been identified (also under Solutions Evaluation above)
- Includes diverse or long-term funding sources.

PROJECT CRITERIA AND SCORING RUBRIC

To assess how well a project proposal meets the potential proposed criteria, a scoring rubric has been developed to guide the evaluation process, as shown in Table 12.

Table 12. Recommended Project Resilience Screening Criteria

Criteria	Score	Score Description
Alignment with Regional and System Resilience Goals	1 2 3	1. General assessment of alignment; limited integration of specific plans or goals. 2. Moderate assessment of alignment; some integration of specific plans or goals. 3. Full assessment of alignment; clearly identifies relationship with specific regional plans or goals.
Planning-Level Assessment of Exposure	1 2 3	1. Basic consideration of a small number of hazards; limited consideration of future conditions. 2. Moderate consideration of a few hazards with some forward-looking elements. 3. Comprehensive assessment of multiple hazards, including current and future conditions, with lessons learned from past disruptions incorporated.
Solutions Evaluation	1 2 3	1. Minimal discussion of applicability of adaptive design or nature-based solutions; brief discussion of general benefits. 2. Some discussion of adaptive design and/or nature-based solutions (as applicable); detailed discussion of some environmental co-benefits. 3. Robust consideration of adaptive design and nature-based solutions (as applicable) with quantified environmental benefits and cost savings for asset owners and/or users.

Criteria	Score	Score Description
Regional Operational Resilience	1 2 3	1. Minimal consideration of network impacts and interdependencies; limited discussion of coordination or roles and responsibilities. 2. Moderate integration of network impacts and continuity-of-operations measures; high-level discussion of roles and responsibilities. 3. Robust discussion of specific cascading network impacts, inclusion of continuity-of-operations measures with clear and detailed roles and responsibilities and interagency coordination.
Social and Community Resilience	1 2 3	1. Brief discussion of general community benefits; minimal evidence of stakeholder engagement in planning process. 2. Discussion of benefits for specific communities and demonstration of stakeholder input. 3. Robust assessment of community benefits with specific vulnerable communities discussed; clear and comprehensive record of engaging stakeholders in resilience strategy co-creation.
Economic and Institutional Resilience	1 2 3	1. Qualitative discussion of the business case for resilience investment; minimal discussion of benefits and additional funding sources. 2. Quantitative discussion of the business case; some benefits and potential funding additional sources identified. 3. Quantitative discussion of the business case; robust discussion and identification of benefits to asset owners, users, and broader community with a comprehensive review of potential additional funding sources.

EVALUATION AND REPORTING CONSIDERATIONS

Projects submitted by member agencies can be evaluated using the standardized project form that scores proposals against the established criteria. Each project would generate a summary that may outline strengths, highlight gaps, and/or recommend resilience enhancements. Agencies would receive clear feedback that can be used to refine project designs and justify funding requests.

While the recommended project criteria are meant to guide project development, it will be just as important to assess and improve long-term organizational resilience. Below is a list of potential additional criteria that may be helpful for SCOG during project evaluation and monitoring.

- Organizational Capacity, Workforce, and Governance
  - Shows adequate organizational capacity to develop and maintain resilience elements.
  - Capacity has been identified for maintaining the functionality of the project's resilience elements over time.
- Monitoring, Performance, and Adaptability
  - Includes resilience performance indicators.
  - Identifies project monitoring and evaluation process to identify degradation in resilience performance.
  - Includes adaptive management and scalable design.

Table 13. Recommended Project Evaluation and Reporting Criteria

Criteria	Score	Score Description
Organizational Capacity, Workforce, and Governance	1 2 3	1. Minimal organizational capacity identified; no clear maintenance plan. 2. Some staff resources identified to develop and maintain resilience elements. 3. Dedicated staff and/or team focused on robust maintenance of resilience elements.

Criteria	Score	Score Description
Monitoring, Performance, and Adaptability	1 2 3	1. Qualitative discussion of monitoring; no specific performance indicators or evaluation process delineated. 2. High-level monitoring plan with discussion of performance indicators broadly; some discussion of adaptive management. 3. Detailed monitoring plan with clear and measurable performance indicators identified; clear plan for adaptive management and scalability.

