

PNNL's Seismic Expertise and Capabilities



Trusted Solutions and Evaluations of Seismic Hazards for Critical Infrastructure

OUR CAPABILITIES

Probabilistic seismic hazard assessment

Remote control and monitoring of subsurface test beds

High-performance computing and large-scale numerical simulations

Risk-informed decision analysis for infrastructure development



**PNNL offers
broad and efficient
seismic expertise.**



Natural and human-made disasters impose potential hazards to critical infrastructure, such as dams, power plants, and transportation routes.

Probabilistic Seismic Hazard Assessment (PSHA) is one of the indispensable tools used for estimating damage to infrastructure from different intensities of ground motion related to earthquakes, hurricanes, tsunamis, or even human-made structures, such as wind turbines.

With comprehensive seismic expertise, Pacific Northwest National Laboratory (PNNL) offers efficient and comprehensive in-house PSHAs, along with site characterization, ground motion estimates, and evaluations of materials under dynamic conditions.

Identifying Hazards to Critical Infrastructure

PNNL's seismic capabilities include:

- **Ground Motion Predictions:** Conducting evaluations and monitoring of vibration impacts from both natural and human-made disturbances. This includes strong motion events like earthquakes and explosions, characterization for wind turbine foundations, and vibration monitoring for large-scale construction or excavation projects.
- **Materials Under Dynamic Conditions:** Developing and conducting specialized laboratory experiments to evaluate strength parameters of geologic materials under varying stress conditions. Applications include seismic hazard analyzes, nuclear power plant design, subsurface contamination monitoring, and wind turbine design.
- **National Environmental Policy Act Integration:** Providing comprehensive, efficient, and in-house National Environmental Policy Act analyses.
- **Probabilistic Seismic Hazard Assessment:** Supporting the strategies, decision-making, and solutions to address potential infrastructure damage by characterizing different ground motion intensity parameters.
- **Real-Time Monitoring and Modeling for Decision-Making:** Providing solutions to help stakeholders make critical operational decisions using computational modeling informed by experimental measurements. Our experts conduct remote control and monitoring of subsurface test beds, such as engineering geothermal systems and underground explosions. This includes autonomous monitoring and control of subsurface hydraulic fracturing stimulations, near real-time seismic and electrical resistivity data acquisition, and inversion with state-of-the-art computational codes.



- **Seismic Event Monitoring and Noise Imaging:** Providing expertise to monitor seismic events from the laboratory to field-scale, as well as subsurface imaging by ambient noise techniques through development and deployment of seismic arrays. Recent efforts include microseismic analysis of a mesoscale hydraulically fractured geothermal test bed along with ambient noise investigations of permafrost dynamics, soil desiccation, and subsurface fracture detection and imaging.
- **Seismic Tomography:** Developing imaging techniques based on seismic waves generated by earthquakes or explosions, as well as ambient noise data, to create images of the Earth's subsurface. PNNL has used these methods extensively on environmental, geothermal, and national security projects.
- **Site Characterization:** Developing spectral analysis of surface waves, refraction microtremor, and cross borehole and ambient noise tomographic imaging for characterization of the subsurface. Recent efforts include the imaging and monitoring of subsurface test beds, such as enhanced geothermal systems and underground explosions.
- **Other Hazards Triggered by Seismic Events:** Drawing upon broad expertise in subsurface characterization of potential tsunamigenic sources from landslides with applications to tsunami hazard analyses to identify other hazards triggered by seismic events.

Enhancing Probabilistic Seismic Hazard and Risk Assessments

With increasingly sophisticated societal demands and advances in scientific understanding, PNNL is uniquely positioned to enhance and refine several elements within PSHAs, including:

- **Enhanced Monitoring of Seismic Activity:** Providing expertise, building, installing, and operating geophysical monitoring stations in areas where instrumentation is limited, or in regions of enhanced seismic activity. Additional monitoring coverage near nuclear power plants will prove key in assessing plant safety following seismic events.
- **Seismic Source Characterization:** Providing seismic source zone characterization via several techniques, including fault trenching, geological mapping, as well as computational methods like moment tensor inversion and magnitude estimation. Our capabilities include high-resolution geologic field mapping via LiDAR, including fault mapping, paleo-seismic studies to develop improved local and regional fault maps that better inform source zone characteristics.

- **Seismic Vulnerability Mapping:** Supporting informed decision-making by state and local authorities for pre- and post-seismic event response. Our capabilities include updating pre- and post-event assessments of airfields, roads, and water supply lines to enable robust emergency planning.
- **Probabilistic Risk Assessments:** Providing technical support for integrated decision-making based on risk-informed, performance-based assessments of hazards on infrastructure (e.g., facilities, utilities). PNNL has supported development of probabilistic hazard analysis methodology, peer reviews, and gap assessments to probabilistic risk assessment standards, fragility analyses, plant/system response analyses, consequence analyses, maintenance of safety margins, site response from multiple loading scenarios, adequacy assessments of defense-in-depth, and performance measurement of mitigating systems.



PNNL Bench Depth

PNNL’s interdisciplinary team of seismologists, geophysicists, and engineers offer a breadth of applied industry and professional experience with both site and structural evaluations (e.g., tunnels, bridges, dams, and power plants). This team is uniquely positioned within the national laboratories to advance cutting-edge research and monitoring and has supported the Department of Energy across a broad scope of mission spaces, including environmental, geothermal, and national security projects.

About PNNL

Pacific Northwest National Laboratory advances the frontiers of knowledge, taking on some of the world’s greatest science and technology challenges. Distinctive strengths in chemistry, Earth sciences, biology, and data science are central to our scientific discovery mission. PNNL’s research lays a foundation for innovations that advance sustainable energy through decarbonization and energy storage and enhance national security through nuclear materials and threat analyses.

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