Performance Monitoring and Reporting

Ongoing performance monitoring and transparent reporting will be essential to ensure that resilience strategies and projects deliver their intended benefits and adapt to evolving risks. The TRIP proposes a framework for tracking the implementation and effectiveness of resilience improvements across Skagit County's transportation network. This framework should include systematic documentation of completed and in-progress projects, enabling member agencies and stakeholders to assess progress toward regional resilience goals.

Hazard data and the vulnerability analysis should be regularly updated as new information becomes available, ensuring that prioritization criteria remain relevant and responsive to emerging threats. Disruptions to roadways and bridges caused by climate-related hazards should be documented and analyzed to identify trends, inform future planning, and refine resilience strategies. Performance indicators should be integrated into project design, such as measures of asset reliability, reduction in service disruptions, and improvements in emergency response times.

Reporting activities should be designed to be transparent and accessible, providing clear summaries of project outcomes, lessons learned, and areas for improvement. Member agencies are encouraged to share monitoring results and best practices, fostering a culture of continuous learning and adaptive management. As State and Federal guidance evolves, the TRIP's monitoring and reporting processes will be adjusted to align with new standards and requirements, ensuring that Skagit County remains at the forefront of transportation resilience.

Conclusion

The SCOG TRIP represents a pivotal advancement in the region's approach for safeguarding transportation infrastructure against the escalating risks posed by climate change and natural hazards. The TRIP will improve SCOG's ability to support regional preparedness and responses to the impacts of hazard events, natural disasters and changing conditions. The TRIP provides insight and understanding of the threats facing Skagit County's roadways and bridges, enabling data-driven prioritization of resilience investments. Central to the TRIP is the commitment to inclusive and transparent stakeholder engagement. By actively involving member jurisdictions, tribal governments, emergency services, and the broader community, the plan ensures that local knowledge, community considerations, and local priorities are fully integrated into its recommendations. This collaborative approach not only strengthens the technical foundation of the TRIP but also fosters a shared sense of ownership and responsibility for resilience of the region's transportation system.

The TRIP is designed to be dynamic and adaptive, evolving in response to new data, emerging hazards, and lessons learned from implementation. By embedding resilience into the RTP, from project selection and policy development to performance monitoring and reporting, SCOG and its partners are laying the groundwork for a transportation system that is more robust, reliable, and resilient.

Next Steps

To translate the vision and strategies outlined in the TRIP into tangible outcomes, SCOG and its partners will undertake the following next steps:

- *Continually Integrate TRIP Recommendations into the RTP:* Resilience goals and policies have been embedded into Move Skagit 2050 RTP. During future RTP updates, it is recommended that the TRIP's findings, project criteria, and prioritized investments continue to be incorporated into the RTP and local comprehensive plans. This integration supports long-term planning and ensures that resilience remains a central consideration in all transportation decision-making.

- *Apply Member Agency Resources to Advance Project Development:* Member agencies are encouraged to use jurisdiction-specific risk assessment results, GIS map layers, the guide to applying risk assessment results, the resilience guidance form, benefit-cost analysis examples, and the solutions toolkit to inform their own project development, prioritization, funding, and implementation efforts.
- *Develop an Adaptive Management and Review Approach:* Support the use of consistent approaches for tracking the progress and effectiveness of resilience projects. Periodic updates to hazard data, vulnerability assessments, and performance indicators can inform adaptive management and continuous improvement. Reviewing and refining project priorities, resilience strategies, and performance measures based on emerging risks, new information, and lessons learned from completed projects can support continued relevance and effectiveness.
- *Foster Ongoing Collaboration and Engagement:* Maintain coordination among member jurisdictions, state and federal agencies, and regional partners through regular communication, shared learning, and the exchange of best practices to strengthen regional capacity.

MOVE SKAGIT
TRANSPORTATION RESILIENCE IMPROVEMENT PLAN

Appendix A. Public Comment Tracker (reserved)